How can digital technologies be optimised and implemented within surgical pathways to support patients in making healthier lifestyle changes to improve surgical outcomes?

The results of three systematic reviews and three patient-informed qualitative studies.

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Abstract

There have been successful shifts toward the integration of digital technologies into clinical practice, benefitting clinicians and patients alike. Unanswered questions still remain regarding the optimisation of digital technologies when used by patients; specifically, to support lifestyle changes when undergoing bariatric, orthopaedic and cancer surgeries (Chapter 1). A systematic review of the existing quantitative literature was conducted to explore digital technology use during the aforementioned surgical specialities, with a focus on supporting lifestyle changes to be made (Chapter 2). Three knowledge gaps were identified: (i) the possibility of behavioural theory underpinning digital health technology design, (ii) the optimisation of design features to best suit patient needs, and (iii) the timing of digital health technology implementation and use during the surgical pathway. A second systematic review (meta-ethnography) was undertaken to synthesise important digital capabilities to support lifestyle change (Chapter 3), along with a literature review to identify current digital strategies in use (Chapter 4). Both reviews recognised a paucity of data identifying 'optimal' technology constituents from patient perspectives – thus, three patient-informed qualitative studies were conceptualised to address the knowledge gaps across bariatric, orthopaedic and cancer surgical cohorts. Chapter 5 details the methodology, research question, aims and objectives for this programme of work, while Chapters 6-8 detail the results, discussions and conclusions from the 54 pre- and post-operative participants involved. An overarching discussion and conclusion from the findings of the qualitative studies is included in Chapter 9. This research identified the importance of implementing person-centred approaches and including participant involvement in the ongoing development, optimisation and implementation of digital technologies in healthcare. Unique to each surgical cohort, underpinning features of technology were identified in order to optimally support behaviour change. These findings should be used to shape future co-design studies to inform healthcare providers, technology developers and further research in this area.

COVID Impact Statement

This thesis is a piece of work affected by the COVID-19 pandemic. In a time of unprecedented change, the pandemic presented the researcher with practical, methodological and emotional challenges that required careful navigation to ensure the smooth running of various aspects of this work. Public health restrictions and social distancing measures impacted the researcher's ability to carry out this qualitative investigation as initially planned. Participant recruitment and data collection were two substantial areas where the research methodology for this programme of work was impacted. Consequently, the researcher was required to make amendments to her anticipated study design and transition this project from face-to-face qualitative research, to instead use other 'socially-distant' and remote methods; details concerning this are discussed in the study methodology (Chapter 5).

Consideration was also given to the emotional impact that the pandemic may have on study participants. The researcher was mindful of the potential effect on the number of participants who were willing partake in research during a period of global uncertainty. This was particularly significant for participants from the surgical cancer cohort, who may have already felt and experienced an emotional burden, as a consequence of their underlying disease diagnosis. It was also essential to consider the views, emotions and concerns of patients who may have experienced delays and/or cancellations to their scheduled surgeries; the pandemic presented a significant burden on the NHS and, as a result, many elective surgeries were cancelled.

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List of Abbreviations

Abbreviation	Full Description
AKH	Andrew K Husband
AR	Anna Robinson
BMI	Body Mass Index
CASP	Critical Appraisal Skills Programme
CINAHL	Cumulative Index to Nursing and Allied Health Literature
COM-B	Capability, Opportunity, Motivation-Behavioural model
COVID-19	Coronavirus-19
GP	General Practitioner
HSRPP	Health Services Research and Pharmacy Practice conference
iCBT	internet-delivered Cognitive Behavioural Therapy
MDT	Multidisciplinary team
MeSH	Medical Subject Heading
NHS	National Health Service
NICE	National Institute for Health and Care Excellence
NIH	National Institute of Health
OSOP	One Sheet of Paper
P&P	Pre- and Post-operative
Post-op	Post-operative
PPIE	Patient and Public Involvement and Engagement
Pre-op	Pre-operative
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PROSPERO	International prospective register of systematic reviews
RDS	Robert D Slight
rTA	Reflexive Thematic Analysis
SCT	Social Cognitive Theory
SPS	Sarah P Slight
TTM	Transtheoretical Model of Change
UK	United Kingdom
UO	Umay Ozsuk
WHO	World Health Organisation

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It is safe to say that my family and friends have helped me beyond measure – thank you for believing in me and for encouraging to go back to university and pursue a career change. Mam and John, thank you for always reading my pieces of writing (even if you didn't understand it!) and to my husband Graeme for being my strength throughout, in so many ways.

Dedication

This thesis is dedicated to my two role models – firstly, my late Grandma, Joan Goodfellow, who always supported me in every aspect of my life. And to my Grandpa, William Goodfellow, who encourages me to keep writing every day – I finally did it!

About the Author

Anna Robinson graduated with a First Class Masters of Pharmacy degree in 2015, from the University of Sunderland, and passed the General Pharmaceutical Council's registration exam to qualify as a pharmacist in 2016. Anna worked as a clinical pharmacist and then specialist clinical pharmacist for over 2 years. She was recognised for this work with the Safe and High-Quality Care award from Northumbria Healthcare NHS Foundation Trust. During her Foundation Training, Anna also obtained a Distinction in her Post-Graduate Clinical Diploma in Advanced Clinical Pharmacy Practice from Queen's University Belfast.

In September 2018, Anna began her PhD at Newcastle University. During this time, she has contributed to teaching within the School of Pharmacy and Faculty of Medical Sciences, delivering sessions to undergraduate pharmacy and medical students. Anna received Fellowship of the Higher Education Academy (FHEA) status in December 2019. During her PhD, Anna held a national position on the Health Education England (North) board for pre-registration pharmacist education and was appointed a national member of the Royal Pharmaceutical Society's Early Career Pharmacist Advisory Group. As part of this PhD programme of work, the author has published 6 articles in international peer-reviewed journals and has presented at both national and international conferences. Anna was awarded the Royal Pharmaceutical Society Best Research award at their National Annual Conference in 2019, and Best Oral Presentation at the University Institute of Health and Society Annual Conference in 2019. Anna was shortlisted as a TEDx Newcastle University Speaker in 2019 and she placed third in the Newcastle University 3-Minute Thesis competition, going on to present at the regional final in 2020. In January 2021, Anna was appointed as Editorial Board Member to two journals, Research in Social and Administrative Pharmacy (RSAP) and Exploratory Research in Clinical and Social Pharmacy (ERCSP).

Anna also maintained her clinical practice as a Specialist Clinical Pharmacist throughout her PhD. During the COVID-19 pandemic, she worked on the NHS front line and represented the pharmacy profession on various media outlets including BBC radio. She also supported the roll out of the COVID-19 vaccination at two of the mass vaccination sites in Newcastle. In September 2021, Anna accepted a full-time position as a Lecturer at the School of Pharmacy.

Publications and Academic Outputs

PEER-REVIEWED PUBLICATIONS FROM THIS PHD:

1. **Robinson, A.**, Husband, A., Slight, R., Slight, S., *Designing digital health technology to support patients before and after bariatric surgery: a qualitative study exploring patient desires, suggestions and reflections to support lifestyle behaviour change.* JMIR Human Factors, 2022. DOI: 10.2196/29782.
2. **Robinson, A.**, Husband, A., Slight, R., Slight, S., *Designing the optimal digital health intervention for patients' use before and after orthopaedic surgery: a qualitative study.* JMIR, 2021. DOI: 10.2196/25885.
3. **Robinson, A.,** Husband, A., Slight, R., Slight, S., *The effectiveness of digital technologies to support surgical patients in changing their health behaviours: a systematic review*. BJS Open, 2021. DOI: 10.1093/bjsopen/zraa009.
4. **Robinson, A.**, Oksuz, U., Slight, RD., Slight, SP., Husband, AK., *Digital and mobile technologies to promote physical health behaviour change and provide psychological support for elective surgical patients: a meta-ethnography and systematic review.* JMIR mHealth and uHealth, 2020, 8(12): e19237. DOI: 10.2196/19237.
5. **Robinson, A.,** Husband, A., Slight, R., Slight, S., *Digital support for patients undergoing bariatric surgery: narrative review of the roles and challenges of online forums.* JMIR Perioperative Medicine, 2020, 3(2): e17230. DOI: 10.2196/17230.
6. **Robinson, A.,** Husband, A., Slight, R., Slight, S., *The value of teachable moments in surgical patient care and the supportive role of digital technologies.* Perioperative Medicine, 2019. DOI: 10.1186/s13741-019-0133-z (corresponding author).

PUBLICATIONS UNDER REVIEW AT THE TIME OF THESIS SUBMISSION:

1. **Robinson-Barella, A.**, Husband, A., Slight, R., Slight, S., *Designing a digital health lifestyle support tool for lung cancer patients requiring surgery: a qualitative exploration of digital technology capability, functionality and design.* JMIR Perioperative Medicine, 2023.
2. Pakirathan, S., Husband, A., **Robinson-Barella, A.**, *Inclusive digital healthcare to meet the needs of people from ethnic minority communities: a systematic review exploring barriers and enablers in digital health technologies.* JMIR, 2023.

ORAL PRESENTATIONS FROM THIS PHD:

1. *How can digital technologies be optimised within surgical pathways to best support patients in making lifestyle changes to improve surgical outcomes.* Newcastle University School of Pharmacy Research Series, April 2023.
2. *Conducting qualitative research remotely: learning points and methodological considerations from my PhD programme of work.* Newcastle University School of Pharmacy Research Series, December 2022.
3. *Designing the optimal digital health intervention for patients' use before and after elective orthopaedic surgery: a qualitative study.* Link UK Orthopaedic Symposium, November 2021 – keynote speaker.

4. *Technology enabled research.* Great North Pharmacy Research Collaborative Conference, breakout session co-speaker, July 2021.
5. *A qualitative study exploring patient suggestions for the design, functionality and implementation of digital health technologies before and after bariatric surgery.* Health Services Research and Pharmacy Practice Conference (HSRPP), April 2021 – awarded runner-up best oral presentation.
6. *A prescription for technology.* INSIGHTS Public Lectures, Doctoral Thesis presentation, Newcastle University, March 2021.
7. *Supporting surgical patients in a modern NHS: can we prescribe apps?* North East of England Regional Finalist, 3 Minute Thesis Competition, June 2020.
8. *Supporting surgical patients in a modern NHS: can we prescribe apps?* Newcastle University 3 Minute Thesis Finalist, June 2020 – awarded 3rd place and invited to the Regional final.
9. *The effectiveness of Digital Health Technologies to support surgical patients in changing health behaviours: a systematic review and narrative synthesis.* Health Services Research and Pharmacy Practice Conference (HSRPP), April 2020.
10. *Evaluating the effectiveness of eHealth and digital health technologies to support behaviour changes in surgical patients.* North East Postgraduate Conference, November 2019.
11. *Digital technologies for surgical patients in the NHS.* Newcastle University TEDx Shortlist interviews for the annual Student Speaker Competition, November 2019.
12. *Future of pharmacy prescribing panel: Teaching undergraduates to prescribe; current practice and future vision*. Clinical Pharmacy Congress, June 2019. Panelist on the Leadership stage.
13. *Changing Careers: Journey from Clinical Pharmacist to Academia and PhD Student.* Clinical Pharmacy Congress, June 2019 – Individual guest speaker on the Changing Careers stage.
14. *Exploring the use of digital technologies to support health behaviour changes in surgical patients.* Institute of Health and Society Post Graduate Conference, June 2019 – awarded best oral presentation.

CONFERENCE ABSTRACTS & POSTER PRESENTATIONS:

1. *Designing person-centred technologies to support patients undergoing cancer surgery: a pharmacist-led, qualitative study.* Royal Pharmaceutical Society (RPS) Annual Conference, November 2022.
2. *Exploring patient suggestions for the design, functionality and implementation of digital health technologies before and after bariatric surgery.* Great North Pharmacy Research Collaborative Conference, July 2021.
3. *Designing the optimal digital health intervention for patients' use before and after elective orthopaedic surgery: a qualitative study.* Great North Pharmacy Research Collaborative Conference, July 2021.
4. *A qualitative study exploring patient suggestions for the design, implementation and use of digital health technologies before and after bariatric surgery.* Health Services Research and Pharmacy Practice Conference (HSRPP), April 2021. (Published – International Journal of Pharmacy Practice, April 2021).

5. *Digital health technologies to support physical and psychological behaviour change in elective surgical patients: a meta-ethnography and systematic review.* Royal Pharmaceutical Society Science and Research Summit 2020. (Published – International Journal of Pharmacy Practice, June 2020).
6. *The effectiveness of Digital Health Technologies to support surgical patients in changing health behaviours: a systematic review and narrative synthesis.* Health Services Research and Pharmacy Practice Conference (HSRPP) 2020. (Published – International Journal of Pharmacy Practice, April 2020).
7. *Evaluating the effectiveness of eHealth and digital technologies to support health behaviour changes in surgical patients: a systematic review and narrative synthesis.* Royal Pharmaceutical Society Annual Conference 2019 – award winner for best abstract & research.
8. *eHealth and digital technologies to support health behaviour change in surgical patients.* Great North Pharmacy Research Collaborative Annual Conference 2019.
9. *Exploring the use of digital technologies to support health behaviour changes in surgical patients.* Institute of Health and Society Post Graduate Conference 2019 – award winner for best presentation.
10. *Evaluating the effectiveness of eHealth to support health behaviour changes in surgical patients.* North East Post Graduate Research Conference 2019.

Chapter 1: Introduction to the programme of work and setting the scene for this research

1.1 Introduction

This PhD will focus on a current, timely, and novel topic within healthcare at present; it will evaluate the use and role of digital technologies within modern healthcare settings. More specifically, the use of technologies to provide support to patients undergoing surgery to make healthier changes to their lifestyle to improve their post-operative outcomes. This work will focus on, and be informed by, the patients at the centre of the surgical journey. Findings will highlight key goals for digital treatment strategies moving forward, with the aim of improving patients' physical and psychological health and well-being. Work within this chapter has been published as a commentary piece: Robinson A, Slight R, Husband A, Slight S. *The value of teachable moments in surgical patient care and the supportive role of digital technologies.* Perioperative Medicine 9, 2 (2020), DOI: 10.1186/s13741-019-0133-z (Appendix 1).

1.2 The pathways of surgery

Emergency (or acute) surgery is the term used for operations that require immediate admission to hospital and are performed due to an urgent, potentially life-threatening, condition.(1, 2) In contrast, elective surgeries do not involve an emergency. Whilst there is still an underlying need for the patient to have the procedure, in the interests of their physical and/or psychological health, elective surgeries do not need to be performed immediately;(3) instead, they can be scheduled in advance and planned for a certain time.

Most elective surgeries are scheduled for a time that best suits the person's clinical need; however, this decision should also be balanced alongside staffing availability and other demands on healthcare settings.(3, 4) If surgery was required for an emergency, it would be undertaken without delay; if it were needed for an urgent (but non-life-threatening) condition it may be undertaken in 48-hours, once a patient is stabilised. In contrast, the timelines for elective surgery can vary, dependent on the surgical speciality and the underlying disease or issue being treated. Generally, the traditional model or 'pathway' to elective surgery is approximately 50-60 days, but this period may be shortened or lengthened depending on factors such as general patient health, staffing, surgical backlogs, and underpinning diagnoses. Figure 1 has been adapted from Grocott *et al.*(1) to demonstrate the traditional elective surgery pathway and the steps and timings involved; this figure has been produced with a generalised approach and may not reflect (i) shortened surgical pathways (for instance, in cancer diagnoses where the pre-operative period can be up to 14-20 days) or (ii) lengthened surgical pathways (for instance, in elective bariatric surgery where pre-operative weight loss governs eligibility for surgery).

As demonstrated in Figure 1, traditionally, the pathway to elective surgery begins with a primary care practitioner (most often a General Practitioner, GP) referring the patient to a secondary care specialist (hospital clinic). It is after the clinic consultations, blood tests and multidisciplinary (MDT) surgical team meetings have taken place that usually the decision is made to undergo surgery; the time between making this decision and the surgery taking place, is termed the 'pre-operative period'.(5, 6) Following their surgical procedure and subsequent discharge from hospital, the 'post-operative' period encompasses the time it takes to recover and rehabilitate.(4) The post-operative period also includes the period of time when the patient is still under the care of the secondary care team, when they may have follow-up appointments, up until the time when they are formally discharged. The term 'perioperative period' has also been used within recent surgical literature to describe the time between a patient's surgical procedure taking place (including their pre-operative ward admission and anaesthesia), their initial recovery whilst still in hospital, and the time of them being discharged from the hospital.(1, 7) The terms pre-, peri- and post-operative will be used throughout this programme of work to describe these timepoints within a patient's surgical journey.

Elective surgical pathways offer a particular opportunity to plan and capitalise on opportunities for lifestyle change. Due to their planned, non-emergency nature, participants can be clinically stable enough to make changes to their lifestyles (and potentially engage with digital technologies to support them in doing so) at pre- and post-operative timepoints during their surgical pathway. The plans for lifestyle change could be delivered and tailored in a manner that is based on individualised patient-need which, in turn, may enable the delivery of potentially improved patient experience and surgical outcomes.(4)

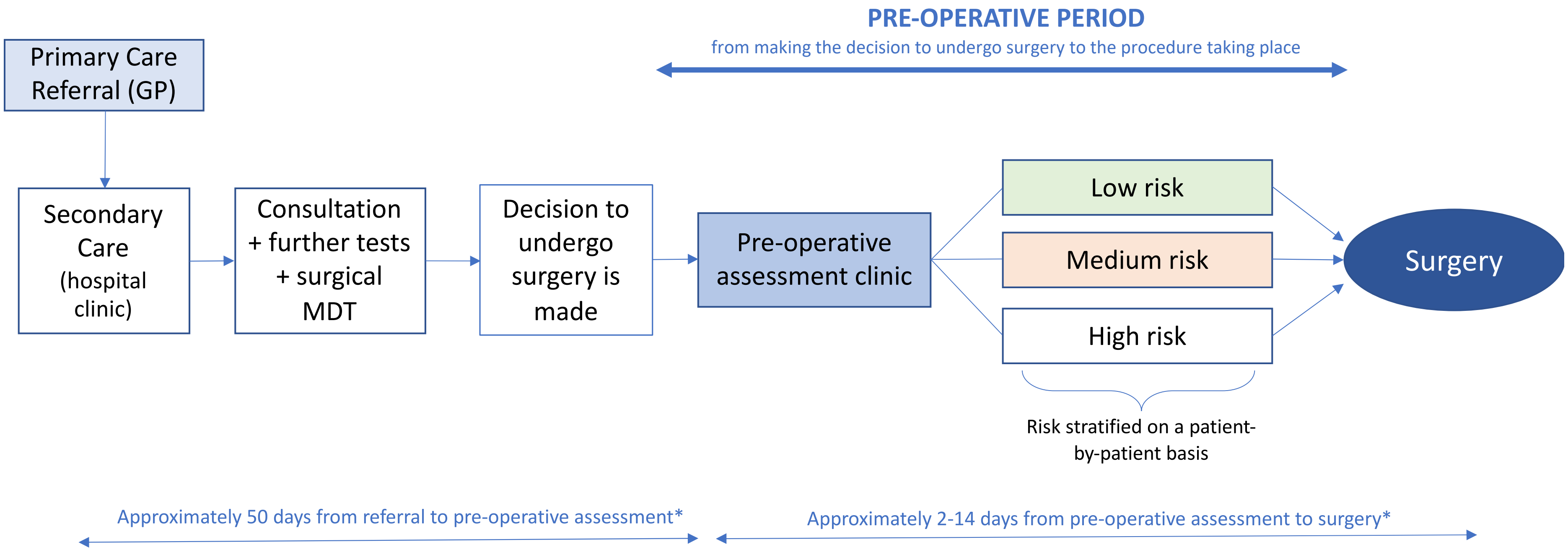


Figure 1: The traditional pathway to elective surgery (created by the researcher, adapted from Grocott et al.(1)

**N.B. these timings may not reflect shortened surgical pathways (e.g. following the cancer treatment pathway of 14-days from referral to secondary care consultation) or lengthened surgical pathways (e.g. because of the backlog of elective surgeries following the coronavirus COVID-19 pandemic).*

1.3 Lifestyle changes during the surgical journey

1.3.1 'Prevention is better than cure'

In November 2018, the United Kingdom's Secretary of State for Health and Social Care, Matt Hancock, released the new Department of Health and Social Care policy 'Prevention is better than cure: Our vision to help you live well for longer'.(8) This policy highlighted a shift in focus within healthcare, away from the diagnosis and treatment of diseases, and more towards modifying health behaviours to *prevent* disease and *improve* disease outcomes in the UK population. While policy writers acknowledged the gold-standard 'ideal' of disease prevention, they also recognised the practicalities in supporting those already diagnosed with disease. In doing so, emphasis was placed upon better understanding and supporting health behaviour change for those already experiencing ill-health. Through patient education, empowerment and motivation, people could be better supported to make healthier choices and healthier changes to their lifestyles. Ultimately, in turn, these changes can contribute to improved health and wellbeing outcomes.(1)

Positive lifestyle behaviours have a huge impact on health but previously, they have received little attention or investment from healthcare systems. For many years, healthcare interventions have been focused on detection and treatment of illnesses, not targeting or preventing the cause. For instance, in September 2018 the World Health Organisation (WHO) reported that, globally, one third of all cancers and long-term conditions are caused by poor health behaviours, such as a sedentary lifestyle, regular tobacco use, and poor dietary habits.(9) Furthermore, WHO states that 30-50% of deaths associated with cancers or long-term conditions could be prevented, simply by avoiding these aforementioned risk factors. (9-11) Advocating and instilling positive health behaviours in our population has never been timelier.

1.3.2 Within the context of surgical care

This thinking has also been applied in surgical contexts, to support patients to make healthier lifestyle changes pre- and post-operatively.(1, 12) Adopting healthier changes during the surgical pathway may result in improved health and well-being outcomes relative to their surgical procedure and long-term health. Post-operative complications can arise due to a multitude of factors, which may result in increased morbidity and mortality, extended stays in hospital and consequently, increased costs for healthcare provision.(12-14) While having a surgical procedure carries risk of complications, in and of itself, there are other risk factors which can predispose a patient to experiencing complications. Evidence exists to support that unhealthy lifestyle behaviours like poor dietary intake, low levels of physical activity, increased alcohol intake and smoking history, are all modifiable risk factors that contribute to post-operative complications and thus, poorer post-surgical outcomes.(2, 15-19) Evidence supports that surgical patients who practice healthier lifestyles have a lower risk of disease recurrence, reduced likelihood of multi-morbidity and improved post-operative outcomes.(20, 21) This highlights the need to identify and implement effective techniques to support healthier lifestyle behaviours within the surgical pathway.(22-24)

1.3.3 The significance and strategies of prehabilitation

Prehabilitation is a term that has relatively recently entered the medical literature and has been defined as 'the process of enhancing an individual's functional capacity before scheduled surgery'. In the same way that rehabilitation seeks to optimise patient outcomes *after* surgery, prehabilitation serves to better prepare the patient *prior* to surgery. As a concept, it is based on making early pre-operative interventions to optimise the potential for improved post-operative outcomes.(17) Prehabilitation includes numerous approaches for conditioning the surgical patient; these include methods to improve education, physical activity, nutritional intake and psychosocial support, all of which focus on pre-operative fitness and preparedness of patients.(2, 12, 17) In doing so, prehabilitation represents a shift away from the current model of care, which is rather more 'reactive' in nature. The proactive approach of prehabilitation signifies the importance of preparedness for surgery, truly giving weight to the phrase being *'fit enough for surgery'*. For instance, leaving physical activity recommendations until the post-operative period may change perceptions that exercise merely offers a rehabilitation-based benefit to patients; whereas if physical activity is encouraged by healthcare professionals when the surgical decision is made, it reinforces the importance of fitness throughout the surgical continuum and beyond.(4) Secondly, establishing an improved baseline level of physical fitness (dependent on each individual) would better prepare patients for the intensity of the surgical procedure itself, and any associated treatments that accompany it.(2, 25)

In existing literature, pre-operative physical activity is by far the most common prehabilitation approach that is reviewed. The effectiveness of exercise-based prehabilitation programmes has been demonstrated in a number of specialities including cardiothoracic,(26, 27) orthopaedic,(28) and bariatric surgeries.(29) Pre-operative physical activity has been shown to improve both a person's physical and psychological readiness for surgery.(30-34) Pre-operative physical conditioning has been reported as a widely used strategy to support improved post-operative outcomes.(17, 35, 36) Studies have demonstrated correlations between pre-operative aerobic lung capacity and the rate of post-operative pulmonary complications.(12, 34) Furthermore, a statistically significant difference has been reported for shorter length of hospital stay for patients who were physically active prior to undergoing surgery for a total hip replacement, compared to those who were not (pre-op walking: $F(1,15) = 6.5$, $p=0.01$).(37, 38)

Those with poor pre-operative nutritional intake have been linked to experiencing greater post-operative complications and poorer surgical outcomes.(39) Evidence has also demonstrated links between malnourished patients and higher post-operative morbidity and mortality rates.(2, 40-42) Post-operative consequences associated with poorer dietary intake include loss of muscle tissue, which is necessary to facilitate post-operative functional recovery.(43) Ensuring that patients are consuming appropriate, nutritious foods pre-operatively and immediately post-operatively has been linked to providing energy for optimal healing and recovery, as well as reducing post-operative muscle catabolism.(41) Nutritional management (and weight-management) have been recognised as a key component of Enhanced Recovery after Surgery programmes for surgeries including gastrectomy,(44) hysterectomy,(45) pelvic surgery(46), cardiac surgery(30) and gynaecologic oncology surgeries.(47)

In their recent systematic review, Thomsen *et al.* demonstrated that pre-operative interventions that focused on smoking cessation, supported short-term quitting and changes to behaviours.(48) This is significant given the association between smoking and the higher risk of respiratory complications during anaesthesia. For a number of years, smoking has been attributed to a three- to six-fold increased risk of post-operative cardio-pulmonary complications.(49-51) In addition, authors have linked smoking with poorer wound-healing and subsequent wound-related complications, such as wound-leakage following surgery.(48, 52, 53) There is no evidence to demonstrate a negative effect on post-operative outcomes when patients use nicotine replacement therapy during the surgical pathway, as opposed to smoking.(53)

Such approaches to healthier lifestyle change have been adopted and implemented into some surgical pathways, with the aim of improving outcomes.(14, 15, 32) Previously, these interventions have been made in a face-to-face manner, often with patients being provided information on making lifestyle changes through paper-based formats (like leaflets). In a modern world where digital innovations in healthcare are readily being adopted, this project aims to build on recent digital advances to explore the use and optimisation of digital technologies to support healthier lifestyle changes during surgical pathways, fit for a modern NHS; further explored in Section 1.5.

1.3.4 The role of teachable moments within health and surgical care

A teachable moment is defined as an event that motivates and creates opportunity for positive behaviour change.(54, 55) A popular concept within educational settings, teachable moments have been linked to unplanned teaching opportunities and have been described as “the time at which learning a particular topic becomes easiest” and when a student is “most receptive” to messages of learning and adapting their behaviours.(56)

The concept and approach of teachable moments has also been linked to a plethora of health-related contexts. In this way, teachable moments are viewed as a unique opportunity to capitalise on patient receptiveness and instil positive health behaviours. Healthcare-related teachable moments have been advocated for promoting health behaviour change in a variety of settings such as encouraging smoking cessation in dental clinics;(57) improving attendance at cancer screening;(58) seeking treatment for non-cardiac related chest pain;(59) and promoting adherence to new medications.(60) Across numerous medical disciplines, health-related teachable moments have been accepted as an approach of important focus when promoting health and wellness.(61)

In their case overview, McBride, Emmons and Lipkus described teachable moments as an event that “motivates individuals to spontaneously adopt risk-reducing health behaviours”.(54) The teachable moment can follow a life-changing diagnosis where patients are acutely receptive to messages of healthier lifestyle change. Further, a teachable moment may also arise proximal to surgical decision-making. For many individuals, the decision to undergo an elective surgery can be as life-changing as the procedure itself. The decision involves weighing up the risks and benefits of the procedure, and it should not be made lightly by the clinician or patient. The decision-making alone may cause individuals to reflect on poor health behaviours that they may engage in, especially if they are contributing factors for requiring the surgical procedure. In doing so, individuals may be motivated to change their lifestyles for the better - which is where the concept of *surgical teachable moments* comes into play.

The surgical teachable moment presents a unique opportunity to inspire patients to modify their pre- and post-operative health behaviours for the better. It is a point in time where the clinician or member of the surgical team can opportunistically exploit patient insight regarding suboptimal lifestyle behaviours when the patient is most receptive to change.(62) In this way, healthy behaviours can be encouraged and unhealthy behaviours discouraged, in a bid to improve the likelihood of more favourable surgical outcomes both on the short- and long-term.

Each interaction between the patient and healthcare professional during the pre- and post-operative period can provide an opportunity to maximise the surgical teachable moment and begin positive behaviour change. Evidence supports that surgical patients who practice healthier pre-operative lifestyles have improved post-operative clinical outcomes, as well as an overall lower risk of disease recurrence and reduced likelihood of multi-morbidities if positive health behaviours are sustained.(20, 21) The surgical teachable moment can act to trigger smoking cessation,(63) promote an increase in physical activity,(64) and encourage the adoption of healthier dietary habits(65) across a range of patients from different surgical specialities. These positive lifestyle changes within the surgical period can contribute to improved post-operative clinical outcomes, quicker recovery times, and enhanced quality of life – whilst also reducing the overall burden of multi-morbidity within patient populations.(22, 66) In essence, capitalising on a surgical teachable moment can offer benefits to the patient and wider individuals, linking closely to wider preventative public health agendas.(67, 68)

In their 2019 report, the Royal College of Anaesthetists refer to the approach of using prehabilitation programmes to capitalise on the teachable moment and describe it as effective and efficient, where "every patient for whom it is clinically appropriate, receives a programme of care to optimise their condition before their operation".(69) The College recognised the receptiveness of patients within their surgical journey and the benefits to individual health, public health, and socioeconomic return that could arise from improved lifestyles and physical well-being. The report acknowledges the forward-thinking vision of capitalising on surgical teachable moments to support positive health behaviour change in patients, referring to the approach as "pragmatic medicine… (that) is good for patients, good for the NHS and good for the wider economy as well".(69)

Beyond the impact that the teachable moment brings, there ought to be consideration given to an underlying element of each person's individual 'readiness' to commit to this behaviour change.(22, 55) Accepted behavioural theories and concepts have previously reinforced the importance of recognising cues for 'getting the timing right' in order to prompt a patient's motivation for behaviour change; one in particular being the Capability, Opportunity and Motivation-Behaviour model by Michie *et al.*, termed 'COM-B', which is discussed further in Section 1.3.5 below.(70)

1.3.5 Appreciating teachable moments alongside behaviour change theories

It is important to consider relevant concepts and theories that exist to inspire changes in a person's lifestyle. Researchers have previously reflected that a health-related intervention which is based on behavioural theory, is more effective than an atheoretical one.(71-73) After all, behavioural theories provide a framework for researchers to understand the factors that mediate behaviour change, identifying the reasons why interventions might succeed or fail.(74)

One theory which enables researchers to understand *why* patients make, and maintain, certain health behaviour changes is Social Cognitive Theory (SCT). SCT encompasses the cognitive, emotional, and behaviouristic aspects of each individual, so that effective strategies for behaviour change are created.(75) It is a reactive concept which encourages patients to learn through personal experience, or by observing the actions of others, to understand the results and benefits that come from these actions, for instance the benefits of regular physical activity.(74) According to Bandura, the key elements which influence behaviour include: *knowledge* (of health benefits or health risks), *self-efficacy* (an individuals' confidence in controlling their own behaviour), *expectations* (of the benefits or costs that the behaviour will bring), *goals* (to guide action and provide incentives), and *facilitators* to inspire behaviour changes (which can be personal and/or environmental in nature).(75) Previous meta-analysis studies have concluded that SCT-based interventions are successful when applied to surgical cancer patients for instance, confirming improved physical activity levels, improved diagnosis-related depression scores, and improved quality of life outcomes.(73, 76-79)

Although making the decision to undergo a surgery presents a unique opportunity to capitalise on a teachable moment and instil positive healthier lifestyle changes, not every patient is ready to change immediately. Linking with this, another commonly utilised theory is Prochaska's Transtheoretical Model (TTM) of Change, sometimes referred to as Stages of Change.(80) The stage-based TTM proposes that each individual patient falls within a stage for 'readiness to change' or willingness to adopt positive health behaviours. In the TTM theory, individuals are classified depending upon where they fall within the cycle of behavioural change. There are five key stages within the TTM cycle: precontemplation (the individual has no interest in changing behaviours), contemplation (they are considering change), preparation (they are planning to change), action (the individual has adopted the new, changed behaviour), and maintenance (ongoing positive health behaviour, without relapse, still defying temptation to go back on the change). When presented with the decision to undergo surgery, it is often unclear which stage the individual may fit into on this cycle of change.(81, 82) In their work, drawing reference to the TTM, Riemsma *et al*. proposed that interventions will be most effective when they are tailored to an individual's current stage.(83) Not only does this stage-based approach seem intuitive and plausible, it may explain why interventions that are aimed for a wide-spread, mass audience, may not result in successful behaviour change.(83)

The value of exploiting the surgical teachable moment rings true here; it highlights the benefits that may arise if clinicians make good use of the teachable moment to empower and educate patients. Encouraging patients to assess their current lifestyle behaviours, and explaining the underlying benefits that may arise from changing them, may trigger an individual to take a positive step towards the stage of ‘action’.

The Capability-Opportunity-Motivation-Behaviour Model (COM-B) considers an individuals’ behaviour to be the result of an interaction between their *capability* to perform the behaviour, the *opportunity* to engage in a behaviour and the *motivation* to direct the occurrence of a behaviour.(70, 84, 85) *Capability* can be further broken down to encompass the physical and psychological components behind changing behaviours; for instance, physical components may include possessing certain skills and dexterity, while psychological components may include having the ability to comprehend information or possess knowledge of a behaviour. In a similar way, *Opportunity* encompasses components relating to physical opportunity (for instance, having access to resources to support behaviour changes) and social opportunity (such as understanding expectations relative to changing behaviours). *Motivation* is also underpinned by two components, automatic motivation (such as habit-breaking and habit-forming in relation to healthier lifestyle behaviours) and reflective (such as planning and making decisions to change behaviours). Evidence has demonstrated that in order for behaviour changes to occur, all three elements of the COM-B model (and their components) need to be considered.(84, 86, 87)

What appears certain about behaviour change and the theories underpinning *why* individuals change their health behaviours, is that it is difficult to sustain a change to what can be a ‘lifetime habit’. If exploited correctly, the surgical teachable moment may trigger the dissolution of these habits. For instance, it is well-evidenced that smoking is associated with poorer surgical outcomes and is directly linked to increased post-operative complications, such as reduced wound healing and increased mortality.(54, 88) Statistics have shown that, per annum, only 3-5% of smokers in the United States spontaneously quit smoking of their own accord.(88, 89) However, in smokers who required surgery, there have been reported post-operative success rates of up to 50% following advice from surgical clinicians.(88) These statistics indicate that there may be an underlying teachable moment or ‘trigger’ proximal to the surgical decision which spurs individuals to evaluate their health behaviours and habits, motivating a change. This demonstrates how powerful capitalising on the teachable moment can be; any intervention that exploits this can influence and motivate a significant proportion of patients. Ensuring the delivery of such interventions is an area that needs pragmatic focus, particularly from the standpoint of a surgical clinician and members of the surgical multi-disciplinary team.

1.3.6 Taking advantage of the surgical teachable moment to inspire lifestyle change

Historically, clinicians involved in the provision of surgical care have not always taken advantage of the value that surgical teachable moments offer.(90) Considering the range of healthcare professionals in the surgical multidisciplinary team, there are multiple opportunities to utilise teachable moments to provide behaviour change advice to patients at various time points in their surgical journey. However, this is not readily or easily done and consequently, opportunities to optimise and address patient health behaviours are often missed.(1)

In their paper on the re-design of the surgical pathway, Grocott *et al.* discussed lost opportunities "for perioperative physicians to improve patient care".(1) The authors acknowledged that clinicians working with a perioperative approach can add value in the pre-operative pathway. Yet, the first interactions these clinicians have with patients may only be a number of days away from the surgery taking place – at which point, the surgical teachable moment may have passed, along with the opportunity to collaboratively modify patient behaviours. The authors called for a re-working to create a more "patient-focused, pathway-driven vision of perioperative medicine… facilitated by early engagement between perioperative physician and patient".(1)

Early engagement with patients before surgery offers the opportunity of collaboration between clinician and patient, whereby the surgical teachable moment can be better exploited and utilised to encourage positive change to behaviours. By better taking advantage of the surgical teachable moment, clinicians can work with patients to discuss behaviour change that beneficially modifies their personal risk profile and potentially optimises their outcomes.

1.4 Surgical cohorts of choice for this work

Going forward, three specific elective surgeries were chosen to be the focus of this PhD thesis: bariatric, orthopaedic and lung cancer surgery. All three cohorts involve patients whose post-operative outcomes could be improved as a result of making healthier lifestyle changes during the surgical period. There are clear differences and similarities between these surgical specialities, such as the lengths of both the pre-operative and post-operative time periods, which also presents the researcher with a unique opportunity to understand the remit of supportive digital technologies for patients from these cohorts. Patients from these three contrasting surgical groups are linked by the fact they are undergoing an elective surgical procedure and consequently, will experience a perioperative surgical pathway similar to one described earlier in this chapter. Regardless of whether the pre-operative time period differs slightly in length between the surgical types, it presents a window of time for the patient to learn about and implement lifestyle changes prior to the operation, which may improve post-surgical outcomes. In the same way, the post-operative periods of these surgical specialities may differ in length too; however, the underpinning rehabilitative efforts and subsequent possibility for lifestyle changes to influence post-surgical outcomes remains constant. The characteristic patient demographics (such as a person's age, sex, previous lifestyle behaviours, including levels of physical activity, dietary intake and weight, and prior digital engagement) and underlying motivations for making and maintaining lifestyle changes may also differ between the cohorts too; the researcher seeks to gain further insights into this currently under-researched area.

1.4.1 Lung cancer surgery

In general, the diagnosis of lung cancer is often underpinned by health behaviours that have been present for a sustained period (for instance, a long-term history of smoking).(91) Within this patient group, the diagnosis of cancer can trigger a significant change to lifestyle behaviours. Populations with lung cancer have previously displayed receptivity towards advice and support to change their lifestyles following their diagnosis.(92, 93) Potentially, the motive for modifying their health behaviours is one that fits onto both a pre-operative and post-operative (short-term and a long-term) scale. Pre-operatively, participants need to be prepared and sufficiently fit enough to tolerate surgery and other cancer treatment they may require. Post-operatively, participants may modify health behaviours on a short-term basis to support their recovery, and on a long-term when faced with the possibility of preventing disease recurrence. Investigation is warranted as to whether this cohort would benefit from a form of digital technology to support healthier lifestyle changes during the pre- and post-operative periods.

1.4.2 Orthopaedic surgery

In contrast, orthopaedic surgery cohorts can present a diverse mix of patients; there can be patients needing surgery due to underlying joint osteoarthritis (associated most often with ageing(94)), as well as more physically active patients requiring orthopaedic surgery as a consequence of their active lifestyles.(95) Herein lies a contrast in terms of the underlying *need* for the surgery, and potential *need* to undertake lifestyle behaviour change, which would make for interesting research. For many elective orthopaedic patients, the possibility and reality of surgery has been demonstrated to represent a 'fix' or a solution to an underlying physiological problem. This presents a contrasting opportunity to further explore the use of, and engagement with, a digital technology across the pre- and post-operative periods in this cohort – which may well differ to that of lung cancer.

1.4.3 Bariatric surgery

Different again, are the lifestyle changes commonly underpinning bariatric surgeries. Commonly bariatric surgery is referred to as a 'last resort' method for weight loss, where patients have tried and failed to lose weight in the past.(96) For instance, to meet the UK NICE Guidance 'criteria' to proceed with a bariatric operation, patients must: have a BMI of 30.0 or higher, which is equivalent to obese or morbidly obese (in combination with another significant disease, *e.g.* diabetes or hypertension); have attempted appropriate non-surgical weight loss measures but failed to achieve and maintain clinically beneficial weight loss; have been under the care of a tertiary care setting for intensive disease management; be 'generally fit' for anaesthesia and surgery; and commit to long-term follow up (for two years post-operatively).(97, 98) In the literature, patients undergoing bariatric surgery have demonstrated lifestyle changes that were reportedly strong to begin with (in the pre-operative and immediate post-operative periods), but reduced over time.(29, 35, 96) There may be potential for other lifestyle changes, in addition to dietary advice and physical activity, that could positively influence post-operative outcomes and it would be worth exploring the role digital technology can play.

By comparing and contrasting these different cohorts, the researcher seeks to gain understanding into how digital technologies can be optimised for each surgical group.

1.5 The growing role of digital technologies in healthcare

The introduction of digital technologies has influenced many aspects of modern living. Recent reports from the UK Office of Communications and the Office of National Statistics estimates that 78% of adults own a smartphone, 90% of people regularly access the internet in their home, 58% own a tablet-device, and 20% use wearable technology, such as smart watches and fitness trackers.(99, 100) A recent US-based review found that almost 60% of American smartphone users have reported downloading and using fitness or health-related applications, more commonly termed 'apps'.(101) This digital-influence is also being seen in the world of healthcare, where there has been a successful shift towards the integration of technologies into clinical and operational practice. For clinicians, digital technologies can improve communication and information transfer between clinical teams and healthcare sectors.(102, 103) For healthcare providers and organisations, digital technologies can assist in reducing the burden associated with working at increased capacity and managing patients with increasing numbers of co-morbidities.(104, 105) For patients, digital technologies are being used to enhance education provision, improve communication with clinicians, and to empower them to play an active role in their own care.(102, 106-108) Digital technologies have played important roles in empowering patients and allowing shared decision making to guide treatment options. By equipping patients with information to take ownership of their pre- and post-operative care, digital technologies promote a proactive and holistic strategy to influence healthier lifestyles in a modern NHS.

During the past decade, healthcare policies have committed to strengthening the implementation of digital technologies within national health and care systems. Each country within the United Kingdom (UK) has published strategies and policy developments that acknowledge working towards a digitally-enabled national healthcare system.(109, 110) In 2015, the Welsh government published a policy called 'Informed Health and Care: A Digital Health and Social Care Strategy for Wales' and within this, expectations included engagement with all stakeholders (including patients and healthcare professionals) to understand requirements and needs for digital tools to support health.(111) In 2016, the 'eHealth and Care Strategy for Northern Ireland' was published, which recognised priorities in delivering electronic, online and remote care, as well as using information and analytics to develop personalised preventative care interventions.(112) In 2018 (and updated in 2021), Scotland's 'Digital Health and Care Strategy: Enabling, Connecting and Empowering' acknowledged targets to collect real-time data and information to support the implementation of a national digital health and care platform.(113) Also in 2018, the UK Department of Health and Social Care published 'The Future of Healthcare: Our vision for Digital, Data and Technology in Health and Care';(114) this report recognised the importance of creating digital services that best meet the needs of the people using them. Following these reports, the 'NHS England Long-Term Plan' was published in 2019 and discussed commitments to provide digitally-enabled care through online Local Health and Care Records and access to remote consultations with care providers.(115, 116)

Digital health technologies and digital interventions offer many advantages in healthcare, opposed to the conventional face-to-face approaches of the past: (1) they significantly limit the travel burden associated with such poor attrition at hospital follow-up clinics;(117, 118) (2) they can be utilised in a patients' home environment at convenient times;(117, 119) (3) they can be accessed multiple times to reiterate positive health advice and support for patients or carers;(120) (4) they provide real-time data as a form of accountability between clinic visits;(120) (5) they can automatically transfer key data to health providers as needed;(121-123) (6) they provide patients with immediate feedback on progress or encouragement to meet goals; and (7) they can reduce the participant burden when it comes to documenting self-monitoring.(124, 125) There has been a successful acceptability-shift towards using digital technologies in the NHS, with digital interventions becoming increasingly desirable. Thanks to the multitude of advances in digital technology capability as explained above, there has been unprecedented growth in the amount of available information relating to surgery.(126, 127) This information, which may have previously been available only to healthcare professionals, is now freely accessible to surgical patients and their caregivers, influencing the management of pre- and post-operative care in the community.(128) There is great potential for digital technologies (such as smartphone applications, web-based platforms, and wearable activity trackers) to provide safe, evidence-based, and cost-effective interventions to improve patients' health.(2, 15, 129, 130)

However, Lupton said that *"Digital health technologies are positioned to enable people to effectively become 'managers' of their own health and healthcare"*.(131) Thus, for positive outcomes in such technologies to be achieved, digital interventions must be created and accessible in a way that meets the needs of a diverse population.(132) Recognised as an unintended consequence of new digital health technologies, digital inequality can influence a person's ability to engage with such interventions.(133) Digital inequality has been recognised as a multidimensional phenomenon encompassing global divide (the difference internet access in both industrialised and developing countries), social divide (the difference between those who do and do not have the resources to engage with digital technologies) and democratic divide (the difference between those who do and do not have the resources to engage with digital technologies).(134) Existing studies have raised concerns that digital technologies may exacerbate existing health inequalities if they are not designed and implemented in an equitable, person-centred manner.(135, 136)

While many people have smartphones and internet access, there are still significant inequalities in access based on factors such as income, geography, and age.(137) This means that some people may be unable to take advantage of digital health technologies even if they are available. Similarly, technologies that require a certain level of digital literacy or English language proficiency may exclude some people from benefiting.(138, 139) Finally, there is the risk that digital health technologies may widen the gap between those who can afford high-quality healthcare and those who cannot.(138) For example, telemedicine may make it easier for people in remote or underserved areas to access healthcare, but only if they have the necessary technology and infrastructure in place.(140) To address the aforementioned concerns, it is important to ensure that digital health technologies are designed and implemented with equity in mind. There are distinct gaps within existing research about how best to achieve this, which is something this programme of work seeks to investigate. Further, there remains a need to clarify the impact of digital health on fostering health equality across different settings of health and surgical care.(141)

Various forms of digital technologies have been proven to play a successful role in motivating changes to patient lifestyles regarding wider-scale public health issues. They have been shown to empower patients to take ownership of their care, provide educational information to influence behavioural change, and allow shared decision making to guide treatment options. Recent examples of their success within healthcare includes interventions for smoking cessation(142), safer sex(143), and alcohol consumption.(144) Additionally, digital technologies have contributed to improvements in patient self-management of long-term conditions, like diabetes(145) and cardiovascular disease.(146) Thus, there is no reason to suggest that certain elective surgical pathways would not be amenable to the benefits of digital technologies promoting changes to patient lifestyles too.(35, 130, 147)

For the purpose of this programme of work, the researcher has sought to provide a clear definition of 'digital health technologies' with examples to illustrate what forms of technology are within the scope of this research (or not). The National Institute for Health and Care Research (NIHR) recently defined digital health technologies as forms of technology that aim "to boost health and wellbeing or improve health systems".(148) Very specifically, the NIHR view the scope of digital health technologies as including "smartphone apps, wearable devices (such as step trackers), and platforms that provide remote healthcare... (including) software to help track symptoms, online tools to diagnose conditions, and programmes that analyse data from medical devices such as blood pressure monitors".(148) The researcher chose to align with the NIHR definition and scope of digital health technologies, along with acknowledging the UK Department of Health and Social Care plan, titled 'Reshaping health and social care with Data', which states the UK government aims of health and care transformation through use of digital health technologies.(149) It is also important to note examples of interventions that were deemed outside of the scope of this work, for example, telephone calls. Given the digital-focus of this programme of work, interventions such as telephone calls were not deemed to meet the definition of digitally-delivered health interventions.

1.6 Digital technology to support surgical patients

1.6.1 What is known?

In recent digital health literature, there are various interventions that have successfully supported patients in the management of long-term health conditions(122) and medicines adherence,(150, 151) as well as supporting positive lifestyle behaviour change before and after surgery to improve post-operative outcomes.(16, 152) Health behaviour changes made during the surgical journey (from pre- to post-operative) can be fundamental in determining the outcomes and success of elective surgeries.

When it comes to bariatric surgery, Coleman *et al.* investigated the use of digital technologies in encouraging post-operative exercise in bariatric surgery patients.(153) In the intervention group (n=26), each patient was provided with a digital pedometer (a form of wearable technology) and granted access to a personal activity-based website to log their physical activity progress, in addition to the twice weekly group exercise sessions. The usual care control group (n=25) attended twice weekly group exercise sessions only. At six months, statistically significant improvements in physical activity and 6-minute walking test were recorded for the intervention group (p=0.001) compared to the control (p=0.92), with over 87% of intervention participants using the website on 6.3 (±0.7) days per week. Additionally, results demonstrated sustained physical activity improvements in the intervention group at the twelve-month follow-up for steps per day (goal: 10,000) (p=0.03, vs. p=0.865 for control). Authors reflected on digital technologies as a successful method to complement current care provided post-operatively, especially focusing on maintenance of an active lifestyle to ensure successful weight loss following bariatric surgery.

Similarly, this was echoed in recent work by Lemanu *et al.*(154) In their randomised controlled trial, a mobile health-based digital intervention (mHealth) was delivered through text messaging and focused on increasing pre- and post-operative physical activity of patients. The intervention group (n=44) received daily, one-way, text messages to encourage regular exercise, whilst the control group (n=44) were managed through usual care. Despite the short intervention period (four weeks pre-operative to six weeks post-operative), there was statistically significant evidence of pre-operative behaviour change in the intervention arm for all physical activity primary outcome measures ($p<0.05$); this was not demonstrated in the control group, or post-operatively in either group. The authors reflect that although their data supports adherence to healthier lifestyle change in the pre-operative period, it does not directly correlate with sustained change in the post-operative period. Perhaps the follow up period was too short to allow full recovery from the surgical procedure; the optimal post-operative intervention period remains unclear, and it could be quite possible that once the incentive of surgery has passed, motivation to exercise lessens.

In the context of orthopaedic surgery, increases in pre-operative physical activity levels and smoking cessation have been associated with improved post-operative bone healing,(155) wound healing,(156) quicker recovery times, and reduced pain scores.(157) Physical rehabilitation after orthopaedic surgery is an essential component of treatment as it helps to improve functional outcomes and patients return to their daily activities.(158) There remains a limited understanding of how best to support patients during this time, particularly through the use of digital interventions. The role of digital technologies to facilitate changes to lifestyles has been explored in elective arthroplasties, such as a total knee arthroplasty (TKA) and total hip arthroplasty (THA). Doiron-Cadrin *et al.* investigated the role of a digital intervention in the pre-operative 'prehabilitation' phase, known as 'tele-prehabilitation', compared to usual care of in-person sessions prior to hip or knee arthroplasty.(159) In their randomised controlled trial, the authors reported a high retention rate of 97% for the digital intervention, which ran over a twelve-week pre-operative period. End results demonstrated no difference in physical activity capacity between the tele-prehabilitation intervention group (n=12), an in-person comparator group (n = 11) who completed exercises at appointments, or the control group (n=11) who were given leaflet instructions on exercises ($p>0.05$). Russell *et al.* also employed tele-rehabilitation in their randomised controlled trial.(160) Similar to Doiron-Cadrin *et al.*, the authors also found no statistical difference in the end results in patients where rehabilitation exercises were delivered by tele-rehabilitation compared to in-person appointments; the authors reported how participants in the intervention group achieved comparable outcomes to those in the control group ($p=0.12$). What differs in these results is the exercise compliance rates; instead of being equal as seen in previous studies, patients were more engaged with the digital intervention than the in-person arm, completing an average of 2.2 (±0.5) sessions/day compared to 1.7 (±0.8) in the control. Like the previous study, there was a high retention rate (97%) for patients in the intervention group, and a high level of satisfaction reported; a common theme is that digital interventions are well received by participants.

There is growing interest in using digital technologies to engage surgical cancer patients and inspire healthier lifestyle changes throughout the surgical pathway for this disease too.(14, 161-163) In their twelve week feasibility study, Ormel *et al.* investigated the use of a smartphone application (app) to encourage both pre- and post-operative changes around physical activity (intervention group, n=16), in comparison to the control group (usual care), where verbal physical activity advice was provided (n=16).(164) In the intervention group, there was a statistically significant increase (51%) in daily physical activity levels reported at six weeks (p=0.024) and a statistically significant increase in total weekly physical activity (46%) compared to control (p=0.038). However, these changes were not sustained at twelve weeks, possibly due in part to the diminishing novelty of using the application over time.(165) The authors reported that most patients (n=12) in the intervention group were enthusiastic about the app use, with eleven still continuing to frequently use it to self-monitor physical activity following formal completion of the study.(166)

Kanera *et al.* investigated the capability of a web-based intervention (online portal providing personalised educational modules) to change lifestyle behaviours, namely physical activity and vegetable consumption in post-surgical cancer patients.(167) The intervention group (n=231) had access to the online portal, whereas the control group (n=253) experienced usual care (it is not clear what this entailed). These authors reported a statistically significant difference in moderate physical activity levels in the intervention group at six months (p=0.037) continued to twelve months (p=0.011), indicating a sustained long-term change to lifestyles. Regarding vegetable consumption, there was a statistically significant difference seen at six months (p=0.027) but this was not sustained to twelve months (p=0.132). The authors reported findings to indicate that the intervention was significantly more successful on moderate physical activity in younger patients (aged <57 years) compared to older people (p=0.04 after 6 months, and 0.000 after 12 months). There were no statistically significant effects found in relation to participant sex (p=0.296) or education level (p=0.351) in respect of intervention success.

Developing tailored digital interventions and understanding how they fit into care interventions for particular surgical procedures, is critical to ensure that they meet the particular needs of these patient groups. Ultimately, in doing so, there may be benefits including positive influences on pre- and post-operative outcomes, as well as longer-term lifestyle change. By motivating patients and equipping them with the information required to take ownership of their own care, from the onset of the surgical pathway, we can develop a proactive and holistic care strategy fit for a modern surgical service.

1.6.2 What is not known?

In their recent UK-wide study exploring public attitudes towards the use of novel technologies in future healthcare systems, Sauchelli *et al.* stated the following:

> *"Innovation in healthcare technologies can result in more convenient and effective treatment ... but a persistent challenge to widespread adoption in health and social care is end user acceptability."(168)*

A gap in knowledge and evidence remains, which concerns patient perspectives on digital health technologies to support them during their elective surgical pathway. Given that digital technologies are now commonplace within everyday life and their integration into healthcare settings has begun, it is imperative to explore the use and optimisation of digital technologies to support healthier lifestyle changes during surgical pathways. This includes assessing the perspectives of those who will be potentially using it; this will be conducted within this PhD programme of work.

1.7 Focusing forward: content, intentions and areas of focus for this PhD programme of work

The content of this thesis follows work conducted by the researcher and the supervisory research team; the structure of which is described below:

- Chapter 2 takes the form of a systematic review and narrative synthesis; the researcher explored the next stage of logical investigation to systematically review the existing quantitative literature concerning digital technology use during the surgical journey to support patient lifestyle changes and thus, improve post-operative outcomes.
- The work included in Chapters 3 and 4 was inspired and driven by the findings from the quantitative systematic review in Chapter 2. A qualitative evidence synthesis, in the form of a meta-ethnographic systematic review, was conducted in Chapter 3; here, the researcher wished to further delve into the qualitative data in existence that may have influenced a person’s use of digital technologies during the surgical pathway.
- The researcher wished to further investigate the existing qualitative evidence concerning technologies to specifically support patients undergoing bariatric surgery; this literature review forms the content for Chapter 4.
- After drawing together all of the knowledge gained from work in Chapters 1-4, the researcher describes the planned qualitative investigation, including the methodology and analytical approaches taken, in Chapter 5.
- Chapters 6, 7 and 8 include the results and discussion of the three patient-informed qualitative studies conducted. These chapters detail findings and draw conclusions from 54 pre- and post-operative participants from three surgical cohorts; this covers the bariatric, orthopaedic and cancer surgery groups, respectively. Cohort-specific discussions and conclusions are included in these results chapters.
- An overarching discussion and conclusion is written in Chapter 9; in this chapter, the researcher sought to collate the high level findings from this programme of work. Drawing on the Medical Research Council framework for the development and implementation of complex interventions, the researcher described how results could be used to inform future practice for the surgical cohorts studied.

Chapter 2: Determining the effectiveness of digital technologies to support health behaviour change of surgical patients: a systematic review and narrative synthesis

The introductory literature review described in Chapter 1 provided a useful overview of digital technologies to influence health behaviours of surgical patients. As part of the next stage of logical investigation, the researcher conducted a systematic review in the specific area of elective surgeries. Elective surgeries are procedures that are planned in advance, following a surgical pathway, whereby the patient and the surgeon make a shared decision to operate. In this process, there are defined periods of time before and after the surgery (termed pre- and post-operative, respectively), which present us with opportunities to promote lifestyle changes.

From the evidence demonstrated in Chapter 1, it is well known that positive lifestyle changes, both pre- and post-operatively, benefit surgical outcomes; however, there is a distinct gap in the literature around the use of digital technologies to support patients to make health behaviour changes in the elective surgical pathway. Until the review detailed in this Chapter, there had not been a systematic review conducted concerning the use of digital technologies by elective surgical patients to improve surgical outcomes. The aim of this chapter was to systematically review existing literature in this area. The focus for this was to assess the effectiveness of digital technology interventions that are implemented within a surgical pathway, and whether these promoted or supported health behaviour change in surgical patients. This systematic review and narrative synthesis is published in the British Journal of Surgery Open: Robinson A, Husband AK, Slight RD, Slight SP. *Digital technologies to support lifestyle and health behaviour changes in surgical patients: systematic review.* BJS Open 2020, DOI: 10.1093/bjsopen/zraa009 (Appendix 2). The findings from this chapter have also been presented at two national research conferences: the Health Services Research and Pharmacy Practice Conference (HSRPP) in April 2020 and the Royal Pharmaceutical Society Annual Conference in 2019.

2.1 Introduction

In the context of elective surgeries, it is the patient-empowerment aspect of digital health technologies, which the researcher wanted to explore further; in particular, the ability to empower beneficial lifestyle behaviour changes, which the patient could undertake themselves, to improve their surgical outcomes. The concept and approach of 'prehabilitation' was explored within Chapter 1; a similar mindset of pre-operative preparedness to improve post-operative outcomes is also discussed within this review.

Recent evidence has linked better patient physical-preparedness prior to surgery, with improved outcomes and benefits following surgery.(27, 130, 169) More specifically, improvements in patients' dietary intake,(170) physical activity levels,(159) and smoking cessation,(2) have been linked to improved recovery, a better tolerance of post-surgery treatment, and prevention of related disease in the long-term.(106, 171-173) At present, however, there are variable amounts of support and education made available for elective surgical patients in order to motivate these beneficial changes to lifestyles. For instance, prior to weight loss surgery (termed bariatric surgery), patients are encouraged to change their diets and lose weight, but many feel unsupported in doing so.(174-176) Patients recovering from cancer surgery have previously reported poor lifestyle support and this has also been recognised by healthcare professionals.(177, 178) In order to encourage changes to their lifestyles, education and information needs to be better communicated to elective surgical patients; a role that digital technologies (such as apps, activity trackers and telemedicine) could support with.

There are still unanswered questions relating to the optimisation of digital technologies to motivate these important changes to lifestyle behaviours, especially for those undergoing elective surgeries. This review was conducted to determine whether digital technologies are effective at supporting elective surgical patients with behaviour changes that could improve their surgical outcomes. This work focuses on increased physical activity, weight loss and improved dietary habits made across the entire surgical journey (pre- and post-operatively).

2.2 Methods

2.2.1 Protocol registration

The review is registered with PROSPERO (Registration number CRD42019127972, Appendix 2) and has been conducted in accordance with the 'Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)' guidelines.(179)

2.2.2 Search strategy and study selection

A comprehensive and systematic literature search was conducted in March 2019 across six electronic databases including Medline, Embase, CINAHL, PsycINFO, Web of Science and Scopus. No limit on the publication date was applied. Experimental and observational studies that evaluated a digital intervention supporting behaviour change(s) in adult elective surgical patients (>18 years), of any sex, ethnicity, or nationality, during the pre- or post-operative period were included. The studies must have conducted an initial baseline measurement of participants and (at least) one follow-up measure, to evaluate whether a change in lifestyle behaviour (physical activity levels, weight and/or dietary habits) took place in the population group. Any study where the intervention focused on healthcare professionals, family and/or caregivers, or patients more than five years post-operative were excluded; the reason for this is to mirror the typical post-operative follow-up period in the UK, where patients remain under the care of the surgical team for typically between two and five years, depending on the speciality.(180-182) Any studies that evaluated digital interventions from a psychological or quality of life point of view, or where the lifestyle change related to disease screening (rather than active surgical care), were excluded. Qualitative studies, editorials, reviews, conference abstracts, or study protocols were also excluded. This review focused on elective surgical procedures, specifically bariatric, cancer and orthopaedic surgeries, where patients (and their surgical outcomes) may benefit from pre- and/or post-operative lifestyle changes; abdominal, cardiac, gastrointestinal, gynaecological and trauma surgeries were excluded.

Additional papers were identified *via* grey literature within personal libraries of the authors, professional research networks and by reference-checking. All search terms are described in Tables 1, 2 and 3. N.B. the search strategy for all journals = [all terms in column 1 linked using 'OR'] AND [all terms in column 3 linked using 'OR'] AND [all terms in column 4 for each surgery type linked with 'OR'].

2.2.3 Eligibility criteria

Experimental and observational studies were included that evaluated a digital intervention supporting behaviour change(s) in adult elective surgical patients (>18 years), of any sex, ethnicity, or nationality, during the pre- or post-operative period, and were published in the English language. The studies must have conducted an initial baseline measurement of participants and (at least) one follow-up measure, to evaluate whether a change in behaviour (physical activity levels, weight, and/or dietary habits) took place in the population group.

2.2.4 Selection of eligible studies

Titles and abstracts from the database search were reviewed by two authors (AR and AKH). Full-texts were retrieved for articles, which met the inclusion criteria for further evaluation and for articles that could not be rejected with certainty. The full-texts of eligible articles were independently screened by two authors (AR and AKH). Disagreements could have been resolved through discussion with the wider team (RDS and SPS), however this was not necessary (n=0).

Table 1: Search strategy for Medline, EMBASE and CINAHL

1. Digital Tech Intervention	2. Sustained	3. Lifestyle Change	4. Surgery speciality benefitting from a lifestyle change		
			Cancer Surgery	Bariatric Surgery	Orthopaedic Surgery
digital technology.mp.	Identified using inclusion/exclusion criteria after searching	exp Health Behavior/	cancer.mp.	exp bariatrics/	orthopaedic.mp.
digital intervention.mp.		health behavior.mp.	cancer patient.mp.	bariatrics.mp.	knee replacement.mp.
eHealth.mp.		exp Life Style/	exp cancer survivors/	exp bariatric surgery/	hip replacement.mp.
mHealth.mp.		life style.mp.	cancer survivor.mp.	bariatric surgery.mp.	arthroplasty.mp.
exp TELEMEDICINE/		exp Healthy Lifestyle/	cancer surgery.mp.	weight loss surgery.mp.	joint.mp.
telemedicine.mp.		healthy lifestyle.mp.		exp obesity management/	joint surgery.mp.
telehealth.mp.		Lifestyle change.mp.		obesity management.mp.	exp general surgery/
digital healthcare.mp.		exp Health Promotion/		exp overweight/	exp elective surgical procedures/
smartphone application.mp.		health promotion.mp.			surgery.mp.
exp SMARTPHONE/		behavio* change.mp.			general surgery.mp.
smartphone.mp.		health information.mp.			elective surgery.mp.
exp Cell Phone/		exp Health Education/			exp preoperative care/
cell phone.mp.		health education.mp.			exp postoperative care/
exp Mobile Applications/		exp Health Risk Behaviors/			exp perioperative care/
mobile applications.mp.		health risk behaviors.mp.			preoperative care.mp.
exp Internet/		exp Attitude to Health/			postoperative care.mp.
internet.mp.		attitude to health.mp.			perioperative care.mp.
web-based.mp.		social cognitive theory.mp.			surgical pathway.mp.
internet-based.mp.		SCT.mp.			
computer-based.mp.		exp Self Efficacy/			
exp Computer-Assisted Instruction/		self-efficacy.mp.			
exp Wearable Electronic Devices/		transtheoretical model of change.mp.			
wearable technology.mp.		transtheoretical model.mp.			
exp Fitness trackers/		stages of change.mp.			
activity tracker.mp.					

Table 2: Search strategy for PsycINFO database

Digital Tech Intervention	Sustained	Lifestyle Change	Surgery speciality benefitting from a lifestyle change		
			Cancer Surgery	**Bariatric Surgery**	**General Surgery**
digital technology.mp.	Identified using inclusion/exclusion criteria after searching	exp Health Behavior/	cancer.mp.	bariatrics.mp.	general surgery.mp.
digital intervention.mp.		health behavior.mp.	cancer patient.mp.	exp bariatric surgery/	elective surgery.mp.
eHealth.mp.		life style.mp.	cancer survivor.mp.	bariatric surgery.mp.	surgery.mp.
mHealth.mp.		healthy lifestyle.mp.	cancer surgery.mp.	weight loss surgery.mp.	preoperative care.mp.
exp TELEMEDICINE/		Lifestyle change.mp.		exp obesity management/	postoperative care.mp.
telemedicine.mp.		exp Health Promotion/		obesity management.mp.	perioperative care.mp.
telehealth.mp.		health promotion.mp.		obesity surgery.mp.	surgical pathway.mp.
digital healthcare.mp.		behavio* change.mp.		exp weight control/	surgical recovery.mp.
smartphone application.mp.		health information.mp.		weight control.mp.	preparation for surgery.mp.
smartphone.mp.		exp Health Education/		exp overweight/	exp surgical patients/
cell phone.mp.		health education.mp.		overweight.mp.	
exp Internet/		health risk behaviors.mp.			
internet.mp.		attitude to health.mp.			
web-based.mp.					
internet-based.mp.					
computer-based.mp.					
exp Computer-Assisted Instruction/					

Table 3: Search strategy for Web of Science and Scopus databases

Digital Tech Intervention	Sustained	Behaviour Change	Surgery speciality benefitting from a lifestyle change		
			Cancer Surgery	**Bariatric Surgery**	**General Surgery**
((digital technology OR digital intervention OR eHealth OR mHealth OR telemedicine OR telehealth OR digital healthcare OR smartphone application OR smartphone OR cell phone OR internet OR web-based OR internet-based OR computer-based)) *AND* **LANGUAGE:** (English)	Identified using inclusion/exclusion criteria after searching	((health behavio* OR health behavio* change OR healthy lifestyle OR lifestyle change OR health promotion OR behavio* change OR health education OR health risk behaviors)) *AND* **LANGUAGE:** (English)	((cancer OR cancer patient OR cancer survivor OR cancer pathway) AND (cancer surgery))	(bariatrics OR bariatric surgery OR weight loss surgery OR obesity management OR obesity surgery OR weight loss management OR weight control OR overweight)	(surgery OR general surgery OR elective surgery OR preoperative care OR postoperative care OR perioperative care OR surgery pathway OR preparation for surgery)

2.2.5 Data extraction and quality appraisal

Data extraction was carried out by two authors (AR and AKH), using a customised data extraction form containing the following headings: the study, intervention, population, behavioural change outcome, key findings and study limitations. Quality and risk of bias assessment was conducted by two authors (AR and AKH) using the Joanna Briggs Institute critical appraisal tools.(183) This checklist includes questions relating to sampling, inclusion criteria, confounding, outcomes and statistical analysis. All studies were assigned a methodological quality (bias) score (%) for ease of reporting. Interventions were grouped into three delivery time-points for analysis: 'pre-operative' interventions (implemented prior to the surgical procedure); 'post-operative' interventions (implemented following the surgical procedure); and 'pre- and post-operative' interventions (when interventions were implemented pre-operatively and continued post-operatively, termed P&P).

2.2.6 Analysis and synthesis

A narrative synthesis thematically describing studies was undertaken. Studies reported heterogeneous measures so a meta-analysis was not possible. Overall effectiveness in supporting behavioural change in surgical patients was reported in terms of (1) the delivery method; (2) the timing of intervention delivery; and (3) the theoretical underpinning of the digital interventions.

2.3 Results

Initially 2,999 citations were screened. An additional 22 studies were identified through hand searching and grey literature. After removal of duplicates and appliance of eligibility criteria (including whether the work was published in the English language), 17 studies were included in this review (as demonstrated in Figure 2, the PRISMA flow chart below). Ten of these were randomised controlled trials (RCTs), whilst the remaining seven included feasibility and efficacy studies, controlled observational studies and a study employing a pre-/post- test design.

The 17 included studies were published between 2011 and 2019. They were conducted in seven different countries, including the United States of America (n=5),(153, 184-187) Netherlands (n=4),(164, 167, 188, 189) Canada (n=3),(159, 190, 191) New Zealand (n=2),(154, 192) South Korea (n=1),(193) Australia (n=1),(160) and Spain (n=1).(194)

Studies covered three different surgery types including bariatric surgery (59%, n=10), cancer surgery (29%, n=5) and orthopaedic surgery (12%, n=2). Further study characteristics including participant demographics, the timing of intervention implementation and the health behaviours targeted for change are detailed in Table 4.

All studies varied in the delivery method of the intervention (as covered in Section 2.3.2). There were also differences between the studies concerning the timing of interventions, including the duration and frequency of use, as well as retention rates over the study period. Further details of timing are discussed later, in Section 2.3.3. Two papers did not report any statistical analysis of their results.(189, 194) Of the remaining 15 articles, nine (60%) reported a significant effect indicating a change in health behaviours following the use of a digital intervention ($p \leq 0.05$). Eight studies referred to the use of Behaviour Change Theory or frameworks within their work, as discussed later in Section 2.3.4.

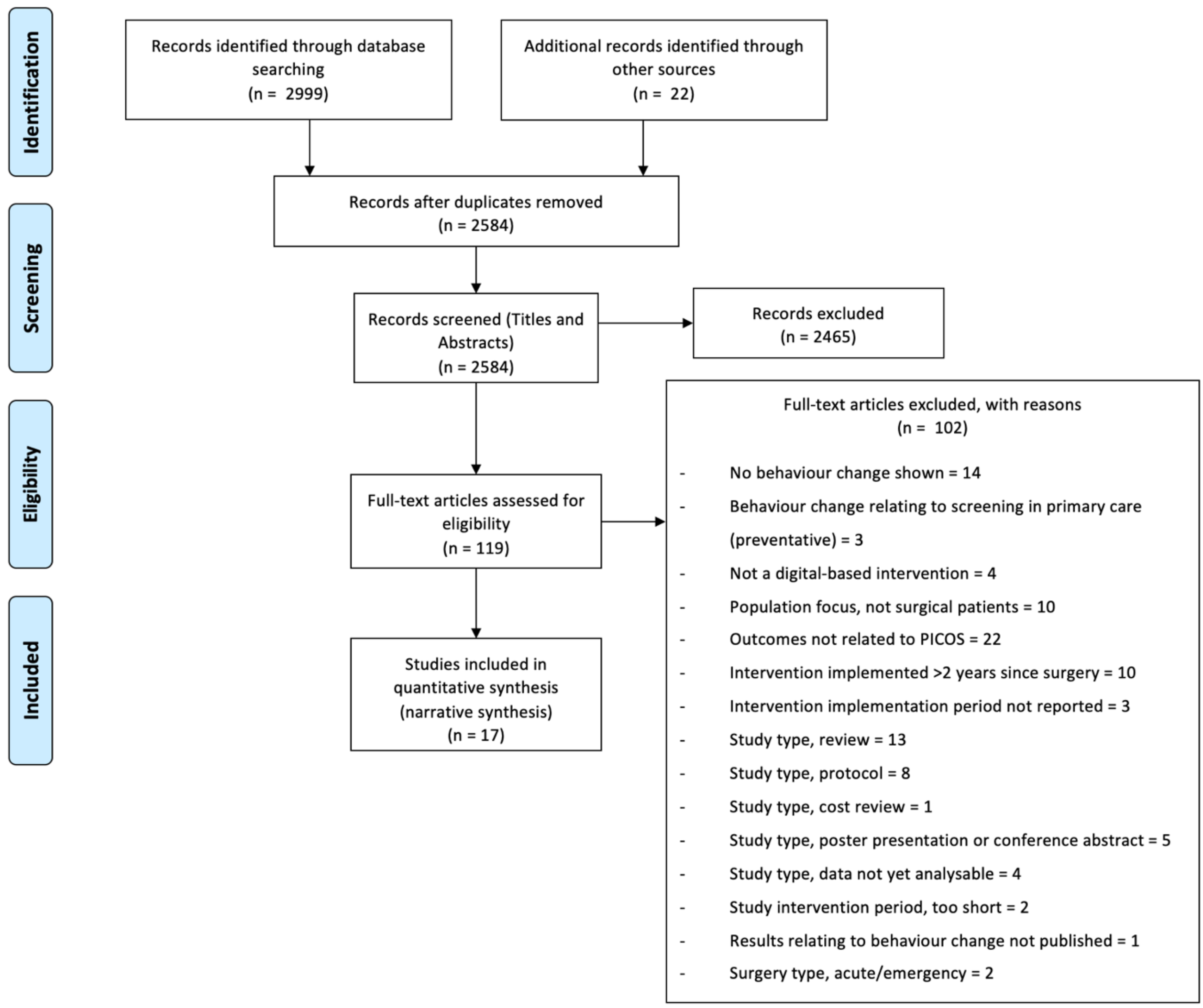


Figure 2: PRISMA flow chart for the data selection process.

2.3.1 Study quality

The overall methodological quality of included studies was good. The average quality score of all studies was calculated as 69%, as demonstrated in Table 5. Of the 17 included studies, Bailott *et al*. and Ormel *et al.* had the highest scores (100%),(164, 190) whilst Lemanu *et al.* and Mayer *et al.* both had the lowest scores 54%.(186, 195)

Table 4: Study characteristics

Author, year	Type of Surgery	Intervention Target			Behaviour Change Target			Population size in Intervention Group	Participant sex	Control or comparator group (Y/N)
		Pre-op	*Post-op*	*P&P*	*PA*	*Wt*	*Diet*			
Baillot et al., 2017 (190)	Ba S	X			X			6	F	Y
Bradley et al., 2017 (184)	Ba S		X			X		20	F+M	N
Coleman et al., 2017 (153)	Ba S		X		X			26	F+M	Y
Doiron-Cadrin et al., 2019 (159)	Or, TKA+THA	X			X			12	F+M	Y
Kanera et al., 2016 (188)	Ca, mixed		X		X		X	265	F+M	Y
Kanera et al., 2017 (167)	Ca, mixed		X		X		X	231	F+M	Y
King et al., 2012 (185)	Ba S			X	X			310	F+M	Y
Lauti et al., 2018 (196)	Ba S		X			X		47	F+M	Y
Lee et al., 2014 (197)	Ca, breast		X		X		X	29	NR	Y
Lemanu et al., 2018 (195)	Ba S	X			X			44	F+M	Y
Mayer et al., 2018 (186)	Ca, colon		X		X			144	F+M	Y
Mundi et al., 2015 (198)	Ba S	X			X	X		30	F+M	N
Ormel et al., 2018 (164)	Ca, mixed			X	X			16	F+M	Y
Padwal et al., 2013 (191)	Ba S	X				X		225	F+M	Y
Russell et al., 2011 (160)	Or, TKA		X		X			31	F+M	Y
Tenhagen et al., 2016 (189)	Ba S			X		X		14	F+M	N
Vilallonga et al., 2013 (194)	Ba S		X			X		10	F+M	Y

Key: Ba S = bariatric surgery, Or = orthopaedic surgery, TKA = total knee arthroscopy, THA = total hip arthroscopy, Ca = cancer surgery, Pre-op = pre-operative target, Post-op = post-operative target, P&P = pre- and post-operative target, PA = physical activity, Wt = weight, F = female only participants, F+M = female and male participants, NR = not reported, Y = yes, N = no.

Table 5: Quality of the included studies

Author, year	Study design	Critical bias score													Total Score	
		1	2	3	4	5	6	7	8	9	10	11	12	13	(n)	(%)
Baillot et al., 2017(190)	Pre-/post- test design	Y	Y	Y	Y	Y	Y	Y	Y	Y					9/9	100
Bradley et al., 2017(184)	Feasibility and efficacy	Y	X	X	N	Y	Y	X	Y	Y					5/9	56
Coleman et al., 2017(153)	RCT	Y	?	N	N	?	?	Y	Y	Y	Y	Y	Y	Y	8/13	62
Doiron-Cadrin et al., 2019(159)	RCT	Y	Y	Y	X	?	?	Y	Y	Y	Y	?	Y	Y	9/13	69
Kanera et al., 2016(188)	RCT	Y	Y	N	N	?	?	Y	Y	Y	Y	Y	?	Y	8/13	62
Kanera et al., 2017(167)	RCT	Y	Y	N	X	?	?	Y	Y	Y	Y	Y	?	Y	8/13	62
King et al., 2012(185)	Observational	Y	N	Y	Y	Y	?	Y	N	Y					6/9	67
Lauti et al., 2018(192)	RCT	Y	Y	Y	N	X	Y	Y	Y	Y	Y	?	?	Y	9/13	69
Lee et al., 2014(193)	RCT	Y	Y	N	Y	X	X	Y	Y	Y	Y	?	Y	Y	8/13	62
Lemanu et al., 2018(154)	RCT	N	N	Y	N	X	Y	Y	Y	Y	Y	Y	N	X	7/13	54
Mayer et al., 2018(186)	RCT	?	?	Y	X	N	N	Y	N	Y	Y	Y	Y	Y	7/13	54
Mundi et al., 2015(187)	Feasibility	Y	Y	X	N	Y	Y	X	Y	Y					6/9	67
Ormel et al., 2018(164)	Feasibility	Y	Y	Y	Y	Y	Y	Y	Y	Y					9/9	100
Padwal et al., 2017(191)	RCT	Y	Y	N	X	Y	Y	Y	Y	Y	Y	Y	Y	Y	11/13	85
Russell et al., 2011(160)	RCT	Y	Y	N	X	Y	Y	Y	Y	Y	Y	?	Y	Y	10/13	77
Tenhagen et al., 2016(189)	Feasibility and efficacy	Y	X	X	N	Y	Y	X	Y	Y					5/9	56
Vilallonga et al., 2013(194)	Observational	Y	N	Y	Y	Y	Y	Y	N	N					6/9	67
															Average	**69**

Key: Y = yes, N = no, X = not applicable, ? = unclear, RCT = randomised controlled trial

2.3.2 Delivery of the intervention

Different digital technologies were used to deliver the interventions including internet-based interventions (telemedicine, emails and e-platforms),(159, 160, 167, 188, 190, 191, 193) phone-based interventions (text messaging and apps),(154, 164, 186, 192) wearable interventions (activity monitors),(185) and combination interventions (more than one form of digital technology to support health behaviour change).(153, 184, 187, 189, 194) Table 6 provides an overview of the method of delivery, target and engagement rate of the digital interventions from the 17 included studies.

Internet-based interventions

Seven studies utilised internet-based interventions to promote health behaviour change, three of which employed telemedicine(159, 160, 190) and the remaining four used an e-platform system, made up of educational modules.(167, 188, 191, 193) None of the three telemedicine studies led to change in health behaviours, although the authors did recognise the potential benefits of utilising this method of delivery to overcome provision and geographical barriers.(160)

The e-platform approach produced health behaviour change across three of the four studies.(167, 188, 193) Two studies employed the 'Kanker Nazorg Wijzer' e-platform to provide personalised educational modules to post-operative cancer patients, concerning physical activity (in minutes of exercise per week) and diet (measured and reported as vegetable consumption, in grams per day).(167, 188) Authors reported how the intervention group improved moderate physical activity levels (by +150.73 minutes per week, p=0.037) compared to control over a six month period, whilst also seeing this improvement sustained over a 12 month period (p=0.011).(188) However, the increased vegetable consumption (grams per day, p=0.027) over the six month period was not sustained at 12-months (p=0.132). Authors also demonstrated that improvements in PA were significantly more successful in younger patients (<57 years), compared to older, over a 6-month (minutes per week, p=0.04) and 12-month (minutes per week, p=0.00) period.(167) This echoes findings from previous work, which showed how younger cancer survivors were more likely to improve their PA levels, possibly due to their perceptions of future risk compared to older survivors.(199, 200)

Another study focused on a web-based self-management exercise and diet intervention e-platform to support post-operative breast cancer patients to improve their exercise and dietary intake health behaviours.(193) The results demonstrated an improvement in diet (servings of fruit and vegetables per day, $p=0.001$) and PA levels (minutes of exercise per week, $p= <0.0001$) compared to control.

Phone-based interventions

Four studies delivered health behaviour change interventions using phone-based methods, two through text messaging services(154, 192) and two through smartphone applications (apps).(164, 186) Lemanu *et al.* found that text message delivery over a 4-6 week period was successful at improving bariatric patient adherence to pre-operative exercise (median of 5-days of exercise per week, $p<0.046$),(154) although this improvement was not sustained 6-weeks post-operative follow-up.(154) Ormel *et al.* showed significant improvements in PA in pre- and post-operative cancer patients with app usage, which was not maintained at the 12 week follow-up.(164) Mayer *et al.* also showed an improvement in PA in post-operative colon cancer patients' with the SurvivorCHESS app. This was not different however when compared to control patients (minutes of moderate and vigorous physical activity per week (MVPA), $p=0.122$) and only lasted as long as the intervention period.(186)

Wearable-based interventions

King *et al.* provided participants with a wearable digital activity monitor (which tracked PA, including daily step counts and active minutes) to use alongside self-reporting their PA levels in a paper diary, from one week prior to surgery up until 1 year after.(185) More participants changed from inactive to active, than from active to inactive, over the intervention period (minutes of exercise per week, $p<0.001$). By using the diary, more participants self-reported PA levels, improving from <150mins/week pre-op to ≥150mins/week at 1-year post-op (p<0.001). Using the activity monitor, an increase in the number of steps per day and active minutes per day from pre- to 1-year post-op (p<0.001 for both) were observed.

Combination interventions

Five studies utilised a combination of different digital approaches to motivate health behaviour change in bariatric surgical patients. One study used a combination of three digital elements (triple-approach)(184) and the other four used a dual-approach.(153, 187, 189, 194) One study trialled a combination intervention pre-operatively,(187) three studies post-operatively,(153, 184, 194) and one was implemented both pre- and post-operatively across the surgical journey.(189) Out of the five combination interventions, three demonstrated behavioural change improvements,(153, 184, 187) whilst two did not perform a statistical analysis.(189, 194)

In their triple-approach study, Bradley *et al.* implemented an e-platform in combination with an app and online log to investigate efficacy of reduced weight regain in patients following bariatric surgery.(184) Educational information was delivered through the e-platform and daily calorie intake calculated using an app. At intervention completion, 91% (n=18) of participants demonstrated weight loss or weight stabilisation (in kilograms, p=0.01). Weight loss was maintained at the final follow-up appointment, 3-months post-surgery.

Coleman *et al.* implemented a dual-approach, where participants used a form of wearable technology (pedometer) in combination with online activity logging to complement post-operative exercise programmes.(153) An improvement was demonstrated in participants' 6-minute walk test time (distance in meters, p=0.001) during the intervention period and maintained at 6-month follow up.(153)

Mundi *et al.* employed a dual-approach intervention, consisting of an educational app and a daily text message service, for 12 weeks prior to bariatric surgery.(187) At study completion there was a reduction in weight (from 127.4kg ± 27.5 to 123.9kg ± 28.6, p=0.006), BMI (from 46.3kg/m^2 ± 7.4 to 45.1 kg/m^2 ± 85, p=<0.001) and an increase in physical activity (minutes of vigorous activity per week, from 25.5 ± 43.9 to 49.4 ± 51.1, p=0.04) in the intervention group.(187)

Patients tracked their real-time weekly parameters, pre- and post-bariatric surgery, by using digital weighing scales (technology at home) connected to an online log in another dual-approach study.(189) Upon study completion, participant mean BMI reduced to 30.6kg/m^2 ± 4.2 (from 44.7kg/m^2 ± 4.6), the mean percent estimated weight loss was 72% (± 19.1) and the mean percent BMI change was 32%. Vilallonga *et al.* also utilised a dual-approach, with WiFi-enabled weighing scales logging weight loss onto an online account and members of the surgical team using emails to liaise with patients on post-operative weight-loss progress.(194) The results demonstrated improvements in percent excess weight loss (as a target measure for recommended weight loss), with the intervention group losing 65.3% compared to 58.2% for the control (which were deemed an acceptable amount of weight loss at nine months post-operative). The mean post-operative BMI for the intervention participants was 32.7kg/m^2 (down from 48.4kg/m^2), compared to 33.2kg/m^2 (down from 45.3kg/m^2) for control.

2.3.3 Timing of intervention delivery

Table 6 shows the timing details of each intervention in the studies, specifically, how long patients used the interventions (intervention period) and their active engagement (retention rates). Four studies initiated interventions 12-weeks prior to surgery(159, 187, 190, 191) and one 4-6 weeks prior.(154) Nine studies used post-operative interventions, with some patients beginning almost immediately after surgery with a rehabilitation focus,(160) some during their follow-up monitoring,(167, 184, 188, 193, 194) and up to 2-years after surgery in three studies.(153, 186, 192) The overall intervention period of the included studies differed substantially, with the shortest being 6-weeks(160) and the longest continuing over 12-months.(193) The pre-and postoperative intervention by Ormel *et al.* was initiated pre-operatively following the decision to undergo surgery and was continued for 12-weeks post-operatively.(164) Tenhagen *et al.* also initiated their intervention pre-operatively following the surgical decision but continued for 12-months post-operatively,(189) whereas King *et al.* initiated their intervention for a 7-day period in the week prior to surgery and repeated again for another 7-day period, 1-year post-op.(185)

Overall, retention rates over the intervention period were high; only one had a retention rate below 60%.(184) Four studies reported 100% retention rates, including two with pre-operative interventions,(154, 190) one with a post-operative intervention,(194) and one with a pre-and postoperative intervention.(164)

2.3.4 Theoretical underpinning: behaviour change theories

Eight of the 17 studies (47%) referred to behaviour change theories or frameworks within their work, either as a way of designing their intervention or for analysis of results.(153, 164, 167, 184, 186, 188, 192, 193) Across these, Social Cognitive Theory was utilised twice,(167, 188) whilst theories like Acceptance and Commitment Therapy,(184) the Trans-Theoretical Model (TTM),(193) Self-Determination Theory,(186) the Behaviour Change Wheel,(192) and goal-setting(153) were used once. Ormel *et al.* did not specify which behavioural change theory informed the design of their app, however the authors acknowledged it was rated best on using behavioural change techniques to stimulate a healthy lifestyle.(164) Out of the eight studies, six produced significant improvements in health behaviour changes ($p \leq 0.05$) relating to reduced weight regain,(184) increased PA(153, 164) and improved lifestyle choices for PA and diet.(167, 188, 193)

Table 6: The method of delivery, target, and engagement rates of digital interventions

Author, year	Method of intervention delivery	Delivery platform	Intervention description	Intervention target	Intervention period	Statistically significant HBC seen ($p \leq 0.05$) (Y/N)	Retention rate (%)
Baillot et al., 2017(190)	Internet-based	TM	Telemedicine intervention: 'TelePreSET' in-house strength and endurance exercise training *via* videoconferencing.	Pre-op	12 weeks	N	100
Bradley et al., 2017(184)	Combination	SA, eP, OL	Mixed-delivery digital interventions: - Module-based intervention, delivered via an online eLearning platform. - MyFitnessPal® smartphone app to document daily food diary. - Online spreadsheet to document daily weight and calorie intake.	Post-op	10 weeks	Y	55
Coleman et al., 2017(153)	Combination	OL, WT	Mixed-delivery intervention: wearable technology and web-based activity logging, complementing group exercise sessions. - 2 x weekly group exercise sessions, - 3 days/week self-directed exercise, - daily pedometer wear for real-time recording, - daily logging of physical activity and steps via 10,000 steps website, - and weekly counselling sessions via telephone.	Post-op	6 months	Y	81
Doiron-Cadrin et al., 2019(159)	Internet-based	TM	Telemedicine-based intervention: one-to-one tele-prehabilitation sessions (2x/week with a physical therapist) via tele-communication software (iPad), alongside PA log book to self-report exercise at home.	Pre-op	12 weeks	N	97
Kanera et al., 2016(188)	Internet-based	eP	Internet-based intervention: via an online portal (KNW), providing advice and support to patients, with personalised modules for education, including PA, diet, and QoL.	Post-op	12 weeks	Y	87

Kanera et al., 2017(167)	Internet-based	eP	Web-based intervention: computer tailored intervention via an online portal (KNW), providing advice and support to patients, with personalised modules for education, including PA, diet, and QoL.	Post-op	6 months	Y	83
King et al., 2012(185)	Wearable	WT	Wearable-based intervention: activity monitor provided by researchers to wear for the intervention period and PA diary to document self-reported activity levels for intervention period.	P&P	1 week	Y	NR
Lauti et al., 2018(192)	Phone-based	TX	Text message-based intervention: daily, one-way, text messages sent each to participants every morning for a 12 month period.	Post-op	12 months	N	90
Lee et al., 2014(193)	Internet-based	eP	Internet-based intervention: web-based self-management exercise and dietary intervention (WSEDI) aimed at enhancing PA and dietary behaviours through information, educational modules, and assessment modules, underpinned by behavioural change theories including action planning and goal setting.	Post-op	12 weeks	Y	98
Lemanu et al., 2018(154)	Phone-based	TX	Text message-based intervention: daily, one-way, text messages sent for 4-6 weeks prior to surgery to encourage/remind patients to keep exercising pre-operatively.	Pre-op	4-6 weeks	Y	100
Mayer et al., 2018(186)	Phone-based	SA	Smartphone-based app (Survivor CHESS): with components for PA tracking, peer-peer social networking, PA educational information, care planning, and one-to-one motivational messaging with coach (also provided with leaflets).	Post-op	6 months	N	82
Mundi et al., 2015(187)	Combination	SA, TX	Mixed-delivery: smartphone-delivered intervention, including: smartphone app consisting of educational modules (n=9) with assessments on completion (70% pass mark - modules were either nutrition related or physical activity related) and daily text messages encompassing lifestyle domains (including PA and meal planning).	Pre-op	12 weeks	Y	67

Ormel et al., 2018(164)	Phone-based	SA	Smartphone-based intervention: using a smartphone app (RunKeeper®) to track PA levels during and after cancer treatment in comparison with usual care.	P&P	12 weeks	Y	100
Padwal et al., 2017(191)	Internet-based	eP	Internet-based intervention: online modular intervention, delivered via an online eLearning platform, accessible any time over a three month period.	Pre-op	12 weeks	N	71
Russell et al., 2011(160)	Internet-based	TM	Internet-based intervention: weekly tele-rehabilitation exercise program to aid patient recovery following total knee arthroplasty (TKA). Once weekly, supervised, 45 minute session with clinician, encouraged to perform twice daily exercise.	Post-op	6 weeks	N	97
Tenhagen et al., 2016(189)	Combination	OL, TaH	Mixed-delivery: online-based monitoring of weight, via digital-internet connected scales. Online platform/dashboard for monitoring participant weights (baseline, current), graphical representations of progress, and digital-internet connected scales provided for weekly home measurements (weight data is transferred wirelessly and sent to central online database).	P&P	12 months	SNP	79
Vilallonga et al., 2013(194)	Combination	Email, TaH	Mixed-delivery intervention: TaH and email-based intervention: Remote virtual follow up assessments, email contact with surgeons, and online account with data to track weight loss progress. WiFi-enabled weighing scales to generate readings for BMI and percentage of fat and muscle tissue. All of the data stored electronically on their account, shared with surgeons, to track weight loss progress. Follow up assessments done via email, using shared real-time data. Data can be shared with social media if patient wanted.	Post-op	3 months	SNP	100

Key: Y = yes, N = no, TM = telemedicine, SA = smartphone app, eP = e-platform, OL = online log, WT = wearable technology, TX = text message, TaH = technology at home (*e.g.* digital scales), QoL = quality of life, Pre-op = pre-operative target, Post-op = post-operative target, P&P = pre- and post-operative target, HBC = health behaviour change, SNP = statistical analysis not performed by authors.

2.4 Discussion

This is the first systematic review and narrative synthesis to examine the effectiveness of digital technologies to support lifestyle change in elective surgical patients. In this patient cohort, various forms of digital technologies have been shown to successfully support positive health behaviour change across the surgical pathway; in particular increased physical activity levels, weight loss and improved dietary habits. The duration of making and sustaining this behaviour change has proven to be variable, with some technologies demonstrating more success on a short-term basis, compared to long-term.

From this review, three factors were identified that could contribute to digital technology effectiveness in the elective surgical population: (i) the method of delivery of an intervention, (ii) the time at which an intervention is implemented within the surgical pathway and (iii) the behavioural change theories underpinning the intervention design.

High overall retention rates across studies indicated the acceptability of integrating digital technologies within surgical care pathways. This is not an unusual finding, with previous research supporting the transition and success of digital technology use and integration from social to healthcare-related settings.(201-203) Some delivery methods were associated with higher retention and satisfaction rates among participants. Within the telemedicine intervention group in the study by Baillot *et al.*, there was 96% recorded attendance at appointments compared to 80% for the control group.(190) In addition, high satisfaction rates amongst intervention group participants were seen in the internet-based studies, with 100% reporting their overall satisfaction with the delivery format.(159) When reflecting on the choice of delivery method versus the participant retention rates, Padwal *et al.* concluded that e-platforms were often more expensive and labour-intensive to produce and run.(191) This signals that the decision to integrate effective digital strategies is based on more than an intervention's acceptability to the participant, where clinician preferences and the practicality of operational costs should also be considered.

Although none of the studies using telemedicine demonstrated improvements in health behaviours, authors acknowledged many benefits underpinning this delivery method. These included reduced travel to face-to-face appointments,(167, 188) increased accessibility to healthcare services for those who are geographically, economically or functionally disadvantaged,(190) and improved continuity of care with the same physician working to programme completion.(160) This adds to the already growing body of literature supporting the wide-ranging opportunities that telemedicine interventions present.(204) Specifically, in a surgical context, this can reduce the need for in-person consultations before and after surgery.(125, 205) The benefits of phone-based interventions included convenience for the patient (accessible at any time), low-cost and user-friendly.(154, 186, 192) Higher sophistication, such as text messages that allow a response, offers more personalised advice as well as the possibility to link with self-monitoring applications to track progress, which may produce superior results.(192) Tenhagen *et al.* used digital weighing scales connected to an online log (*i.e.* a dual approach) and concluded that links to an automated weight reminder system employing text messages (*i.e.* a triple-approach) could strengthen combination-based interventions further. Similar conclusions were reported in recent work where traditional weight loss programmes were enhanced with digital technologies, such as text messaging, social media and virtual coaching.(187, 206) Newer forms of delivery, such as wearable technologies, have increased in popularity over recent years yet, only two studies utilised wearable technologies in this review; one wearable was successful in isolation(185) and one in combination.(153) Given their popular uptake, future studies may look to involve and evaluate this delivery platform more readily.(207-209)

There were no interventions which included digitally-based peer support networks in this review. Peer-forums supporting and motivating pre- and post-operative lifestyle changes have demonstrated success in past studies.(206, 210, 211) Authors have reflected on peer-peer benefits, including increased patient knowledge and decreased patient isolation.(212, 213) Peer support has been found to enhance the effectiveness of behaviour change, with authors postulating how this may increase motivation and adoption of social-norm approaches through social interactions.(214-217) When it comes to seeking assistance or advice, some patients prefer to approach their peers in comparison to healthcare professionals.(218-220) The topic of peer support will be discussed further in Chapter 3 (Meta-ethnography), Chapter 4 (Narrative Review), Chapters 6-8 (Results) and Chapter 9 (Discussion and Conclusions).

The optimum value of intervention timings, specifically initiation, duration and frequency, on outcomes is also unclear. Other factors such as the surgical procedure (or the underlying disease meaning that surgery is required) may contribute to variation in behaviour change and may in fact determine the timing of when, how long for, and how often patients engage with digital technologies. It would appear that pre-operative digital interventions are beneficial in cementing a culture of behaviour change for the patient at the earliest opportunity.(55, 90, 221) The challenge is continuing the intervention post-operatively in an attempt to sustain changes to lifestyle and obtain greater improvements in outcomes.(89) In their pre- and post-operative (P&P) study, Tenhagen *et al.* reported 100% participant agreement that once-weekly weights were sufficient to track weight loss progress.(189) Specifically for patients undergoing bariatric surgery, research has demonstrated a positive correlation between the frequency of follow-up and success of weight loss,(222) with regular self-monitoring found to be one of the most protective strategies against weight regain.(223) This is consistent with findings from patients who are obese and managed non-surgically, where regular tracking of dietary intake, weights and physical activity were vital for avoiding weight regain.(222-224) Uniquely, a novel phenomenon associated with digitally-supported care was acknowledged, where the use of (and subsequent adherence to) technologies lessens over time.(164) Recent research papers have reported similar findings,(225-227) emphasising the importance of finding the best ‘engagement balance’ for the patient cohort being treated.

Previous reviews have described effective interventions as those that employ behavioural change theories in their design, particularly goal-setting, self-monitoring and feedback.(228, 229) Participating in goal-setting has given patients a sense of ownership and personal importance, empowering successful behaviour change.(230, 231) As Greaves *et al.* discuss in their systematic review of reviews, interventions that are designed alongside behaviour change theories were associated with greater weight loss and increased physical activity, both sought-after aspects to improve surgical outcomes and patient wellbeing.(232) Kanera *et al.* reflected on results from previous meta-analyses, which concluded that Social Cognitive Theory-based interventions were successful when applied to surgical cancer patients: confirming improved physical activity levels, diagnosis-related depression scores and quality of life outcomes.(228, 229, 233-237) These authors identified the importance of tailoring behaviour change interventions to each patient and recognised the differences in determinants and motivational phases at an individual-level.(167, 188) They referred to the limited amount of theory-based studies in current research and acknowledged the promising results yielded for theory-grounded, web-based interventions. It appears that the individualised approach of goal-setting and working towards achievable targets (*e.g.* daily step-counts) is an effective strategy to successfully motivate behavioural change.(185, 238, 239) More research is needed to determine which motivational theories and frameworks are most effective and in what combination.(240) Consideration of these strategies should be echoed in the design of digital health technologies, aiming to produce the same improved post-surgical outcomes.

This systematic review and narrative synthesis is subject to some limitations. Only elective surgeries with a defined pre- and post-operative period were included, allowing for changes to patient behaviours to occur and be evaluated; hence the findings may not be generalisable to all surgical types. Studies were limited to the English language and adult populations, and relied on self-reported data which can contribute to bias.(166) Further, outcome measures were heterogeneous and often adapted to the specific population in that study, rather than for surgical patients on a whole; this made it difficult to judge the optimum approach(es) responsible for contributing to statistically significant behaviour change in each surgical cohort. Although it was possible to identify some elements of intervention delivery and timing that may be effective for supporting surgical patients, the most effective element could not be determined. It was also unclear which combination(s) of intervention delivery approaches would be optimal. In the future, there may be sufficient studies with uniform reporting outcomes and large populations to facilitate a formal meta-analysis to be undertaken; this would allow a more precise determination of the effectiveness of digital interventions in supporting behavioural change in elective surgical patients.

2.5 Conclusion

In conclusion, this systematic review suggests that digital technologies can play a role in effectively supporting lifestyle behaviour changes in elective surgical patients. Further research is needed to optimise digital interventions available for specialist surgical subgroups.

Although we were able to identify elements of intervention delivery and timing that may be effective for supporting surgical patients, based on the available evidence, we could not determine which of these are the most important and effective. In a world where digital technologies develop at rapid pace and are implemented more than ever within healthcare systems, these components should be established in order to have maximal effectiveness in supporting behaviour change of elective patients, thus improving surgical quality and safety.

2.6 Summary of Chapter 2

This chapter and review sought to synthesise the existing literature base of quantitative studies, in order to identify key areas and knowledge gaps to focus future research. Three factors were identified that appeared to contribute to digital technology effectiveness in supporting lifestyle change: (i) the delivery method of an intervention, (ii) the time at which an intervention is implemented in the pre- and post-operative period and (iii) the inclusion of behaviour change theory within the intervention design. Further work is needed in order to provide more clarity on these when working towards identifying optimal technology design to support lifestyle change in elective surgical populations (considered in three specific surgical cohorts in Chapters 6, 7 and 8 respectively). Following on from the knowledge-building literature review of Chapter 1 and this structured systematic review, Chapter 3 aims to further address additional knowledge gaps that were identified by applying qualitative research methodologies.

In Chapter 3, a meta-ethnographic approach is employed, in order to systematically review and synthesise the existing qualitative data in this field. By gaining an understanding into the '*why*' behind the factors influencing a technology's effectiveness (and by including the qualitative voices of the patients at the centre of the surgical journey), it may be possible to recognise which components are deemed most important to patients when determining the use of a digital technology to support lifestyle changes during the surgical journey.

Chapter 3: Promoting physical health behaviour change and providing psychological support to surgical patients by using digital technologies: a meta-ethnography and systematic review

The systematic review in Chapter 2 appreciated quantitative measures of technology effectiveness to support and motivate health behaviour change in the cohorts of bariatric, cancer and orthopaedic surgery. Findings identified elements of intervention delivery and timing that may be effective for supporting surgical patients, however, determining which of these are the most important and effective was not possible. By gaining an understanding of the qualitative literature base and awareness of the perspectives of patients, the detail of '*why'* behind the effectiveness of technologies may be better understood; consequently, it may then be possible to recognise which components are deemed important to support successful change to lifestyles. As part of the next stage of logical investigation, the researcher sought to bridge this gap in understanding by conducting a further systematic review of the existing literature, this time exploring qualitative studies.

This review uses a meta-ethnographic approach to analyse and synthesise qualitative findings. Meta-ethnography was originally developed by Noblit and Hare,(241) but has recently been used in healthcare-based social science research by Britten *et al.,*(242) Campbell *et al.,*(243, 244) Pound *et al.*(245) and others. It is an inductive and interpretive systematic qualitative evidence synthesis approach, which involves the translation of papers and findings into one another. Meta-ethnographies encourage researchers to understand and transfer ideas, themes and metaphors across different studies to gain a deeper understanding or to inform the development of broader concepts.(241, 246) Meta-ethnographic systematic reviews hold value in their ability to lead to insights or interpretations that were not apparent in the individual included studies alone, whilst still scrutinising the literature to produce exemplar research.(241) They can also identify absences of knowledge and reveal areas that may have previously been considered as gaps in the evidence base.

This meta-ethnographic systematic review has been published in an international peer-reviewed open access journal: Robinson A, Oksuz U, Slight R, Slight S, Husband A. *Digital and mobile health technologies to promote physical health behaviour change and provide psychological support for elective surgical patients: a meta-ethnography and systematic review.* JMIR mHealth and uHealth, 2020; 8(12) e:19237, DOI: 10.2196/19237 (Appendix 4). The findings from this chapter have also been presented at a national research conference: the Royal Pharmaceutical Society Science and Research Summit in July 2020.

3.1 Introduction

Whilst healthier lifestyle changes made in the pre- and post-operative periods can be fundamental in determining the outcomes and success of elective surgeries,(4, 16, 152) there are variable amounts of support and education currently provided to surgical patients in order to motivate and achieve them.(177, 178, 247) A recent study evaluating patient attitudes to health behaviour changes found that although pre-operative patients understood the health benefits of improved behaviours, they lacked the confidence to make such changes without intervention or support.(16)

Many physical and mental health interventions offered in the elective care pathways utilise face-to-face, in-person delivery for individuals or small groups of patients. Such approaches are resource- and time-intensive for staff already working in high-pressure healthcare sectors.(248-250) In addition, geographic isolation, travel costs, and the time burden of attending classes can all negatively affect patient engagement with post-operative appointments.(120, 125) Understanding the potential unmet needs of surgical patients is central to motivating positive health behaviour changes. Integrating digital technologies within the surgical pathway could be one strategy to remotely deliver behavioural change advice and lifestyle support, consequently improving patient engagement and post-operative success rates.(1, 169)

There are still unanswered questions relating to the optimisation of digital technologies to support surgical patients, especially in the cohorts of bariatric, cancer and orthopaedic surgery. This review sought to synthesise findings from existing qualitative research to determine whether digital technologies are effective in supporting patients undergoing surgery to change their health behaviours, specifically focusing on physical activity, weight, dietary intake and mental health support (*e.g.* cognitive behavioural therapy).

3.2 Materials and methods

This meta-ethnographic systematic review is registered with PROSPERO (registration number CRD42020157813, Appendix 5) and has been conducted in accordance with the 'Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)' guidelines.

3.2.1 Search strategy and information sources

A comprehensive and systematic literature search was conducted in October 2019 across six electronic databases: Medline, Embase, CINAHL, PsycINFO, Web of Science, and Scopus. No limit on the publication date was applied. Additional papers were identified *via* grey literature using Google Scholar and we hand-searched the bibliographies of all included studies. The full database search strategy, including the MeSH search terms are included in Table 1.

Table 4: Database search terms

Search strand	Search terms
Full search = *(Digital intervention) AND (Behaviour changes) AND (Mental health) AND (Surgical specialities) AND (Qualitative methodology)*	
Digital intervention:	(exp mobile health application/ or mobile phone/ OR smartphone/ OR phone.mp. OR exp text messaging/ OR digital technology.mp. OR digital device.mp. OR digital healthcare.mp. OR exp activity tracker/ OR fitbit.mp. OR videotape.mp. or videotape/ OR videotape.mp. or exp videotape/ OR wearable technology.mp. OR pedometer.mp. or pedometer/ OR exp mobile application/ or exp mobile health application/ OR social media.mp. or social media/ OR exp social network/ OR instagram.mp. OR facebook.mp. OR exp telehealth/ OR exp telerehabilitation/ OR electronic mail.mp. or e-mail/ OR ipad.mp. or tablet computer/ OR exp mobile application/ or mhealth.mp. OR video conferencing.mp. or videoconferencing/ OR smartwatch.mp. OR mobile health application/ or exp mobile application/)
Behaviour change:	(physical activity.mp. OR walking.mp. OR running.mp. OR physiotheraphy.mp. OR step count.mp. OR weight loss.mp. OR weight reduction.mp. OR diet.mp.

	OR lifestyle.mp. OR obesity.mp. OR health behaviour.mp. OR exp Health Promotion/ OR exp Healthy Lifestyle/)
Psychological health:	(exp Anxiety/ OR worry.mp. OR stress.mp. OR cognitive behaviour.mp. OR cognitive behavioural therapy.mp OR mindfulness.mp. OR wellbeing.mp OR mental health.mp. OR quality of life.mp. OR depression.mp OR exp Attitude to Health/)
Surgical specialities:	**Cancer surgery:** (cancer.mp. OR cancer patient.mp. OR exp cancer survivors/ OR cancer survivor.mp. OR cancer surgery.mp.)
	Bariatric surgery: (bariatrics.mp. OR exp bariatric surgery/ OR bariatric surgery.mp. OR weight loss surgery.mp. OR exp obesity management/ OR obesity management.mp.)
	Orthopaedic surgery: (orthopaedic.mp. OR knee replacement.mp. OR hip replacement.mp. OR arthoplasty.mp. OR Arthroscopy.mp. OR joint.mp. OR muscle.mp.)
Qualitative methodology:	(Qualitative analysis/ or exp qualitative research/ OR semi structured interview/ or telephone interview/ or interview.mp. or interview/ OR focus group.mp. or information processing/ OR mixed study.mp. OR thematic analysis.mp. OR ethnography.mp.)

3.2.2 Eligibility criteria

This meta-ethnography focused on surgical procedures, specifically bariatric, cancer and orthopaedic surgeries. Patients undergoing these elective procedures may have improved surgical outcomes following pre- and post-operative health behaviour changes, and therefore can benefit from the support of digital health technologies. Acute, unplanned surgeries and emergency trauma procedures were excluded from this review.

Only the studies that had encompassed the use of digital health interventions to support behaviour changes (such as weight changes, dietary intake, physical activity levels and/or mental health strategies) in adult elective surgical patients (>18 years) during the pre- or post-operative period were included. There were no restrictions placed on participants' sex, ethnicity or nationality. The included studies must be qualitative or mixed-method studies containing a qualitative component to analyse participant perspectives (*e.g.,* patient interviews or focus groups).

Exclusion criteria included studies employing behaviour changes achieved by non-digital interventions; participants who were not scheduled to undergo elective bariatric, cancer and orthopaedic surgery; studies where the intervention was mainly focused on perspectives of healthcare professionals; non-qualitative studies (*e.g.,* quantitative studies, systematic reviews or protocols); and studies in languages other than English.

3.2.3 Selection of eligible studies

Two authors (UO and AR) reviewed titles and abstracts from the database search. Full texts were retrieved for articles, which met the inclusion criteria and for those that could not be rejected with certainty. Two authors (UO and AR) independently screened the full texts of eligible articles. Disagreements (on 3 of the 56 articles) were resolved through discussion with a third reviewer (AKH); these all related to the eligibility of the intervention delivery method and the papers in question were deemed out of scope and, thus, not included after discussion.

3.2.4 Reading, data extraction and quality appraisal

Two authors (UO and AR) closely read and re-read the included studies to ensure close familiarity with the work. Data extraction was performed across the full primary study (by UO and AR)(246) and carried out using a customised data extraction form containing: the study and author details, method of intervention delivery, population data, inclusion criteria, and original quotes and/or concepts developed by the authors of primary studies (within their original context). Both authors worked independently before comparing their work; disagreements were resolved through discussion with a third reviewer (AKH) where necessary. Quality appraisal was conducted independently by UO and AR using the Critical Appraisal Skills Programme (CASP) questions for understanding qualitative research.(251) No papers were excluded on the grounds of quality.

3.2.5 Analysis and interpretive synthesis

Meta-ethnographic approaches were applied to this review, as determined by the 7 phases of meta-ethnography as described by Noblit and Hare: (1) 'getting started', (2) 'deciding what is relevant to the initial interest', (3) 'reading the studies', (4) 'determining how studies are related', (5) 'translating the studies into one another', (6) 'synthesising translations', and (7) 'expressing the synthesis'.(241)

The findings (concepts and metaphors) from the primary studies were compared to determine how they are related. Noblit and Hare suggested that phase five, where findings are translated into one another, follows something like 'one case is like another, except that…'.(241) This phase of a meta-ethnographic approach is termed reciprocal translation, and it enables the development of themes and sub-themes for interpretive synthesis.(241, 243) According to this, we developed four overarching themes (or third order constructs) and subsequent sub-themes which were consistent with the original results, but also extended beyond them.

When translating the studies into one another to develop themes (and sub-themes), we arranged each paper chronologically and compared the themes from paper 1 with those of paper 2, then those of paper 2 with those of paper 3, and so on. As we compared each study, we grouped similar themes and continually reviewed and refined them until they were coherent and distinctive. Two reviewers (UO and AR) were involved in the study translation at all times; however, if agreement was not reached between these, discussion with a third author (AKH) helped to establish a consensus.

To adhere to recommendations for conducting meta-ethnographies, we use the term 'theme' to describe the third order construct, and sub-themes to describe third order construct sub-themes.(246) The development of these overarching themes enables meta-ethnographies to delve further into a topic than a traditional systematic review and contribute new insights to literature.(242)

The overall effectiveness of digital health technologies to support behavioural change in surgical patients has been reported through four established themes: (1) motivational support, (2) patient engagement with interventions, (3) the facilitation of peer networking, and (4) intervention specificity to meet patients' individual needs.

3.3 Results

3.3.1 Search results

A total of 316 citations were retrieved from the database searches. A further five additional records were identified through grey literature and searching references manually from relevant studies. Following the removal of duplicates (n=112), 204 papers were screened, of which 148 were excluded based on their titles and abstracts (n=146) and not being written in the English language (n=2). A total of 56 full-text papers were assessed for eligibility; 38 of these were excluded due to reasons detailed in the PRISMA flowchart in Figure 3. The remaining 18 studies were included in this meta-ethnographic systematic review; of these, 68% (n=13) were qualitative and 32% (n=7) were mixed-method studies.

3.3.2 Study characteristics

All 18 included papers were published between 2013 and 2019. The studies were conducted in 8 different countries: United States of America (n=6),(252-257) United Kingdom (n=3),(258-260) Canada (n=3),(261-263) Australia (n=2),(264, 265) Ireland (n=1),(266) Norway (n=1),(267) South Korea (n=1),(268) and China (n=1).(269)

The 18 studies covered three different surgery types: bariatric surgery (n=2, 11%), cancer surgery (n=13, 72%), and orthopaedic surgery (n=3, 17%). Further study characteristics, including the method of intervention delivery and original themes extracted from the study, are detailed in Table 5.

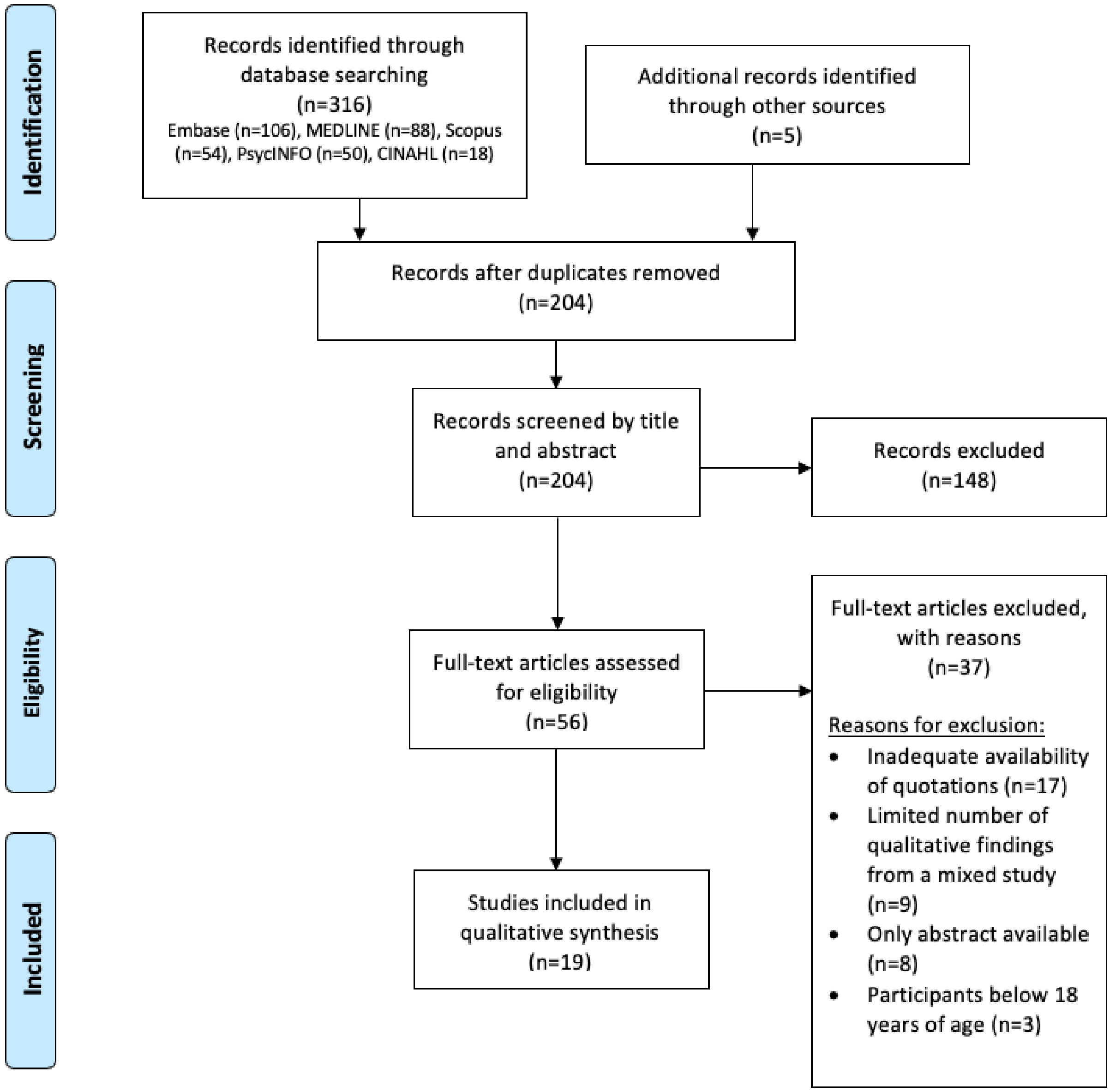


Figure 3: PRISMA Flow Diagram

Table 5: Study characteristics

Authors, year, journal, country and surgical type	Method of data collection	Delivery method	Population data (age, years)	Inclusion Criteria	Aim	Main themes extracted from the original study
Shaffer *et al.*(252) 2019 - *Psycho-Oncology* - USA - Cancer surgery	Semi-structured focus group interviews	Internet-based cognitive behavioural therapy (iCBT) programme	11 Cancer patients (Mean Age: 57yrs)	✓ Aged 21 or older ✓ Have a regular internet access ✓ Being in remission from any stage and any type of cancer ✓ At least 1 month had passed since the completion of active treatment ✓ Meeting DSM-IV-TE criteria for insomnia ✓ Sleep no more than 6.5 hr per night ✓ Self-reporting that insomnia began or worsened as a result of cancer diagnosis or treatment	To examine the cancer survivors' qualitative feedback about internet-based Cognitive Behavioural treatment for insomnia	1. Behavioural treatment during active cancer treatment phase 2. Completing behavioural treatment earlier 3. Align start of behavioural treatment earlier 4. Interest in passive interventions during active cancer treatment 5. Cancer-specific tailoring 6. Acknowledge cancer experiences are unique
Phillips *et al.*(270) 2019 - *Journal of Cancer Survivorship* - USA - Cancer surgery	Semi-structured interviews & Online Questionnaire	Mobile application	35 patients as an interview subsample 26 patients for the interview (Mean Age: 56yrs)	✓ Aged 18 or older ✓ Diagnosed with stage 1-3 breast cancer within the last 5 years ✓ ≥3 months post-primary treatment ✓ Able to read ✓ Able to write and speak English ✓ Own a smartphone	To explore the breast cancer survivors' preferences for mHealth physical activity interventions	1. Importance of relevance to breast cancer survivors 2. Easy to use 3. Integration with wearable activity trackers 4. Provide sense of accomplishment 5. Variability in desired level of structure and personalisation

				✓ Have access to a computer with Internet		
Nguyen *et al.*(264) 2017 - *Supportive Care in Cancer* - Australia - Cancer surgery	Semi-structured interviews	Wearable (FitbitOne, Jawbone up 24, Garmin Vivofit 2, Garmin Vivosmart, Garmin Vivoactive and Polar A300)	14 post-menopausal breast cancer survivors (Mean Age: 59yrs)	✓ Postmenopausal women diagnosed with stage 1-3 breast cancer ✓ Completed their primary treatment at least 6 months ago ✓ Residing in Victoria, Australia ✓ Able to speak and write fluently in English ✓ Have daily access to a handheld device or personal computer or internet	To explore the acceptability and usability of wearable technology activity trackers amongst post-menopausal breast cancer survivors	1. Trackers' increased self-awareness and motivation 2. Breast cancer survivors' confidence and comfort with wearable technology 3. Preferred and disliked features of WAT 4. Concerns related to the disease 5. Peer support and doctor monitoring
Alberts *et al.*(254) 2018 - *Supportive Care in Cancer* - USA - Cancer surgery	Semi-structured interviews	Internet-based, '*Wellbeing after cancer*' iCBT course	13 Cancer Survivors 10 Providers (Age range: 45-76yrs)	✓ Have partial or complete remission from any type of cancer as long as ≥ 1 and ≤8 months had passed since active treatment	To explore patient and provider perceptions of Internet-delivered cognitive behaviour therapy for recent cancer survivors	1. Aspects of the programme participants liked; "I'm not alone", design and organisation, length and pace, flexibility, privacy and fit, relationship with therapist, course content and associated changes 2. Aspects of the programme participants disliked and/or would improve; Additional information on side effects and conditions, increased flexibility, break up lessons, more directive, difficult to identify dislikes 3. Barriers to completing the programme; finding the time & physical and mental barriers 4. Programme strengths; accessibility, programme features, support after treatment, utility in current work

Gell *et al.*(255) 2019 - *Supportive Care in Cancer* - USA - Cancer surgery	Semi-structured interviews	Combination of wearable technology (Fitbit) and text messaging	19 Cancer Survivors (Mean Age: 56yrs)	✓ A history of a cancer diagnosis ✓ Access to a personal cell phone ✓ Expected completion of the oncology rehabilitation programme ✓ Able to speak and write English	To examine female cancer survivor perspectives on remote monitoring and communication to support independent, physical activity maintenance	1. Accountability to a remote partner; silent partner, physical reminder, watchful eye, encouragement fostering accountability 2. Plan Bs, planning for barriers; overcoming interference, accommodations, problem-solving 3. The habit cycle; social support, positive health effects, reinforcement, tenuous transition – 4. Convenience through technology; accessible, ease, informative 5. Reclaiming the health ownership following a cancer diagnosis; overcoming fatigue, emotional and physical aspects of health, renewing social connections
Kokts-Porietis *et al.*(261) 2018 - *Supportive Care in Cancer* - Canada - Cancer surgery	Semi-structured interviews	Activity tracker (Polar A360)	6 Breast Cancer Survivors (Mean Age: 58yrs)	✓ 18-75 years of age range ✓ Diagnosed with Stage 1-3c breast cancer ✓ Physically inactive (<10,000 steps/day and <60 min of moderate-vigorous intensity physical activity/week) ✓ Completed all adjuvant treatment except for hormonal therapy ✓ Resident of Calgary, Canada	To gain breast cancer survivors' perspectives on participation in a home-based physical activity intervention and the factors that contributed to their acceptance and adherence to physical activity	1. Study environment; arch versus fear of failure, power of results, and reminders of cancer, and moving beyond 2. Influence of people; personal relationships and self as a source of motivation 3. Wearable technology; objective insights into health and disconnect of person and technology
Webb *et al.*(258) 2019 - *Public Health* - UK - Cancer surgery	Questionnaire & Semi-structured interviews	Internet-based, '*Move More Pack*'	17 Cancer Patients (Age Range: 28-80yrs)	✓ Aged 18 or older ✓ Having mixed tumour sites, cancer stages and levels of physical activity	To understand if age, gender, cancer status, or tumour site influences use of an intervention supported by Internet-tools to improve physical activity in UK cancer survivors	1. Capitalising the teachable moment 2. Already moving 3. I am highly active 4. Physical activity is not for everybody
Lally *et al.*(256) 2018	Structured interview for synchronous	Web-based, online	23 Breast Cancer Survivors	✓ First diagnosed with Stage 0-3a breast cancer in one month to 10 years	To obtain rural breast cancer survivors' perceptions of the	1. Quality; time, relevance and trustworthy 2. Usability; navigable and comfortable

- *Oncology Nursing Forum* - USA - Cancer surgery	online focus groups	discussion forums	(Mean Age: 59yrs)	✓ Living in rural counties, which designated to 6 to 9 by the U.S. Department of Agriculture Rural-Urban Community Area (RUCA) Codes or living in a zip code designated as 10.	quality and usability of web-based distress self-management programme	
Zhu *et al.*(269) 2018 - *JMIR mHealth and uHealth* - China - Cancer surgery	Semi-structured interviews	Mobile application, eSupport Programme	13 Breast Cancer Patients (Mean Age: 50yrs)	✓ Had commenced chemotherapy at the study sites after diagnosis of breast cancer ✓ Able to access the internet via a mobile phone ✓ Able to read and write Mandarin	To explore the participants' perception of Breast Cancer e-support programme, its strengths and weaknesses, and suggestions to improve the programme	1. Benefits of breast cancer e-support programme; enhanced knowledge, improved confidence level, improved emotional well-being, received advices from experts, easy to use, easily accessible and convenient 2. Challenges to engagement; physical or psychological health status, stigma with breast cancer, instability of the app 3. Suggested improvement; design improvement, interesting, plain, and practical content, the information being updated more often, quicker responses to women's questions Future direction; breast cancer e-support programme as routine care, open to caregivers and applied to other cancer patients
Hardcastle *et al.*(265) 2018 - *PLOS ONE* - Australia - Cancer surgery	Semi-structured interviews	Wearable technology (Fitbit Alta, Garmin Vivofit 2, Garmin Vivosmart, Polar Loop 2 and Polar A300)	20 cancer Patients (Mean age: 63yrs)	✓ Had completed active treatment for cancer within the preceding five years and deemed to be in remission ✓ Insufficiently physically active ✓ Resided in a regional and remote areas of Western Australia ✓ Had daily access to a handled device or personal computer and internet	To investigate the acceptability of, and preference for, wearable activity trackers amongst non-metropolitan cancer survivors	1. Increasing self-awareness of PA and SB 2. Prompts and feedback 3. Accuracy and registry of activities 4. WAT preferences and features; appearance & functionality

Rosenberg *et al.*(257) 2017 - *American Medical Informatics Association* - USA - Cancer surgery	Semi-structured in-depth interview & Baseline survey	Wearable technology (Fitbit)	26 Prostate Cancer Patients (Mean age: 70yrs)	✓ Having prostate cancer ✓ Able to stand ✓ Able to walk one block ✓ Able to speak and read English	To investigate the acceptability of Fitbit for physical activity tracking within clinical care among men with prostate cancer	1. Wearability 2. Ease of using technology 3. Value in using 4. Barriers to use 5. Priority Fitbit features 6. Attitudes toward integrating Fitbit with care
Puszkiewicz *et al.*(259) 2016 - *JMIR Cancer* - UK - Cancer surgery	Semi-structured interviews	Mobile application	11 Cancer Patients (Mean age: 45yrs)	✓ Aged 18 or older ✓ Diagnosis of breast, prostate, or colorectal cancer ✓ Have finished primary curative treatment ✓ Own an iPhone	To assess the cancer survivors' experiences of using a publicly available physical activity mobile application	1. Barriers to PA 2. Receiving advice about PA from reliable sources 3. Tailoring the app to one's lifestyle 4. Receiving social support from other cancer survivors
Clarke *et al.*(260) 2019 - *BMC Health Services Research* - UK - Cancer surgery	Semi-structured interviews	Online Assessment, prostate cancer online holistic needs assessments	16 prostate cancer patients (Age Range: 61-85yrs)	✓ Have a prostate cancer diagnosis ✓ Able to communicate in English ✓ Under the care of the participating practices	To identify perceived barriers and motivators to implementation and continued use of cancer-specific holistic need assessment	1. Perceived consequences and optimism 5. Perceived value and impact on care (Beliefs about consequences, motivation, optimism)
Lee *et al.*(268) 2016 - *Journal of Rehabilitation Research and Development*	Open-ended questionnaire & Physical assessment Surveys	Virtual reality-based rehabilitation	25 Orthopaedic Patients (Mean Age: 36.4yrs)	✓ More than 4 week had passed since the operation ✓ Can stand independently ✓ Have a normal cognition (Mini-Mental State Examination Score>25)	To explore the perspectives of knee surgery patients regarding virtual reality-based rehabilitation	1. Usability; difficulty, enjoyment, concentration, pain and unity 2. Engagement; goals and feedback

- South Korea - Orthopaedic surgery						
Kairy *et al.*(262) 2013 - *International Journal of Environmental Research and Public Health* - Canada - Orthopaedic surgery	Semi-structured interviews	Tele-rehabilitation	5 Orthopaedic Patients (Age range: 44-72yrs)	✓ Previously received physiotherapy services in the community	To explore patients' perceptions regarding tele-rehabilitation services received post total knee replacement	1. Improving access to services 2. Developing a bond with their therapist while maintaining a sense of personal space 3. Complementing tele-rehabilitation with in-person visits 4. Providing standardised yet tailored and challenging exercise programmes using tele-rehabilitation 5. Perceived ease-of-use tele-rehabilitation equipment 6. Achieving an ongoing sense of support
Argent *et al.*(266) 2019 - *Sensors* - Ireland - Orthopaedic surgery	Semi-structured interview System Usability Scale (SUS) Mobile Application Rating Scale (uMARS)	Wearable technology (type NR)	15 Orthopaedic Patients (Mean age: NR)	✓ Living within 30 km of the hospital ✓ Have no history of cognitive dysfunction ✓ No difficulty understanding English	To evaluate an exemplar sensory-based biofeedback system, investigating the feasibility, usability, perceived impact and user experience of using the platform	1. Usability; Functionality and User Experience 2. Perceived Impact**;** Support and motivation, improving adherence and increasing confidence 3. Suggestions for refinements or additional features**;** additional exercises, measurement of the joint angle, quality score, improved graphical interfaces and gamification
Das and Faxvaag.(267) 2014 - *Interactive Journal of Medical Research*	In-depth semi-structured interviews	Web-based, online discussion forums	7 Bariatric Patients (Mean Age: 60yrs)	✓ Age 18 or older ✓ Basic proficiency in the Norwegian language ✓ Enrolment in a bariatric weight loss programme at the hospital	To explore how individuals undergoing bariatric surgery used the moderated discussion forum and to better understand what influenced their participation	1. Informational support, advice, and guidance 2. Social support and networking among peers 3. Concerns regarding self-disclosure

- Norway - Bariatric surgery						
Atwood *et al.*(263) 2017 - *Health Communication* - Canada - Bariatric surgery	Online forums	Web-based, online discussion forums	1,412 messages, pre-op (n = 822) and post-op (n = 590).	✓ Availability of active forums with daily message posts ✓ Availability of a large number of members and message posts ✓ Public accessibility ✓ The willingness and permission of the website authority or administrator to utilize message posts for this study.	To examine the types of social support found on online bariatric surgery support forums, and the frequency with which these support types are exchanged among forum members	1. Informational support; providing factual information, suggestions or advice, alternative perspectives on a situation, and referrals to additional sources of help 2. Emotional Support; Encouragement, Sympathy and Validation 3. Network Support; Presence, Access, Companions 4. Esteem & Tangible Support; Compliment and Willingness to help
KEY: WAT = wearable activity trackers, iCBT = internet delivered cognitive behaviour therapy, mHealth = mobile health, PA = physical activity, SB = sedentary behaviour, pre-op = pre-operative period (before surgery), post-op = post-operative (after surgery), NR = not reported.						

A total of three main intervention delivery methods were identified across the 18 included studies. These included internet-based interventions (*e.g.,* emails, e-platforms, virtual reality and tele-rehabilitation),(252, 254, 256, 258, 260, 262, 263, 267, 268) mobile phone-based interventions (*e.g.* text messages and smartphone apps),(259, 269, 270) and wearable interventions (*e.g.* activity trackers).(257, 261, 264-266) Only one study reported the use of a combination of two intervention methods (dual-approach), including wearable- and phone-based interventions.(255)

3.3.3 Study quality

Table 6 contains details of the quality appraisal conducted using the CASP tool for qualitative studies. Of the included studies, Shaffer *et al.*,(252) Phillips *et al.*,(270) Alberts *et al.*,(254) and Argent *et al.(266)* were identified as having the highest quality. The main area in which the studies were typically lower in meeting the quality criteria concerned the question 'have ethical issues been taken into consideration?'; many of these studies lacked the inclusion of an ethical approval statement within their work.(256-258, 262, 265, 268, 269) Furthermore, some studies also lacked the required information to answer the question 'was the recruitment strategy appropriate to the aims of the research?' One study in particular, by Attwood et al., did not provide any information about selection or inclusion eligibility for the recruited participants.(263)

3.3.4 Findings: Reporting outcomes, synthesising translations, and developing themes

Table 7 presents metaphors and patient perspectives from each of the included studies. Reciprocal translation and refutation of these enabled the development of four overarching themes and sub-themes as a result of the synthesis from this meta-ethnography. The four overarching themes and sub-themes appear to be key in understanding and determining the effectiveness of digital and mobile health interventions to support behavioural change in surgical patients. These are further demonstrated diagrammatically in Figure 4.

The effectiveness of digital health technologies to support behavioural change in surgical patients has been reported through four themes synthesised by this review. All four themes consider the technology’s ability to: (1) provide motivational support, (2) address patient engagement, (3) facilitate peer networking, and (4) meet individualised patient needs.

Table 6: Quality appraisal

Author & Year	Critical Appraisal Skills Tool Screening Questions										Comments
	1. Was there a clear statement of the aims of the research?	2. Is qualitative methodology appropriate?	3. Was the research design appropriate to address the aims of the research?	4. Was the recruitment strategy appropriate to the aims of the research?	5. Was the data collected in a way that addressed the research issue?	6. Has the relationship between researcher and participants been adequately considered?	7. Have ethical issues been taken into consideration?	8. Was the data analysis sufficiently rigorous?	9. Is there a clear statement of findings?	10. How valuable is the research?	
	Yes/No/Can't tell										
Shaffer *et al.* (2019)(252)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Philips *et al.* (2018)(270)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Nguyen *et al.* (2017)(264)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Can't tell	**Q10** – Unclear presentation of how the findings could be transferred to other populations or other ways the research may be used.
Alberts *et al.* (2017)(254)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Gell *et al.* (2019)(255)	Yes	Yes	Yes	No	Yes	Yes	Yes	Can't tell	Yes	Yes	**Q4** – No explanation why the selected participants were the most appropriate.
Kokts-Porietis *et al.* (2019)(261)	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	**Q4** – No discussion around why some participants chose not to take part in the qualitative study.
Webb *et al.* (2019)(258)	Yes	Yes	Yes	Yes	Yes	Yes	Can't tell	Yes	Yes	Can't tell	**Q7** – Lacking details of how the research was explained to participants. **Q10** – No specification on new areas where research is necessary.
Lally *et al.* (2018)(256)	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Can't tell	**Q7** – No statement around approval of the ethics committee to assess whether ethical standards were maintained.

											Q10 – No report of new areas where research is necessary and whether the findings can be transferred to other populations.
Zhu *et al.* (2018)(269)	Yes	Yes	Yes	Can't tell	Yes	Yes	No	Can't tell	Yes	Yes	**Q4** – Unclear discussion around the recruitment. **Q7** - No statement around approval of the ethics committee. **Q8** – Only two quotations were reported for each subthemes, so there is insufficient data presentation.
Hardcastle *et al.* (2016)(265)	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	**Q7** - No statement around approval of the ethics committee to assess whether ethical standards were maintained.
Rosenberg *et al.* (2017)(257)	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	**Q7** – No statement around approval of the ethics committee or whether the research was explained to the participants for the reader to assess whether ethical standards were maintained.
Puszkiewicz *et al.* (2016)(259)	Yes	Yes	Yes	Yes	Yes	Can't tell	Yes	Yes	Yes	Yes	**Q6** - Unclear if the researcher critically examined their own role, potential bias and influence during formulation of the research question.
Clarke *et al.* (2019)(260)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Can't tell	Yes	Yes	**Q8** – Thematic analysis is used, however it is unclear how the categories/themes were derived from the data.
Lee *et al.* (2016)(268)	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	**Q7** - No statement around approval of the ethics committee for the reader to assess whether ethical standards were maintained.

											Q8 – Insufficient data presentation to support the findings (small sample size). **Q9** – Inadequate discussion around the qualitative analysis.
Kairy *et al.* (2013)(262)	Yes	Yes	Yes	Yes	Yes	Can’t tell	Yes	Can’t tell	Yes	Can’t tell	**Q6** – Unclear if the researcher critically examined their own role, potential bias and influence during formulation of the research question. **Q7** – The researchers have stated the study was approved by the appropriate ethics review board, but the name of the committee was not specified. **Q8** – Small sample size, therefore the findings cannot be generalised. **Q10** - The researchers have not reported any new areas where research is necessary and whether or how the findings are transferable.
Argent *et al.* (2019)(266)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	
Das *et al.* (2014)(267)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Can’t tell	Yes	Can’t tell	**Q8** – Small sample size, therefore findings cannot be generalised. **Q10** – The study is limited to one discussion forum for bariatric surgery patients, and the results cannot be transferred to other patient population or other health forums.
Atwood *et al.* (2018)(263)	Yes	Yes	Yes	No	Yes	Yes	No	Can’t tell	Yes	Yes	**Q4** – No information regarding the selection or the inclusion criteria of the participants. **Q7** - No statement around approval of the ethics committee for the reader to

											assess whether ethical standards were maintained. **Q8** – Messages analysed are from one publically available online support forum for individuals who have undergone RYG, thus the findings cannot be generalised.

Table 7: Determining how the studies are related – common metaphors and perspectives from the included studies that led to the development of the four overarching themes and sub-themes.

Study	1. Providing motivational support	2. Addressing patient engagement	3. Facilitating peer networking	4. Meeting individualised patient needs
Shaffer *et al. (252)*				When to offer DHT intervention vs. when not to offer, what to include vs. what not to include, appropriate tailoring.
Phillips *et al. (270)*	Provide sense of accomplishment, personal motivation, goal-setting, reward behaviours.	Easy to use, simplistic design.		Importance of tailoring information (relevance to breast cancer survivors), content specificity to intended patient cohort, integration of DHT with wearable technologies, structure and personalisation of DHT,
Nguyen *et al. (264)*	Self-awareness and motivation, personal goal-setting, value of HCP monitoring to drive motivation.	Importance of building confidence with technology, comfort affects engagement with wearable DHTs.	Peer support, helping each other.	Tailoring to concerns relating to specific disease or treatment, preferred and disliked features,
Alberts *et al. (254)*	Personal support, 'starting to realise' motivation, awareness, value of HCP monitoring to drive motivation.	Simplicity, important to feel relaxed whilst using, desire to engage, recognised accessibility and availability of DHTs.	Peer support, 'I'm not alone' in experiences, shared coping techniques and support.	
Gell *et al. (255)*	Reclaiming health ownership, source of personal support, support to overcome challenges and stay on track, creating a habit cycle.	Convenience of use.		
Kokts-Porietis *et al. (261)*	Self as a source of motivation, personal responsibility, but caution in case of 'over-motivating' turning into technology as a source of judgement	Offering objective insights into personal health, usability.		Improvements, suggestions to improve study environment and DHT intervention.

	(disconnect between person and tech).			
Webb *et al. (258)*	Personal motivation and responsibility to keep moving, capitalising on teachable moments, motivation and responsibility, awareness of responsibility of not exercising.			
Lally *et al. (256)*		Easy to navigate, search tools, comfort and ease with the online discussion tool.	Relevant information shared from peer support.	When to start, reflections about initiation and expected engagement, tailoring to the specific needs of patient cohort.
Zhu *et al. (269)*	Supported through readily accessible information from HCP, tailored expert advice to support.	Stigma of breast cancer can affect engagement – not using due to reminding them of the disease, instability of the app (app failure and inaccurate measurements of activity resulted in lack of engagement, users 'gave up' with logins).	Improved confidence and well-being.	Specific information for disease and surgery type, keep learning/education focused for patient cohort, individually tailoring content and amount of information (not too much if unwell), suggested improvements,
Hardcastle *et al. (265)*	Motivation from DHT prompts and feedback, personal motivation and responsibility.	Recognised inaccuracies with registering activities, not trustworthy.		Preferences and features, preferred style and acceptability.
Rosenberg *et al. (257)*	Finding value in moving, personal motivation, recognising benefits of tracking, attitude to integrating DHT interventions in care, support through data-sharing.	Ease of using DHT, simple, ease to synchronise, wearability of activity trackers, recognised barriers to use (not accurately measuring activity), lack of trust in measurements or total values.	DHT intervention features enabling peer support and motivation	
Puszkiewicz *et al. (259)*	Supporting participant motivation to seek information, weekly reminders to keep motivated,		Social support from other cancer survivors, peer-support.	Tailoring to specific disease states, tailor the app to an individuals' lifestyle.

	receiving advice from reliable sources.			
Clarke *et al. (260)*	Recognised benefits through connectivity with HCPs, supported information-seeking behaviours.			
Lee *et al. (268)*	Engagement as motivation in goal-setting, motivation from feedback.	Avoidance of complex/difficult DHTs, desire for enjoyment with use.		
Kairy *et al. (262)*	Achieving a sense of support through connectivity and information provision, developing a bond with their therapist,	Standardised, easy, simple to use, DHT improving access to services and advice.		Integration into care pathways, complementing DHT intervention with in-person visits,
Argent *et al. (266)*	Perceived impact through improved adherence and motivation to exercise.	Simplicity, easy to use.		Refinements, suggestions for improvement and added features.
Das and Faxvaag. (267)			Social support and networking, providing advice/giving advice to others in the same position, encouragement, sharing experiences, purpose.	
Atwood *et al. (263)*	Emotional support from others like you to keep you motivated, validation and sympathy of experience.		Informational support from peers, dietary advice, advice on personal experiences, medication advice, network support, emotional support, sharing the experience ('journey'), building self-esteem, willingness to help others going through the same, validation and sympathy of experience.	
Key: DHT = digital health technology, HCP = healthcare professional.				

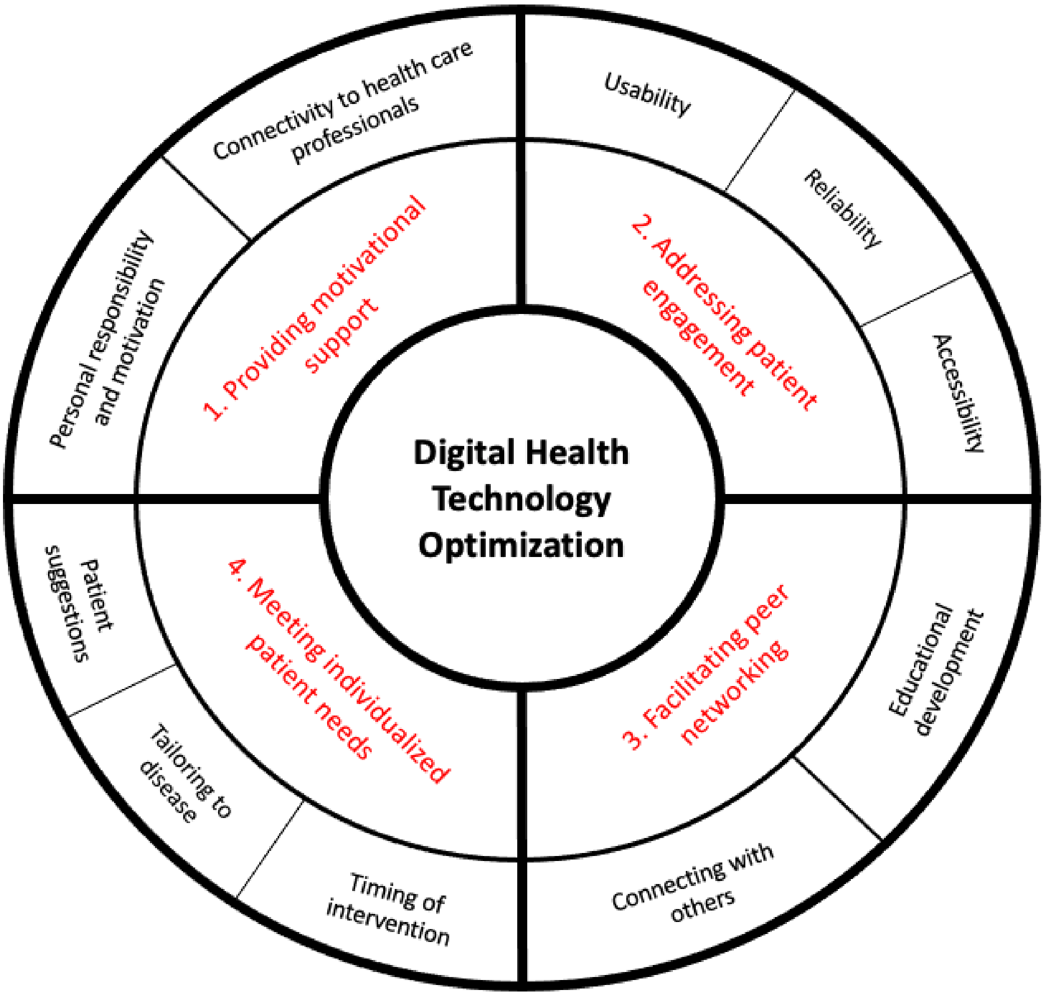


Figure 4: Developed themes and subthemes for Digital Health Technology optimisation. The inner band on the diagram (red text) represents the four overarching themes developed by this review, and the outer band details the subsequent subthemes.

The qualitative data synthesis can be found in Tables 8-11, with each table representing one of the four themes. These tables showcase examples of direct quotations (first order constructs) from study participants, the authors' interpretations of the original findings from the included studies (second order constructs), and our interpretations (third order constructs), which result in the overarching themes and sub-themes.

3.3.5 Providing motivational support

The initial theme developed centres on the ability of the technology to provide motivational support to the patient, as the end-user. When further explored, this theme can be sub-categorised to consider *how* this motivational support can be provided and achieved; with the sub-themes of 'personal responsibility and motivation' (*i.e.,* as a form of intrinsic motivation for patients) and 'connectivity to healthcare professionals' (*i.e.,* as a form of extrinsic motivation). The data synthesised for this theme is demonstrated in Table 5.

Personal responsibility and motivation

Certain features of digital and mobile health technologies increased patient self-awareness and motivation for physical activity. Patients reported that wearable activity trackers (termed wearables) made them more aware of their physical activity levels, as well as levels of sedentary behaviour. In turn, the activity trackers were perceived to be a source of intrinsic motivation that caused the participant to be more engaged with positive behaviour change.(257, 261, 265) Participants described the use of self-regulatory features of the wearables, including goal-setting and performance feedback, as beneficial. In making progress and achieving goals, participants described the technology as facilitating their personal fulfilment. In particular, the wearable technologies provided orthopaedic and cancer surgical patients with a sense of control and accomplishment over physical outcomes within their surgical pathway.(264-266, 268) Participants discussed tracking and planning ahead in order to achieve goals, providing them with an increased sense of personal responsibility over their post-surgical progress.

> *"Seeing your progress, I think is very important. Seeing measurable progress, whether it's in calories burned, or minutes, or meeting a percentage of your goal".*(270)

> *"set goals, like mid-week if I wanna hit 150 [minutes] I should be at half that […] and the application is on my phone and I can see what I've done […] so it's really easy to track how well you're doing or how well you're not doing."(261)*

Feedback from the technology was also perceived as important. Participants described feedback as a method of encouragement, motivation and support; this could be in the form of written text messages or notifications from the technology.(270) Gell *et al.* noted that health coaching, when offered alongside daily wearable use, provided cancer patients with increased sense of personal importance. In addition, the authors described that continued feedback over the course of the post-operative period could encourage the maintenance of physical activity and positive health behaviour outcomes.(255)

"If you get to say 8000 [steps] in a day, you're motivated to do those extra 2000 because you're so close. It's like "Why would I stop now?" I might as well keep going."(264)

However, in their study, Kokts-Porietis *et al.* advised caution when it came to providing feedback and reminders to participants.(261) The authors reported the potential for this continued engagement to shift from encouragement and support, to 'fear of failure' if participants were non-adherent with prompts or failed to achieve their goals. Instead, the authors recognised that prompts or reminders intended to motivate, could turn into having negative judgments or evaluations if a person was unable to fulfil them.

"for now, I don't wanna [sic] be judged or evaluated or anything else… and then that will change…It's just a case of you get tired of [judgment]"(261)

Connectivity to healthcare professionals

As well as influencing their intrinsic motivation levels, participants described the role of digital technologies as providing a source of extrinsic motivation too. Patients undergoing bariatric surgery reported an increased feeling of accountability and responsibility to adhere to treatment plans if they were monitored by their health professional team, through digital or mobile health technologies.(267, 271) Cancer and orthopaedic surgical patients reported benefits of enhanced connectivity to clinicians and their clinical team, including the provision of timely and personalised feedback from members of the multi-disciplinary team (260, 269) and the potential for instant communication for information-seeking needs.(262, 269) A lower threshold for information seeking *via* digital technologies was reported by bariatric surgical patients, with sensitive questions being asked more readily.(267) Das *et al.* evaluated the impact of an online forum on interactions between healthcare professionals and patients undergoing bariatric surgery.(267) The authors recognised that the connectivity allowed for easier access to evidence-based advice, as well as offering a convenient and geographically-independent platform to promote patient engagement and offer connectivity to healthcare professionals.

"I could ask questions through the app regarding my medical condition. I could upload the lab results through your program. Then I received corresponding advice from experts. I felt followed up. When I knew more about my medical condition, I felt more likely to gain control of my life."(269)

"I live far away from the hospital and I have no doctor close to me. When I had questions about my medical condition, I could not find the answer in the internet. Then I asked questions through the app. Aha, the professor or expert responded."(269)

Whilst this increased connectivity with healthcare professionals was reported as beneficial in supporting post-operative recovery, cancer patients still felt that technologies should not replace traditional face-to-face appointments with clinicians. Concerns were raised specifically by this cohort in relation to the importance of in-person follow-up appointments. Patients reported that they may miss out on vital interactions, like displays of empathy, which are important for their underlying diagnosis and which come best from face-to-face communication.

Table 8: Theme 1: Providing motivation and support

Synthesised themes (third order constructs)	Sub-themes	Second order constructs: the authors interpretations of the original findings	First Order constructs: examples of direct quotations from the participants of the study
PROVIDING MOTIVATIONAL SUPPORT	***Personal responsibility and motivation***	Being accountable to text messages and Fitbit motivated the patients to be physically active and alternative exercise options identified through the interaction with health coach, which helped patients to increase confidence. (Gell *et al.*, 2019)	*"I did feel accountable because of the text that came in. So, I think that was definitely a motivator for me…"*
			"I always had a back-up plan…the coach – when we discussed at the beginning of the program, she was asking me, "what other things would you do if you could not do that exact exercise. So, that's when we discussed, oh I've got tapes or if I get bored with the treadmill, or if I want to do something else, so I got the exercise tapes that I can do."
			"I know it's good for me, makes me feel better and it certainly mentally makes me feel better, I'm much happier when I exercise."
		Cancer survivors liked the idea of an app keeping them accountable and oriented towards the goal. Being rewarded via positive feedback and encouraging messages also provided a sense of accomplishment. (Phillips *et al.*, 2019)	"*Seeing your progress, I think is very important. Seeing measurable progress, whether it's in calories burned, or minutes, or meeting a percentage of your goal."*
			"I like the idea of positive feedback wherever the source. I think that's super huge for anyone and especially for survivors because after you have cancer you are always a little bit like how is everything in there?"
		Clear and achievable goal, represented by the specific number of steps was the most significant motivation for the participants. (Nguyen *et al.*, 2016)	*"If you get to say 8000 [steps] in a day, you're motivated to do those extra 2000 because you're so close. It's like "Why would I stop now?" I might as well keep going."*
		The program provided a sense of support and improved the patient's ability to cope with difficulties, such as fear of cancer recurrence. (Alberts *et al.*, 2018)	*"And in all fairness, I will tell you right now, my anxiety levels are through the roof. And I am using every one of your magical steps in the program, because… I have found another lump…So you know again I have tools now, to keep me a little calmer."*
		Since adhering to self-tracking increased the physical activity and motivation, some patients expressed falling short of physical activity goals perceived as failing to achieve one's best self. (Kokts-Porietis *et al.*, 2019)	*"Helps with your mental capacity of how to take it and control it […] I think the more active you are, the less you think about 'Am I gonna live, am I gonna die?'"*
			"Started to enjoy exercise again and felt better […] mental health wise."

			"for now, I don't wanna be judged or evaluated or anything else…and then that will change…It's just a case of you get tired of [judgement]"
		Cancer survivors who are in the early stage of the disease found the intervention more useful in comparison to those experiencing particularly harsh consequences of treatment. (Webb *et al.*, 2019)	*"[The Move More Pack] gave me ideas about different activities I could participate in and where and how to access them. It is a good reminder…and you can keep a record of personal activity. I like the goal-setting and the tips."*
			"When I was going through my chemo I tried to keep as active as possible and I could see even that was helping me. And then radiotherapy, because people said, oh it makes you so, so tired, and yes it did but if you can push through that tiredness it makes you feel so much better."
			"My health is not good… I have been diagnosed with polymyalgia which makes me tired and in constant pain. My involvement in any exercise is practically nil."
		Wearable activity trackers provided continuous self-monitoring and personalised feedback, thus increased self-awareness towards physical activity and sedentary behaviour were observed amongst the patients. (Hardcastle *et al.*, 2018)	*"they motivated me…made me very aware of how much I'm moving and that I need to move more"*
			"Quantitative data are good because you're reminded that you're not meeting your targets…if set at 10,000 and you get 7,000 for a couple of days then maybe you could get direct messages, bit of a psych talk…automated but make it personalised, you missed your target for a few days rather than saying Move!"
		Participants expressed increased activity levels with Fitbit use and also improved motivation to achieve daily step counts. (Rosenberg *et al.*, 2017)	*"I think I like to make sure I'm doing some minimal amount of activity. And it's kind of fun to see what you 've been doing, how many steps you've done, how many miles you've gone."*
			"I like it. I mean, it gives me weekly updates. Every now and then we'll challenge our daughters because the whole family has one now. We bought them for them, too. So we 'll do a challenge every now and then, and I'll try to kick butt."
		Having the specific goal in the game motivated the participants to achieve their daily physical activity levels. (Lee *et al.*, 2016)	*"Having the specific goal of putting the ball in the hole made me interested in the game."*

		The use of wearable sensors offered a biofeedback in support of the home-exercise programme thus increasing the adherence to the rehabilitation programme, following the orthopaedic surgery. (Argent *et al.*, 2019)	*"It kept me doing physio when I might not have done it at home, especially with various things that have been happening at home. So it kept me doing physio and made sure I did it every day."*
	Connectivity to healthcare professionals	Involvement of the healthcare professionals, such as answering queries and providing timely feedback upon patients' needs optimised efficacy on information delivery and reinforced the engagement with the application. (Zhu *et al.*, 2018)	*"When I faced with something I didn't know, I was so anxious. But my doctor was very busy and he had no time to communicate with me. After I joined your program, I could ask questions through the app regarding my medical condition. I could upload the lab results through your program. Then I received corresponding advice from experts. I felt followed up. When I knew more about my medical condition, I felt more likely to gain control of my life."*
			"I have no difficulty in using the app. I live far away from the hospital and I have no doctor close to me. When I had questions about my medical condition, I could not find the answer in the internet. Then I asked questions through the app. Aha, the professor or expert responded. Sometimes they gave me quick feedback. Sometimes, they answered my questions the next day. Yes, we can also make our judgement, but we are not sure at that time. The response from the expert provided me the direction. I believe this is the strength of the app."
		Participants expressed willingness to share their Fitbit data with healthcare providers to be able to discuss their activity levels and receive advice. (Rosenberg *et al.*, 2017)	*"That would be fine with me. I think if it would help a physician or someone understands how you 're doing, there would be no problem with that."*
		The online prostate cancer-specific holistic needs assessment facilitated an opportunity to raise unmet needs that were beyond routine clinical questioning and comforted patients by extra focus from healthcare professionals. (Clarke *et al.*, 2019)	*"…it was a reinforcement of the things that I already had available to me and it was a comfort to know …that I'd got reliable medical people …available to help me if I needed it…"*
		The participants expressed the information on upcoming steps and appointments provided by telerehabilitation technical support team was clear and the	*"They had told me that it would be this way (…). So being advised, you know, you're ok. (…) This way, being advised of the date, that the beginning of the treatments will be on such and such a date. And having the little*

		ongoing communication helped the development of relationship and trust between the patient and therapist. (Kairy *et al.*, 2013)	*handouts that said which exercises to do, well then ultimately, it was positive regardless. We say well we're heading in, in the right direction… to recuperate."*
			"…we talked about fishing, we talked about hunting, (…) we talked about skiing, hum, of all sorts of things, while I was doing my exercises, we talked about anything and we always had something to say. I think that she knew my whole life (laughter) (…)"
		The online forum provided an ease for patients who experience difficulties in making direct contact with the professionals due to personal barriers. (Das and Faxvaag, 2014)	*"I think it is very positive that you can ask questions that are conveyed to a dietician or a doctor because I must admit that picking up the phone and asking someone is very challenging. That barrier–I think it is difficult. What if it's only me? How ridiculous! You get that feeling. Then, it is easier to write online."*

3.3.6 Addressing patient engagement

This theme concerns the potential factors that can impact a patient and their engagement with a digital health technology. Several factors were discussed as influencers in engagement across the included studies and, as a result, these were sub-categorised in this meta-ethnography into 'usability', 'reliability' and 'accessibility' sub-themes. The data for this theme is synthesised in Table 6.

Usability

Simplicity and ease of use were identified as prerequisites for effective engagement with digital health technologies in cancer and bariatric studies.(254, 256, 257, 261, 262, 266, 270) Patients in these studies reported the importance of feeling relaxed and at ease whilst using technology.(254) In addition, it was deemed important that the intervention designers avoided complex or difficult user-interfaces, which could minimise engagement with the technology.(268) Specifically, references were drawn to the ease of use by participants who had undergone cancer surgery (or associated cancer treatments, like chemotherapy), where keeping the intervention design as simple as possible supported user interactions.

"Well it was very simple. It was straightforward. It wasn't complicated…like going through chemo you have kind of a brain scramble and… just the simplest things you can't wrap your brain around sometimes."(254)

"I would say the most important thing is the ease of use, the simplicity of it, because if it's cumbersome I will not use it."(270)

Not only was usability seen to encompass the use of the device (for instance, the user navigating the platform and engaging with the interface), it was also found to include the synchronisation of technologies in setting up, charging and updating them. Participants undergoing cancer surgeries reported that they encountered technical difficulties while operating and synchronising devices. When recovering from a cancer procedure, and also likely to undergo associated cancer treatment like chemotherapy, simplistic usability was felt to be important. In turn, these experiences negatively affected rates of user engagement.(257, 264, 269)

"Largely, I'm not wearing it because it doesn't interact with my computer very easily…why bother? I just go use my manual step counter."(257)

When specifically considering wearable technologies, the usability was also seen to extend to the 'wearability' of the device. References were made which concerned the wearability, comfort and style of the device. Participants were critical of many aspects including the device's weight and whether they found the technology comfortable to wear at various times of day. Consequently, wearability factors were seen to influence usability and user-engagement before and after cancer and orthopaedic surgery.(264-266)

"I didn't like wearing it at night. I didn't feel comfortable."(264)

"I had the Polar first […] I thought it was quite heavy and quite clunky but then I had the two Garmins and in the end I decided that was my favourite even though it was heavier."(264)

Reliability

Another factor that influenced participant user-engagement was the perceived reliability of the digital technology being used. Across the various studies, participants recognised and reported the inaccuracies of devices that were being trialled.(257, 265, 269) The inaccuracies included incorrectly measuring movements of the wearables, for instance logging wrist movements as exercise,(257) and being able to track certain forms of exercise, but not others, for instance swimming.(265) In addition, participants in one study reported an inability to track all of the movements involved in an exercise session, leading to the technology under-recording a person's physical activity.(257) This resulted in a perceived lack of reliability and lack of trust in the technologies, consequently, leading to poorer adherence to post-operative physical activity guidance by some participants.(257, 265, 269)

"It seemed to register less activity than I felt I actually did because it was only measuring steps, and I was doing more than steps. I was lifting. I was bending. I was twisting. I was doing all that other sort of stuff."(257)

One participant also reported reduced reliability in the installation and usage of technologies. In the study by Zhu *et al.*, one user reported that the app failed to open when trying to use it, despite reinstalling it and seeking technical support; this resulted in poor engagement rates with the intervention.

"The app sometimes was unstable. It didn't work when I tried to open it. I contacted with someone in the hospital and reinstalled the app. Then I could log in. However, after a period of time, I couldn't open the app again. Finally, I gave up using your program. I haven't log in for the recent month".(269)

Accessibility

Bariatric, cancer and orthopaedic surgical cohorts in this study perceived that digital health technologies offered improved accessibility to health information. In particular, this was reported by those patients who were geographically, economically, or functionally isolated.(254, 256, 262) In addition, digital interventions were noted to reduce the time and cost of travel to clinics, which was reported to be an advantage over facility-based interventions.(254, 262)

"I really like it (telerehabilitation). I found it fantastic…you know, just the fact of not having to travel when we are in pain (…) I adored it."(262)

"Well, definitely the availability of it to anybody, no matter where you live. I know we work with a lot of rural people and after they're done here, they don't want to travel for more therapy or whatever, so something that they can do at home."(254)

Table 9: Theme 2: Addressing patient engagement

Synthesised themes (third order constructs)	Sub-themes	Second order constructs: the authors interpretations of the original findings	First Order constructs: examples of direct quotations from the participants of the study
ADDRESSING PATIENT ENGAGEMENT	***Usability***	Although most patients found Fitbit easy to wear and comfortable, variation identified regarding perceived ease of use. While syncing the device, some patients experienced technological barriers and some found it easy to use. (Rosenberg *et al.*, 2017)	*"Once I put it on in the morning I was totally unaware of its presence on my body or in my pocket*."
			"Every day or two I sync it. I download it to Fitbit application for my iPhone and so every day or two I sync it. And then I just sort of look at the information there … It's very easy. The Fitbit application is very — I think the term is user friendly."
			"Largely, I'm not wearing it because it doesn't interact with my computer very easily…why bother? I just go use my manual step counter."
		Patients liked the design and organisation of the programme, which expressed as simple and straightforward. (Alberts *et al.*, 2018)	*"Well it was very simple. It was straightforward. It wasn't complicated…like going through chemo you have kind of a brain scramble and… just the simplest things you can't wrap your brain around sometimes."*
		Patients expressed the simplicity is the key for the adherent engagement with the application. (Phillips *et al.*, 2019)	*"I would say the most important thing is the ease of use, the simplicity of it because if it's cumbersome I will not use it."*
		Self-monitoring through the wearable allowed patients to track their step counts and increased convenience through technology. (Gell *et al.*, 2019)	*"It's very easy to use… It's something fun for me to do, to look at where my day ended yesterday and whether I was on target or needed to refocus a bit."*
		The correct balance between the task difficulty and personal skill levels identified as prerequisite for the continuous engagement with the intervention. (Lee *et al.*, 2016)	*"The level of challenge was suitable for me, so I got a good score."*
			"I found it difficult to understand how to perform this exercise."
			"I sensed a lack of unity between my movement and that of the virtual character, so I got a bad score; this made me lose interest in the game."
		Patients reflected a positive reinforcement of self-tracking with ease of using the wearable technology. (Kokts-Porietis *et al.*, 2018)	*"set goals, like mid-week if I wanna hit 150 [minutes] I should be at half that […] and the application is on my phone and I can see what I've done […] so it's really easy to track how well you're doing or how well you're not doing."*

		Some patients encountered technical difficulties while operating the tracker and application, whereas some expressed confidence and comfort of using the intervention. (Nguyen *et al.*, 2017)	*"Once I understood how it worked, it was easy, you know you hit sync on this, open the app and little whirly twirly things happened and it spat out the findings so"*
			"I am a bit old school I don't think the experience [using the tracker] would make me necessarily go out and buy one. If I felt I was reasonably active doing what I do, in my normal daily activities, I would probably be happy with that, but then I tend to ignore technology if I can."
		The usage of the program reduced due to some patients experiencing technological difficulties and stigma with breast cancer which acted as a perpetual reminder of their disease. (Zhu *et al.*, 2018)	*"If I told my friends that I had breast cancer, they would reject me. I had such experience...They perceived me as a different person. How can I have the courage to tell people about my disease? I do not want to touch the topic of "breast cancer". I've tried to put it behind me...Using this program, reading and chatting, it constantly reminds me of my illness. I need to be done with it."*
			The app sometimes was unstable. It didn't work when I tried to open it. I contacted with someone in the hospital and reinstalled the app. Then I could log in. However, after a periods of time, I couldn't open the app again. Finally I gave up using your program. I haven't log in for the recent month."
		Regardless the perceived literacy with technology, most patients found the intervention easy to use. (Argent *et al.*, 2019)	*"Initially I said to you I wasn't very computer literate but it's very simple to use. Once you do it once or twice you can do it with your eyes closed essentially."*
		The visual instructions of the application helped patients to feel confident about how to perform the exercises correctly. (Puszkiewicz *et al.*, 2016)	*"[The visuals] were really good because [they] showed you how to do everything and you felt confident that you are doing it right."*
		Patients found the programme easy to navigate and comfortable, meeting their expectations and needs. (Lally *et al.*, 2018)	*"It just took a moment to log-in and navigation was speedy!"*
			"I like that the color scheme was NOT pink!"
		Patients expressed positive feelings about ease-of-use and usefulness of the program. (Kairy *et al.*, 2013)	*"I installed the things I needed. Like that, all my bicycle, and hum... my step. I installed that and it went well. Look, it took 2 min."*

	Reliability	The instability of the application reduced the patient's reliability to continue engage with the intervention. (Zhu *et al.*, 2018)	*"The app sometimes was unstable. It didn't work when I tried to open it. I contacted with someone in the hospital and reinstalled the app. Then I could log in. However, after a periods of time, I couldn't open the app again. Finally I gave up using your program. I haven't log in for the recent month."*
		The inaccuracy of the statistics and inability of recording the other activities led to disappointment in patients. (Hardcastle *et al.*, 2018)	*"My hand was moving for a couple of minutes, it thought I was running."*
			"It doesn't take into account other exercise like swimming"
		The activity tracker failed to capture important daily living activities which identified as a barrier in terms of engagement with the intervention. (Rosenberg *et al.*, 2017)	*"So I'll give you a case. I filled my laundry, and it's logged I walked 2,000 steps. I did not walk 2,000 steps."*
			"I guess the only surprise was that it seemed to register less activity than I felt I actually did because it was only measuring steps, and I was doing more than steps. I was lifting. I was bending. I was twisting. I was doing all that other sort of stuff."
	Accessibility	The elimination of the transportation time mentioned as predominant benefit of the tele-rehabilitation for both the patient and therapist. (Kairy *et al.*, 2013)	*"I really like it (tele-rehabilitation). I found it fantastic…you know, just the fact of not having to travel when we are in pain (…) I adored it."*
		The availability of the program to the individuals in rural areas reduced the clinic visits. (Alberts *et al.*, 2018)	*"Well, definitely the availability of it to anybody, no matter where you live. I know we work with a lot of rural people and after they're done here, they don't want to travel for more therapy or whatever, so something that they can do at home."*

3.3.7 Facilitating peer networking

This theme specifically concerns the ability of digital technologies to facilitate peer networking. This has been further sub-categorised to consider the impact of peer-peer connections on a person's 'educational development' and why this can provide support during their surgical pathway, and the ability to enable 'connecting with others' going through the same surgery so that peer-connections can be formed. The data synthesised for this theme is demonstrated in Table 7.

Educational development

By building a peer network, digital and mobile health technologies were viewed as a strategy to provide patients with enhanced access to health information, knowledge and support. In turn, patients reported feeling motivated to change their health behaviours to improve their surgical outcomes. For instance, forums and comment boards that were integrated within the technology platform facilitated peer discussions and networking. In this way, informational support could be delivered by peers, to peers. This was perceived as useful and relatable by those undergoing bariatric and cancer surgeries. Various exchanges between peers, such as the sharing of personal anecdotes and advice following bariatric surgery, were seen to improve patient satisfaction and their surgical experience.(263) In addition, participants described peer-education in the form of educational 'hints and tips' as reassuring when hearing from others who have experienced the same journey.(263) Strategies that addressed the pre-operative concerns and the challenges of adhering to surgery guidelines were also shared by patients.(256, 263, 267) Participants were seen to share recommendations on dietary products and even provide advice on using a tablet crusher for large tablets in order to make medicines-taking easier following bariatric surgery.

> *"[Product name]… this is odourless and tasteless and does not clump. You can add it to hot or cold… or just sprinkle over your food. One tablespoon equals a scoop of Whey and has 30 grams of protein. It is approved by [Medical Association] and has 96% absorption…"(263)*

"… You may want to pick up a pill crusher and a pill splitter in the drug store. The large pills such as calcium citrate, I had to crush and mix with drink in order to take them…"(263)

One participant in the study by Das *et al.* discussed seeing peer-education as a strategy that kept them accountable for their recovery.(272) Being able to obtain informal feedback on their diet and mindset was regarded as useful and enjoyable. They did this in the form of a post within an online forum, created specifically for those post-bariatric surgery. In this way, other peers were able to read the content, as well as comment with their suggestions and opinions.

"I think it is more enjoyable to write a "diary" that everyone can read and comment on. I like to get feedback on how I do things, what I eat, and thoughts that I have about the surgery and about life after the operation, so here comes a little of everything…Hope you will read and comment."(267)

Connecting with others

As well as facilitating the provision of informational support, digital and mobile health technologies and online forums also acted as a way of delivering emotional support to patients. Enabling the functionality which allowed surgical patients to communicate with others, rather than a medical professional, was seen as beneficial. Studies referred to the psychological benefits of cancer patients communicating with others who have had the same surgical procedures or experience with the same disease-related condition.(254, 256, 264)

"I feel better to talk to someone who is in similar situations. Cancer is not a good thing. If I always think about breast cancer alone at home, it is so easy for me to feel bad. I didn't feel alone when I talked with peers through your program."(269)

This form of peer interaction helped participants to overcome their feelings of loneliness, as well as giving them a sense of validation in how they were feeling following the diagnosis of cancer and the surgical procedure they had undergone. Improvements in individual mental wellbeing was reported in studies by Zhu *et al,* Alberts *et al.* and Puszkiewicz *et al*.(254, 259, 269)

"You know that you're not alone, but when your feelings are validated just by reading someone's story, I mean that is everything."(254)

In pre-operative peer forums, messages were perceived as sources of encouragement and motivation. In particular for bariatric surgical patients, encouragement was offered to lose weight and adhere to physical activity and dietary guidelines prior to surgery.(256, 263) For cancer surgical patients, a similar form of encouragement was provided in forum-based messages, however these focused on motivating physical activity in the post-operative period instead. (256, 259, 264, 269)

"It is so important to get in touch with people who went through the same thing as you have. […] I think that if an app for cancer survivors had a forum on it as a part of the application to motivate each other, that would be amazing."(259)

"You do need that bit of motivation from other people. It's all about motivation when it comes to exercise […]. When you feel low and can't be bothered to go for a walk, maybe someone else saying 'go on, get up and do it, you can do it' would motivate you." (259)

Table 10: Theme 3: Facilitating peer networking

Synthesised themes (third order constructs)	Sub-themes	Second Order constructs: the authors interpretations of the original findings	First Order constructs: examples of direct quotations from the participants of the study
FACILITATING PEER NETWORKING	***Educational development***	The discussion forum allowed patients to open up and share the challenges of losing weight and motivational difficulties which promoted the acknowledgement and social support. (Das *et al.*, 2014)	*"I think it is more enjoyable to write a "diary" that everyone can read and comment on. I like to get feedback on how I do things, what I eat, and thoughts that I have about the surgery and about life after the operation, so here comes a little of everything…Hope you will read and comment."*
			"It is actually the support and the approval regarding what you are doing, feedback regarding whether it is right, and feedback regarding insecurities."
		The informational support intended to provide recommendations regarding the dietary guidelines and physical activity in order to facilitate the post-surgery weight lost in bariatric patients. (Atwood *et al.*, 2018)	*"[Product name]… this is odorless and tasteless and does not clump. You can add it to hot or cold… or just sprinkle over your food. One tablespoon equals a scoop of Whey and has 30 grams of protein. It is approved by [Medical Association] and has 96% absorption…"*
			"… You may want to pick up a pill crusher and a pill splitter in the drug store. The large pills such as calcium citrate, I had to crush and mix with drink in order to take them…"
	Connecting with others	The statements of encouragement aimed to provide patients confidence regarding the progress of adhering to dietary and physical exercise to increase the surgery outcome. (Atwood, 2018)	*"It does seem like you are hitting a lot of bumps in the road. Keep your sense of humour. It'll all be worth it in the end."*
			"I would be happy to make this journey with you…I would love to be your buddy."
			"… If you have any questions about recipes, diet, or exercise, I am an open book…"
		The social support required to build a sense of community among the patients who could share the same experiences in order to support each other to achieve targeted physical activity goals. (Puszkiewicz, 2016)	*"If you are looking at the issues of cancer survivorship, I think personally that for cancer survivors it would be quite nice to link up with other people and build that community."*
			"You do need that bit of motivation from other people. It's all about motivation when it comes to exercise […]. When you feel low and can't be bothered to go for a walk, maybe

			someone else saying 'go on, get up and do it, you can do it' would motivate you."
		Peer support encouraged and motivated patients to carry out the exercise with the individuals having the same medical condition with the same activity trackers. (Nguyen, 2017)	*"In this day of social media I have a lot of groups of friends that are Fitbit people and they have their own groups and there is a bit of competition amongst the friends and not that it's a "You must do this", "Who made 8000 today", "Who made 9000 today" and they give each other badges and pats on the back and so it becomes quite social and that's quite important I think. We always say if you train with a friend you're less likely to pull out but if you going to say "I am going to do it on my own" then it is easier."*
		The emotional and social connection maintained between the participants who share the same medical condition. (Lally, 2018)	*"I loved the fact that some of the women [in videos] had the same cancer I did."*
		The interaction with the peers through the program improved the emotional well-being of the patients and reassured feeling of not being alone in the struggle with breast cancer. (Zhu, 2018)	*"I feel better to talk to someone who are in similar situation. Cancer is not a good thing. If I always think about breast cancer alone at home, it is so easy for me to feel bad. I didn't feel alone when I talked with peers through your program. They might have worse or better conditions than me, but they understand what I meant (Laugh...). This may be the source of comfort and help."*
		The program allowed patients to feel "less alone" in their experience through the interaction between the peers. (Alberts, 2018)	*"Knowing there's other people taking programs like this and that, it's kind of, you know, you feel like, well, I'm not alone."*
			"You know that you're not alone, but when your feelings are validated just by reading someone's story, I mean that is everything."

3.3.8 Meeting individualised patient needs

The final theme from this review considers the ability of the intervention to meet individualised patient needs. This theme, and sub-themes, recognise the importance of certain factors that could specifically influence and motivate behaviour change; this includes the 'timing of the intervention' and it's 'tailoring to the disease', as well as highlighting specific 'patient recommendations' of strategies and considerations. The data synthesised for this theme is demonstrated in Table 8.

Timing of the intervention

According to surgical cancer patients, initiating and tailoring the content of a digital or mobile intervention appears to be essential in determining its effectiveness to motivate behaviour change. Two papers discussed the optimal time to start an intervention within a surgical journey; some cancer patients suggested that initiation should be early following their diagnosis, but within the pre-operative period, to enable their understanding about the disease and preparedness for upcoming procedures and treatment.(256) On the other hand, others favoured a provision to ask and answer questions sometime after their initial diagnosis, once they had taken time to process the disease and treatment plan.(252)

> *"I had more trouble with sleep issues early on at diagnosis and in between surgeries, so it would have been helpful for me to have enrolled in the program earlier"*(256)

> *"I can see this tool being useful in answering questions that have not come to mind when first diagnosed"(252)*

In addition to timing the intervention correctly around the diagnosis timepoint and pre-/post-operative period of their surgical journey, the participants in the cancer cohort also reported the need to time the intervention around any concurrent treatment for their disease. Specifically, participants reported a preference to start with interventions once adjuvant chemotherapy was completed, citing treatment burden and side effects as factors for lower rates of engagement (or complete disengagement) at this time. Immediate post-operative issues, like fatigue, were also noted to impact early engagement rates.(259) However, some patients appreciated low-effort strategies during the surgical journey to manage symptoms and improve relaxation.(252)

> *"The very end of your treatment when you finished your chemo and…the doctor says 'Ok, see you in six months.' That would be the time to offer it. 'Cause you feel so unwarned [sic]"(252)*

Uniquely, there was an agreement among cancer patients that the best time to begin an intervention is "*when you recognise that you have a problem … and that you want help"*; (252) this suggests that the initiation point should be decided on an individualised basis, rather than implementing a 'one size fits all' approach.

Tailoring to the disease

Surgical cancer participants also expressed desire for intervention tailoring according to their changing physical and psychological health needs,(252, 256, 259, 261, 264, 269, 270) focusing information to their disease and surgical type.(256, 269, 270) Puszkiewicz *et al.* noted preferences for individualisation of digital interventions according to patient lifestyles, rather than a disease on a whole.(259)

> *"The issues I might have as a colorectal cancer survivor are very different from the ones than someone who had breast cancer or prostate cancer."(259)*

> *"Anyone with any condition could use this program, which is beneficial, but it could be more beneficial […] more tailored to the type of cancer or disease you had, to your lifestyle and fitness goals. I think it could be more fine-tuned to your circumstances, lifestyle, then that would be really helpful."(259)*

In the virtual reality-based rehabilitation study, participants expressed positive views upon the personalised task difficulty, where the varied level of difficulties helped them to choose the exercise programme according to their needs, subsequently increasing their satisfaction with the intervention.(259)

Patient recommendations

Participants across all three surgical cohorts suggested design and technical improvements for the future development of digital and mobile interventions. Although these varied depending on the delivery method, a user-centred design was identified as a key solution to enhance and maintain engagement, influencing behaviour changes.

> *"I think that it needs to be aimed towards survivors. That would be the first component. There's a lot on the Internet that gives you a lot of exercises but it's not aimed towards survivors."(270)*

Patient-reported design improvements for wearables included higher accuracy of the devices,(264, 270) different aesthetics (such as the tone of the prompt and colour-scheme),(261, 264, 265) and personal goal-setting.(264)

> *"So I'll give you a case. I filled my laundry, and it's logged I walked 2,000 steps. I did not walk 2,000 steps."(257)*

> *"I'd get a little vibration to say let's go do 250 steps, it was much more polite than MOVE."(265)*

> *"I like that the colour scheme was NOT pink!"(262)*

In online forums for patients undergoing bariatric surgery or cancer surgery, the fear of self-disclosure was a recognised barrier that affected user-engagement. Full anonymity would make it easier to share sensitive issues and ask difficult questions.(263, 269)

> *"On other forums, even though you don't have your name, with a nickname, you can find out who the person is anyway. You have to be very careful if you want to be anonymous."(267)*

Participants also suggested adding 'search' tools to locate information and save time,(269) as well as the inclusion of diet recommendations and/or self-monitored food intake.(269)

> *"The program can be improved by adding search engine in the Learning forum. If I search for "nausea", then all the knowledge related to nausea will come out. Search engine will help save my time."(269)*

> *"We are in a dilemma on what we should eat. The apps can provide detailed information on food choice, the time of food intake, the cooking methods, etc...Such practical information would be very helpful."(269)*

Older users appeared more likely to experience usability issues with interventions.(269) To overcome this, patients reported preferences for 'open-access' so that family members or caregivers can offer support.(269)

> *"I was overwhelmed by the information each time I opened it."(269)*

> *"Some people, like me, 40 or 50 years old. Well, this group believe the apps is a little bit troublesome. They feel challenged to use the new technology... If this program can be available for their family members, such as their son or daughter, it would be helpful."(269)*

> *"Many women with breast cancer come from the countryside. They are illiterate, or they cannot read and speak Mandarin… if you can open the program to other family members who can read and convey the knowledge to the women, they would also benefit"(269)*

Table 11: Theme 4: Meeting individualised patient needs

Synthesised themes (third order constructs)	Sub-themes	Second Order constructs: the authors interpretations of the original findings	First Order constructs: examples of direct quotations from the participants of the study
	Timing of the intervention	The utility and timing of the intervention to be cancer-specific is uncertain. Amongst the patients, the optimal timing agreed to be dependent on the time of need. (Shaffer *et al.*, 2019)	*"I think it would have been a little easier during radiation. Although I had as much fatigue during radiation… I think it would have been more doable then, for me, possibly."*
			"I had more trouble with sleep issues early on at diagnosis and in between surgeries, so it would have been helpful for me to have enrolled in the program earlier"
			"The very end of your treatment when you finished your chemo and…the doctor says 'Ok, see you in six months.' That would be the time to offer it. 'Cause you feel so unwarned'"
		The appropriate timing of the intervention agreed to be during the first diagnosis in order to reduce feeling overwhelmed and enable information access to the newly diagnosed patients. (Lally *et al.*, 2018)	*"I wish I would have had something like this when I was first diagnosed…I can see this tool being useful in answering questions that have not come to mind when first diagnosed."*
		The patient's perceived ability to perform a particular task in a low physical or psychological health status reduced the engagement with the mobile application. (Zhu *et al.*, 2018)	"*During the three days hospitalization for chemotherapy, I felt like dying and I couldn't even think about opening the app. When I came back home and I recovered a little bit, still my health was quite fragile. I couldn't spend long time reading the app or have enough energy to read in depth."*
	Tailoring to the disease	Patients believed the mobile application could be tailored to be better suit the individual's lifestyle and barriers to achieve the required fitness needs. (Puszkiewicz *et al.*, 2016)	*"The only thing that holds me back from exercising frequently, is the fatigue, it's always the fatigue. So […] if an app somehow could consider my fatigue on those bad days. [Because] it really demotivates you… like you know when you just can't complete a workout because of it."*
			"You can't put too much pressure on your arms [after lymph node dissection surgery], but you have to train them too to avoid lymphedema. So I think in those terms the application was really good, definitely suitable."
		The relevance of available information on the program	*"I think that it needs to be aimed towards survivors. That would be the first*

MEETING INDIVIDUALISED PATIENT NEEDS		towards the cancer survivors were found unclear. Patients expressed a desire of having a program that is specific to the cancer survivors. (Phillips *et al.*, 2019)	*component. There's a lot on the Internet that gives you a lot of exercises but it's not aimed towards survivors."*
		The concerns over the treatment side effects limiting the physical activity and the potential adverse effects of the trackers on physical health identified amongst the patients. (Nguyen *et al.*, 2017)	*"Because I'm on medication, and I've got the joint issues. So that's really, I'm really-not struggling but just it stops me doing, you know 5000 I'm all right, if you push me to 6 or 7 [thousand steps], I'm in tears because of the joints"*
			"I didn't like wearing it at night. I didn't feel comfortable. I wanted to be away from all sort of electrical kinds of things when I sleep. I even have the clock radio quite away and I don't sleep near any power points or anything. I've had breast cancer a few times, it's always been caught early but you still think you do what you can to keep away from any kind of an influence you think might be affecting you."
		The advice from the cancer survivors provided trust to the newly diagnosed patients through the comprehensive and accurate content of the program. (Lally *et al.*, 2018)	*"A great tool… because what we need is true information so that we can focus on surviving and I believe that this program would be that tool."*
		Patients explained a desire of receiving credit from all the daily living activities and a more flexible but tailored program goals to achieve their specific needs. (Phillips *et al.*, 2019)	*"I would want it to track everything and also easily convert all the different kinds of activities into some kind of common measure, so that you could have a total idea of what you did."*
			"I think it has to have different levels. Some people have no idea about how much exercise they should do or what's useful but then some people…need more information because [they already]…know that. If it's there and it has different levels available depending on what you need then I would be interested in using it."
		Suggestions for the content, design and technical improvements of the intervention to overcome barriers to use – for instance, these involved	*"There are too many content in the Learning forum. I was overwhelmed by the information each time I opened it. I do not have patience to read all of them...But the screen of the mobile phone is so small and it takes long time to find*

	Patient suggestions	adding a search engine function to instantly locate the information; adding more diet details and specific food recommendations; and addressing the accessibility of the program to help older patients overcome barriers. (Zhu *et al.*, 2018)	*the knowledge you want. The program can be improved by adding search engine in the Learning forum. If I search for "nausea", then all the knowledge related to nausea will come out. Search engine will help save my time."*
			"Please add more information on the food choice. We need to eat every day, however, there is conflicting advice on food choices on the internet, such as whether we should eat honey, chicken, leek, etc. We are in a dilemma on what we should eat. The apps can provide detailed information on food choice, the time of food intake, the cooking methods, etc... Such practical information would be very helpful."
			"Some people, like me, 40 or 50 years old. Well, this group believe the apps is a little bit troublesome. They feel challenged to use the new technology. This is a problem. Although they are not willing to participate, they often consulted me on some questions and they were quite interested in the knowledge. If this program can be available for their family members, such as their son or daughter, it would be helpful."
			"Many women with breast cancer come from the countryside. They are illiterate, or they cannot read and speak Mandarin… if you can open the program to other family members who can read and convey the knowledge to the women, they would also benefit"
		Patients reported the inaccuracy of the devices, as the trackers could not register the light intensity physical activity, and auto-goal function setting adversely affected the patient's motivation. Adherence to the physical activity found to be influenced by the aesthetics of the trackers. (Nguyen *et al.*, 2017)	*"I looked down, it [the tracker] had a message that said "Move!". I thought, that's a bit cheap because I've been busy all day working and busy all day, and now I'm finally sitting down and it wants me to move again."*
			"I had the Polar first […] I thought it was quite heavy and quite clunky but then I had the two Garmins and in the end I decided that was my favourite even though it was heavier. I thought it was easier to push the buttons and see where you were rather than the others."

			"It was a Garmin, say the goal is 10,000 [steps] and you had a lazy morning, it drops down to 8000 and then 6000 and […] "No, I still want to do my 10,000" […] I would rather have the goal set and if I didn't reach my goal, that's something I am going to have to deal with but with the goal changing, I could have sat there and the goal would have just dropped, it didn't seem to be rationale."
		The opinions varied on cancer-specific tailoring. Some patients would like to have more information on cancer-related insomnia whereas some believed the information would be best as an optional content to avoid distress. (Shaffer *et al.*, 2019)	*"General comments about cancer and insomnia would be really helpful. For me the more information I have the better."*
			"There ought to be a way to bypass, because all cancers are different. Make it possible to bypass if it doesn't apply to your cancer."
		The tone of the prompt deemed to be crucial in determining preference and likelihood of use and auto-goal function caused confusion of targeted goal in some patients. (Hardcastle *et al.*, 2018)	*"I'd get a little vibration to say let's go do 250 steps, it was much more polite than MOVE."*
			"it wasn't clear like now the goal, does that mean I have to do 5000 steps, why have they got that I've been doing over 10000"
		Patients reported the benefits of tele-rehabilitation, complementing it with the occasional in-person visits would improve the knee evaluation by the physiotherapist. (Kairy *et al.*, 2013)	*"I'm fairly certain that at least twice, on two occasions certainly if he would have come, it would have been a plus. Well, maybe psychologically, I think, thinking that he could have manipulated your knee, to see in a tangible manner and be able to manipulate it, but hum… it's the suggestion that I would give, to at least meet, I don't know how often."*
		Due to personal barriers and lack of anonymity, some patients were reluctant to actively participate in the online forum. (Das and Faxvaag, 2014)	*"I have reading and writing difficulties as well, so when I start writing, it comes out weird. Then, I become even more reserved regarding writing."*
			"It does not bother me. On other forums, even though you don't have your name, with a nickname, you can find out who the person is anyway. You have to be very careful if you want to be anonymous."
		Additional features of including joint angle measure, a quality score after each exercise session	*"This is probably not possible, but to get the angle of that knee bend, if you knew that… for me that is where I'm really stuck so just to know that… I know it*

		and gamification ideas such as unlocking new levels to sustain the engagement were suggested by participants. (Argent *et al.*, 2019)	*counts it and it said you did it right, but I'm not sure what the angle of the bend is, and I'm rather obsessed with that."*
			"It would be very difficult to rate it from the previous time, there is no linkage from the previous repetitions… So in a way you don't know if you are doing better today than you did yesterday… The quality of how I'm doing them."
			"If there was a games element to it you know you have unlocked the next level… or a medal or something."
		The pink colour wristbands served as negative reminders of lived breast cancer experiences and created a divide between the survivors and general population. (Kokts-Porietis, 2018)	*"…people are bugged with the [activity trackers being the] colour pink, where other people that's all they wear is pink. And […] mail correspondents coming in [hospital], or Cancer Society white envelopes is shocking."*
			"Don't even think about it. It's like, oh this is just another pink thing"

3.4 Discussion

To the researcher's knowledge, this is the first meta-ethnographic systematic review examining the effectiveness of digital and mobile technologies to support health behaviour change in elective surgical patients. Using reciprocal translation, our findings indicate four themes that appear key in determining intervention effectiveness to support surgical patient health behaviour change: (1) providing motivational support, (2) addressing patient engagement, (3) facilitating peer networking and (4) meeting individualised patient needs. Future studies may wish to use the findings from this Chapter to inform future design frameworks for specialist surgical cohorts, embracing digital transformations in healthcare.

Although meta-ethnographies offer an opportunity to synthesise findings to develop new or deeper understandings on a subject, the process is largely interpretive;(241) other conclusions from the same included studies may be possible, but still equally as valid. It is also important to note that the focus of this meta-ethnography was solely elective cancer, bariatric, and orthopaedic surgeries and, as such, the meaning of these findings may not be generalisable for acute surgeries or other specialities.

Digital and mobile technologies acted as a catalyst to engage with healthy behaviours, such as loss of weight, improved dietary intake, and increased physical activity levels. Messages of positive reinforcement were viewed as useful, particularly when tailored to an individuals' surgical type and readiness to make behavioural change. Wider literature echoes that individualised goal-setting has combatted sedentary behaviour,(273-275) personalised feedback and messages of encouragement provided a sense of accomplishment,(248, 270) and visual tracking of step-count was reported as motivational.(264, 274) Recent contributions to the health behaviour change literature have cited the importance of empowered patient-centred strategies, using self-regulation(276) and self-determination theoretical frameworks(277, 278) through which to understand patient motivation. Digital technologies underpinned with behaviour change theory can promote a proactive and holistic strategy to influence behavioural change in a modern NHS.(152)

In the context of surgical cancer patients, internet-delivered cognitive behavioural therapy (iCBT) was associated with numerous benefits.(254, 258) Following digital intervention usage, there have been improvements relating to fatigue, sleep,(279) depression,(280) and psychological distress.(281) But additionally, our findings suggest that iCBT can also educate participants around various coping strategies to manage fears of treatment and disease-recurrence.(254)

Technologies enabling connectivity to healthcare professionals were positively acknowledged. Two-way telemedicine consultations, emails, and text-message discussions facilitated improved information delivery, real-time goal-setting, psychosocial outcomes and confidence in decision making.(282-284) Participants felt motivated, reassured, and encouraged to adhere to post-operative advice through remote monitoring. Having access to healthcare professionals 'behind a screen' also helped patients to overcome personal barriers and raise unmet needs beyond routine clinical questioning.(267, 283) From the perspective of clinicians, digital and mobile health technologies provided them with a means to monitor patient progress, which allowed individualised advice to be given to reinforce beneficial behaviour change.(257, 285)

Despite the benefits of digitally enabled communication, it is worth considering social norms with patient-professional relationships.(286) For some, the continuity of face-to-face appointments is essential to provide empathetic interaction and social support.(286, 287) Empathy, rapport, and compassion through non-verbal behaviour and body language is difficult to establish when communicating digitally. Despite this, Kairy *et al.* reported close relationships and trust between the therapist and patients when communicating *via* telerehabilitation.(262) Perhaps, complementing traditional face-to-face appointments with digital health interventions could be a way to maintain patient-professional relationships.

Usability has been reported as a key determinant to induce and maintain health behaviour change, where interventions should be easy to use, as well as aesthetically- and visually-appealing. Patients' preferences should be considered when it comes to their design and tailoring.(264, 288, 289) It is worth considering ways to overcome digital health literacy to better promote equality, usability and engagement. Additional technical support might be beneficial when targeting older adult populations to increase their engagement and thus, better support health behaviour change.(264, 290)

One reported advantage of digital interventions is the accessibility they offer.(119, 125, 265) Post-operative breast cancer survivors living in rural settings experienced greater depressive symptoms compared to those with shorter commutes, due to the long travel distances required to access health services.(291, 292) Where tele-rehabilitation was implemented for post-operative orthopaedic follow-up, participants reported improved continuity of care with the same physician and improved ability to control the timing of appointments and intensity of the rehabilitation service.(160)

As well as bridging access to health services, digital and mobile health technologies are being increasingly utilised as networking and peer-support tools. Patients going through similar procedures or diagnosed with similar conditions are able to communicate and share personal experiences and coping strategies with others.(267) Peer-support and behaviour change has been reported in elective care previously,(264, 293-296) where increased social support and decreased patient isolation is associated with post-surgical success.(295, 297) Whilst digital technologies offer opportunities to interact with peers on an educational level, concerns have been raised about the accuracy and credibility of shared information.(293, 298-300)

Healthcare professionals should caution patients when interpreting discussions on forums or online groups, given the potential detriments that may arise from following inaccurate information.(267, 300, 301)

The optimal time point in the surgical pathway to initiate digital and mobile technologies remains uncertain, with findings suggesting this may vary between surgical groups. Despite this, what remains clear is the potential benefit of capitalising on a 'teachable moment' in order to empower and educate patients about underlying benefits of health behaviour changes.(221, 302, 303) Evidence suggests that pre-operative interventions based on education of lifestyle changes are significantly more effective in managing post-operative complications and patient expectations.(304)

This meta-ethnographic systematic review has synthesised current data allowing numerous digital technology design considerations to be identified. Moving forwards, technology designers should consider these findings when producing future interventions to support surgical patients remotely. In particular, the following are key take-home messages that would enable the creation of patient-informed strategies: internet-based interventions may benefit from adding a 'search' tool to locate target information;(252) the comfort of wearable technologies should be addressed;(257, 264) negative connotations with using the colour pink for cancer patients have been acknowledged to build the 'cancer culture divide';(305) and possible benefits of incorporating open-access features within interventions were also discussed when considering remote-relationships between patients and their surgical healthcare professionals.

Previous work has shown that opening care access, to include relatives or caregivers, provided patients with an increased sense of pre- and post-operative support.(306-308) This approach has strengthened bonds with family members, improved patient experience, resulted in effective engagement with digital interventions and therefore supported superior outcomes in lifestyle changes.(309-311)

This piece synthesises existing research to gain a deeper understanding of the ways in which digital technologies can support elective surgical patients. This review also identifies key design features that support patients to change their health behaviours, and thus have greater impact over their post-operative recovery and health. Considering the rapidly progressive nature of digital health interventions and digital assistive technology research, co-creation of a person-centred digital strategy may help surgical cohorts to benefit from pre- and post-operative behaviour change on both a short- and long-term basis.(16, 312) In order to deliver on this, further patient-informed work should be conducted to explore the perspectives, opinions and lived-experiences of surgical patients themselves. By doing so, the surgical-specific needs of each cohort can be better understood. In turn, the key features relating to the design, functionality and capability of technologies can be tailored to the people who would use them.

3.5 Conclusion

This meta-ethnographic synthesis developed four key themes that have been identified as significant in determining the success of digital technologies to support behavioural change for surgical patients. These findings have the potential to influence the future design of person-centred digital health technologies. This study also demonstrates the important role that digitally delivered strategies can play in the elective surgical pathway; not only can these technologies help to motivate physical behaviour change, such as improved activity levels and dietary intake, but they can successfully provide psychological support too which is a unique finding thus far in this programme of work.

By performing this meta-ethnographic systematic review of existing qualitative studies, key areas for technology improvement were identified; both to meet the general desires of surgical patients and to meet more specialised surgery-specific needs throughout the perioperative pathway. In particular, digital technologies should optimise the inclusion of tailored content specific to individual patients with the inclusion of self-regulatory features, such as goal setting to provide structured, individualised-support. Moving forwards, there is significant rationale for involving patients in the co-creation of digital health technologies to enhance engagement, better support behaviour change, and improve overall surgical outcomes for patients.

3.6 Summary of Chapter 3

The work in this chapter employed a systematic methodology to synthesise existing qualitative data using meta-ethnography. This systematic and interpretive approach enabled the researcher to contribute new insights to the limited body of literature in existence. This inductive and interpretive approach enabled the translation of existing research papers into one another so that themes and metaphors from different studies could be shared. The themes that were developed identified ways to optimise digital health technologies across the cohorts of bariatric, cancer and orthopaedic surgeries. Findings from this review also identified the paucity of patient-informed, co-creation approaches in current digital health literature – an important area for future work in this thesis, and beyond.

Previous chapters in this thesis have explored the role and use of digital health technologies to support lifestyle change that is physical- (physical activity and weight) and dietary-based. This meta-ethnography also introduced exploration of support with psychological behaviours around the time of surgery; showcasing a potential wider, holistic role that patient-centred technologies could fulfil.

The next chapter in this programme of work focuses on further exploration of a finding from this review and from the systematic review in Chapter 2; it takes the form of a narrative literature review and centres around identifying and understanding the roles, challenges and underutilised opportunities of digitally-facilitated peer support for bariatric surgeries.

Chapter 4: The underutilised opportunity of digital health technologies to facilitate peer support for patients undergoing bariatric surgery: a systematic review and narrative synthesis

The work in this chapter explores an area related to the findings of the meta-ethnographic systematic review in the previous chapter, as well as an identified gap from the systematic review in Chapter 2. Here, focus is placed on further exploring the role and place of digitally-facilitated peer support within surgical pathways.

As well as bridging access to health services, digital and mobile health technologies are being increasingly utilised as peer support and networking tools.(175, 298, 300) In a cohort with high information needs both pre-and post-operatively, online peer forums may present a currently underutilised method of support for patients undergoing bariatric surgery.

Online forums and internet-based platforms appear to have changed the way that individuals engage and manage with their health and wellbeing. In the United States, 86% of the population are now connected online, with estimates reporting that one in three adults use the internet to seek information about their health.(313) One particular cohort that has benefitted from the advancing support of digital technologies is bariatric surgical patients, where adult patients have reported using online forums before and after weight loss surgery.(298) The researcher conducted this review of the literature to identify the roles and opportunities for pre- and post-operative online peer forums, specifically for bariatric surgical patients. There is also focus placed on building a greater understanding of the challenges associated with using online platforms, as well as the wider use of digital health technologies, when it comes to supporting and empowering this patient cohort.

This qualitative narrative review has been published in the international peer-reviewed open access journal, JMIR Perioperative Medicine: Robinson A, Husband AK, Slight RD, Slight SP. *Digital support for patients undergoing bariatric surgery: narrative review of the roles and challenges of online forms.* JMIR Perioperative Medicine 2020; 3(2): e17230, DOI: 10.2196/17230 (Appendix 6).

4.1 Introduction

Obesity has been recognised as a global health concern and is described as an 'epidemic' by the World Health Organisation (WHO). It is a chronic, life-limiting disease, which is associated with numerous serious health conditions including type-2 diabetes, cardiovascular disease, hypertension, sleep apnoea, osteoarthritis, and some types of cancer (such as prostate, breast, ovarian, and pancreatic).(314, 315) The prevalence of bariatric surgery has increased alongside the rising trend in obesity across the Western world.(314)

Bariatric surgery is often regarded as the most effective treatment for severely obese individuals,(316) where evidence has suggested that weight loss can be up to 62% of initial body weight, following the procedure.(317) However, it is well recognised that despite these promising outcomes, patients undergoing bariatric surgery commonly experience challenges beyond the procedure itself in their bid for surgical 'success'. Individuals may need to overcome social (*e.g.*, stigma), physical (*e.g.*, surgical complications), and psychological (*e.g.*, depression and negative body image) hurdles throughout their journey, as well as adjusting to their new lifestyles (*e.g.,* recommendations for improved dietary intake and physical activity) following the procedure.(176, 224) This is where online forums have come into play, supporting patients throughout their surgical journey and beyond.

Online forums and telehealth platforms appear to have changed the way bariatric surgical patients view and engage with their health before and after weight loss surgery.(298, 318) The internet has become an important medium within healthcare, giving patients the opportunity to search for information, guidance, and seek social support. Previous studies have found links between social support and successful weight maintenance,(319, 320) improved quality of life and increased patient empowerment.(321-323)

4.2 Methods

4.2.1 Search strategy

We conducted our search of the literature in October–November 2019 across 5 electronic databases: Scopus, EMBASE, PsycINFO, CINAHL, and MEDLINE. No limits were applied on publication dates. References of all included studies were hand-searched and grey literature (using Google Scholar) identified additional papers. The researcher and the research team worked closely with a librarian to design the search strategy, which included keywords and MeSH terms covering the themes of bariatric surgery, online forums, and qualitative methodology. The full database search strategy and MeSH terms are listed below in Table 12. All articles were exported to EndNote X9 (Clarivate Analytics) for data management.

Table 12: Database search terms and search strategy

Database search terms	
Bariatric surgery	(bariatrics.mp. OR exp bariatric surgery/ OR bariatric surgery.mp. OR weight loss surgery.mp. OR exp obesity management/ OR obesity management.mp.)
Online forum	(digital healthcare.mp. OR social media.mp. OR social media/ OR exp social network/ OR instagram.mp. OR facebook.mp. OR online forum.mp. OR internet forum.mp. OR discussion forum.mp. OR forum.mp.)
Qualitative methodology	(qualitative analysis/ or exp qualitative research/ OR semi structured interview/ or telephone interview/ or interview.mp. or interview/ OR focus group.mp. OR mixed study.mp. OR thematic analysis.mp. OR ethnography.mp.)
N.B. full search strategy included combinations of = (bariatric surgery terms) AND (online forum terms) AND (Qualitative methodology terms)	

4.2.2 Inclusion and exclusion criteria

We included studies that had (1) included an investigation of bariatric surgical patients (or bariatric surgery health care professionals) engaging with, using, or analysing online discussion forums or social media platforms, such as Facebook and (2) conducted a qualitative or mixed-method study (with a sufficient amount of qualitative data reported to enable analysis). For the purposes of data interpretation, studies were excluded if they did not report findings in the English language. In addition, studies that focused solely on the views from members of the surgical teams interacting with discussion feeds (instead of the patients) were excluded. Any studies that utilised face-to-face consultations, rather than online or digitally-delivered interactions, were also excluded.

4.2.3 Review and reflexive thematic analysis

Two authors (AR and AKH) reviewed the papers from the database search. Full texts were retrieved for articles that met the inclusion criteria or those that could not be rejected without certainty. The full texts were independently screened by AR and AKH. Any disagreements were resolved through discussion or by a third reviewer (SPS) where necessary.

Reflexive thematic analysis, as defined by Braun and Clarke,(324) was performed by 2 researchers (AR and AKH) to identify patterns of themes in the data. Significant phrases and sections of available transcripts were coded with initial, descriptive codes; these were then sorted and clustered into common coding patterns, which enabled the development of themes (derived from the data). Working iteratively and reflexively, the themes were reviewed and refined until they were coherent and distinctive. Any discrepancies were resolved through discussion (by AR and AKH; of which there was one instance, based on refining a theme name) and, if agreement was not reached, by consensus with the wider research team (SPS and RDS; this step was not required). NVivo version 12 software (QSR International) was used for the organisation of data and thematic analysis.

4.3 Results

4.3.1 Analysis of search data

The database searches returned a total of 28 papers. A further 6 records were included through grey literature and bibliography hand-searching. Following the removal of duplicates (n=12), 22 papers were screened and, of these, 8 were excluded based on their title and abstract. The remaining 14 full-text papers were assessed for eligibility, of which 6 were excluded with reasons including an incorrect study population (n=1) and an inappropriate research output (n=2, conference abstracts). There were no studies excluded based on language in this review; all were published in the English language. Eventually, 8 studies were included in this review (see Figure 5).

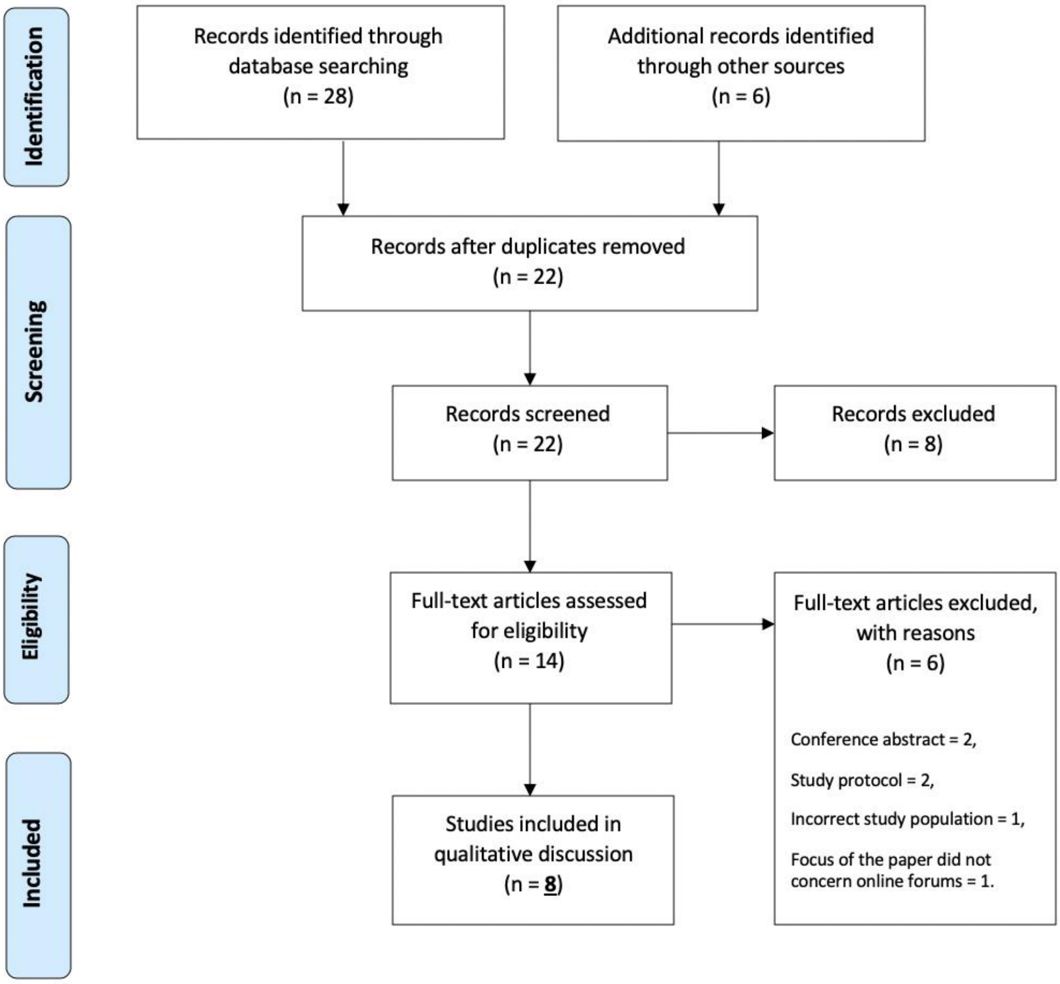


Figure 5: PRISMA flowchart of included studies

All 8 of the included studies were published in the last 6 years and were conducted in the United States (n=4),(175, 300, 325, 326) Norway (n=2),(272, 327) Sweden (n=1),(328) and Canada (n=1).(263) Mixed methods were employed in 3 studies.(272, 326, 327) The remaining studies utilised a form of qualitative methodologies, such as content analysis. Three studies analysed posts on public discussion forums(263, 325, 328) and two studies analysed posts within groups on Facebook.(175, 300) Further study characteristics are included in Table 13, below.

Table 13: Study characteristics

Author and year	Country	Participant sex	Qualitative methodology	Online forum
Willmer & Salzmann-Erikson, 2018.(328)	Sweden	NR	Content analysis of 498 posts	Public discussion forum
Ferry & Richards, 2015.(325)	US	NR	Critical discourse analysis of over 2,000 conversational threads	Public discussion forum
Atwood *et al.*, 2018.(263)	Canada	NR	Content analysis of 1,412 forum messages	Public discussion forum
Koball *et al.*, 2017.(175)	US	NR	Content analysis of over 6,800 posts and replies	Facebook group
Das & Faxvaag, 2014.(272)	Norway	F+M	Observation of discussion forum and 8 semi-structured interviews	Discussion forum in a secure eHealth portal
Geraci *et al.*, 2014.(326)	US	F	Phenomenological approach with 9 semi-structured interviews and observation of posts	NR
Koball *et al.*, 2018.(300)	US	NR	Content analysis of over 10,000 posts and replies	Facebook group
Das *et al.*, 2015.(327)	Norway	F+M	Semi-structured interviews and portal interactions by patients and healthcare professionals	Discussion forum in a secure eHealth portal
Key: US = United States, F+M = female and male, F = female only, NR = not reported				

4.3.2 Findings

Five distinct themes, relating to the roles and opportunities of online peer forums in supporting bariatric surgical patients, were developed from the existing data: 1) managing expectations of a new life; 2) decision making and signposting; 3) supporting information seeking; 4) facilitating connectedness: peer-to-peer social and emotional support; and 5) enabling accessibility and connectivity with health care professionals. These themes (as shown in Figure 6) will be discussed in turn, with participant quotes helping to illustrate the findings. Table 14 below demonstrates examples of patient quotes from the original studies that contributed to the development of each theme in this narrative review.

Table 14: Quotes from the original studies to highlight the five themes developed in this narrative review

Themes	Exemplar patient quotes from their original study
Managing expectations of a new life	*"I look forward to the new me and my new life, I can barely wait".(328)* *"I have a BMI of 39 and long for a lighter existence".(328)* *"But just think how unbelievably good it will feel afterwards".(328)*
Decision making and signposting	*"I went with a bypass because I already had bad GERD [gastro-oesophageal reflux disease], and the sleeve has been known to increase the amount of reflux you have".(263)* *"I thought I'd jump in here too, after many years of struggling with my weight I have now reached "the end" of this struggle and actually thought that maybe a GB is the last way out for me, the only chance of a normal weight life?"(328)* *"I think my story is similar to many others I've read here… I think I'm finally ready to seriously consider surgery, but I don't know where to start… I'm hoping to hear from all of you how surgery worked for you, so I can see if it can work for me".(325)* *"I looked at the percentage of probable weight loss. I thought this was a great tool for that: [website address]."(263)*
Supporting information seeking	*"it's easier to go on here [online forum] ask questions and get answers".(272)* *"I know when I started eating every 3 hours small meals that my energy level increased; speak with your doctor or nutritionist."(263)* *"you can be much tougher on the net, write things that you might not want to say to people because they are difficult to talk about. This becomes easier when you have a screen you can hide behind".(272)* *"This is the time to really make sure you are doing everything right: keep a daily food journal (VERY important!); eat protein every couple of hours; drink a LOT of water; stop drinking water 30 minutes before a meal, don't drink anything DURING your meal, start drinking water again 30 minutes AFTER your meal; CHEW, CHEW, CHEW; exercise; stop weighing yourself every day".(263)*
Facilitating connectedness: peer-to-peer social and emotional support	*"I would be happy to make this journey with you … I would love to be your buddy".(263)* *"It's tough as heck but in a way it's also easier since this time you know you're not doing it for nothing".(328)* *"Believe me, I've been there… feel free to message me with any questions".(325)* *"What have you done, have you told many people?"(328)*

	"I'm sorry that you are going through this… My mother isn't supportive… and while it isn't as important as having a supportive spouse, it still hurts…".(263) *"it is more important to talk to a person who has been there, who knows what you have been through, who can encourage you to continue".(272)*
Enabling accessibility and connectivity with healthcare professionals	*"I think it is very positive that you can ask questions that are conveyed to a dietician or a doctor because I must admit that picking up the phone and asking someone is very challenging. That barrier–I think it is difficult. What if it's only me? How ridiculous! You get that feeling. Then, it is easier to write online".(272)* *"It is actually the support and the approval regarding what you are doing, feedback regarding whether it is right, and feedback regarding insecurities."(272)*

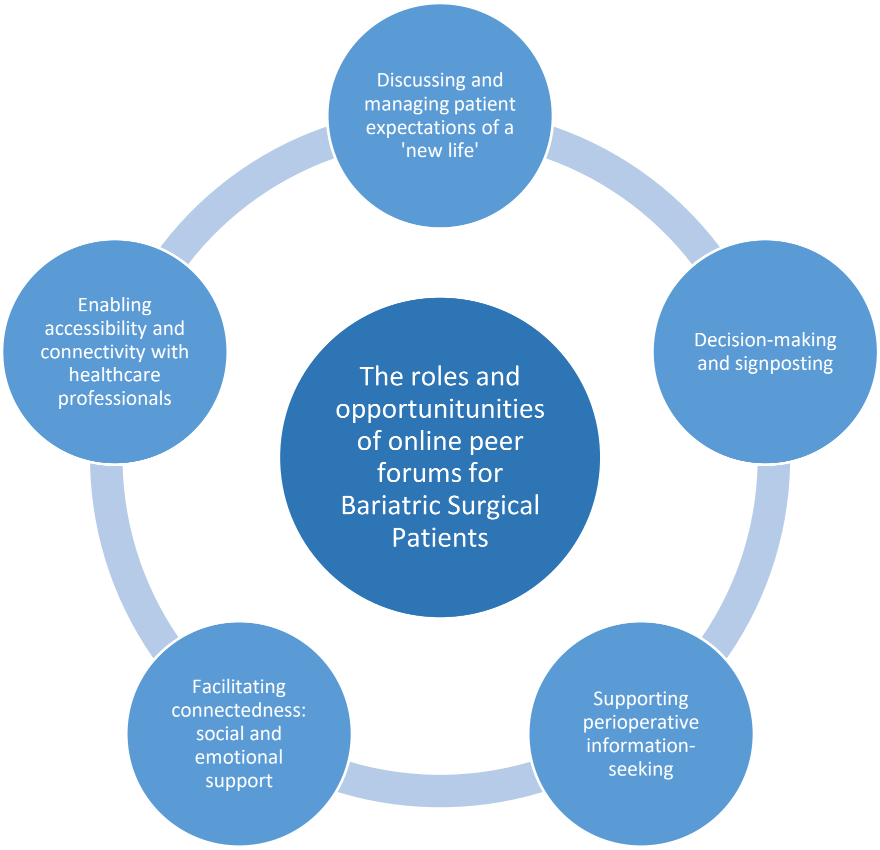


Figure 6: The roles and opportunities of online peer forums for bariatric surgical patients.

4.3.3 Discussing and managing expectations of a 'new life'

Throughout the perioperative journey, patients were shown to use peer forums as a way of discussing their expectations following surgery. When posting pre-operatively, patients appeared ambitious and determined, and displayed excitement for their upcoming surgery. Willmer and Salzmann-Erikson highlighted patient beliefs of being granted a 'new life' following the surgery and reported how common it is for patients to anticipate dramatic changes of body and mind following weight loss surgery.(328) Respondents to these types of posts were also seen to recognise and share in the poster's excitement. Willmer and Salzmann-Erikson also reported patients perceiving their surgery as a 'journey' whereby they change from their current weight and end with a happier, "lighter weight-life".(328)

"I look forward to the new me and my new life, I can barely wait" (328)

A common focus of the posts frequently shared by pre-operative patients centred on "the degree of weight loss" they hoped to achieve.(175) Knowledge that life following bariatric surgery often requires a multitude of interpersonal adjustments, resulted in pre-operative individuals creating expectations or goals for themselves to achieve, following surgery.

Whilst displaying signs of motivation and goal-setting, posters also disclosed how they experienced these expectations of weight loss hand-in-hand with anticipation and nerves relating to the surgery. Patients appeared to focus on the end-result of the surgery as one way of settling their nerves, with one participant stating "I'm going to get into that dress" and "(I can) walk into a shop and know that something's going to fit me".(329)

"But just think how unbelievably good it will feel afterwards".(328)

4.3.4 Decision-making and signposting

Online forums enabled patients to seek relatable and supportive advice from other forum members. Even prior to making the decision to undergo surgery, participants were seen to use the forums to discuss their personal suitability for surgery, the types of surgery on offer to them, and the perceived impact of surgery on their lifestyles.(325) The forums facilitated peers the opportunity to offer their thoughts and share (often very personal) first-hand experiences of having gone through surgery themselves. Atwood *et al.* reported that responders reflected personally to these posts around decision-making, using their own real-life examples to contextualise their choice.(263)

> *"I went with a bypass because I already had bad GERD [gastro-oesophageal reflux disease], and the sleeve has been known to increase the amount of reflux you have".(263)*

In their work, Ferry and Richards acknowledged patients were able to draw similarities between themselves and other members' stories.(325) Authors have acknowledged that the online forums enabled participants to bring real-life contexts and informational guidance and advice to positively influence their decision making.(272)

> *"I think my story is similar to many others I've read here… I think I'm finally ready to seriously consider surgery, but I don't know where to start… I'm hoping to hear from all of you how surgery worked for you, so I can see if it can work for me".(325)*

Pre-operative patients were able to post and share information to help them weigh up the benefits and risks of going through surgery; responders were seen to signpost their peers to alternative online sources of information to support their decision-making: "look at the National Institute of Health (NIH) website and journals such as New England Journal of Medicine" and "I looked at the percentage of probable weight loss. I thought this was a great tool for that: [anonymised website address]".(263) Proactively seeking out digitally-delivered information demonstrates the pre-operative motivation of patients undergoing bariatric surgery and their acceptance of using online tools for support.(330)

Pre-operative patients were also seen to use online forums to seek advice and support about their choice of whether to 'go public' with their surgery. The stigma of undergoing weight loss surgery is a common, and often underappreciated, hurdle that patients undergoing bariatric surgery face.(331, 332) With this in mind, it was not unusual to find posters reflecting on their personal decisions with other forum users: “I’ve chosen not to go public with this, except to family and certain friends. What have you done, have you told many people?” and “I’ve also chosen not to go public with what I’m about to do… will do it little by little”.(328) It appears that emotional support closely links to surgical decision-making, possibly affecting individuals more than is recognised within routine clinical practice. Having a way to openly and freely discuss this using online forums appears to be cathartic and beneficial for patients, with peers showing empathy and respect for those seeking pre-operative support.

4.3.5 Supporting information-seeking

Peer forums can play a facilitative role in empowering patient engagement with their own care.(333, 334) Having educational tools and support at their fingertips means that patients with bariatric conditions can actively seek out information at various stages of their surgical journey. For instance, this information may support patients to change their health behaviours prior to surgery, to learn about managing common symptoms following their surgery, or to normalise any ongoing emotions in post-operative life.(272)

Pre- and post-operative patients have been seen to readily post in online peer forums and lead discussion threads online.(175, 263, 272) Despite both sets of patients posting, there was a clear contrast between the nature of information being sought by pre-operative and post-operative patients.(272, 328) This mainly related to their own personal stage and accompanying information needs within the surgical journey. Pre-operative patients used online forums for advice regarding physical preparation for their journey ahead, whilst also seeking to normalise their emotions and nerves in the build-up to surgery.(272) Furthermore, it was common to see pre-operative posts displaying a close affinity to the motivation and anticipation of a new life following surgery.(328) The patients were particularly keen to seek information about how they can improve the outcomes of their surgery. Pre-operatively, patients were particularly receptive to advice given by post-operative peers who had recently gone through the surgical process.

These motivated information-seeking behaviours are demonstrated by patients post-operatively too; however, the content and type of information being sought differed. Unsurprisingly, following surgery many patients utilised the online peer forums to seek information to support their new diet and lifestyle. In a study by Das and Faxvaag, post-operative patients reported that they preferred to seek information *via* the online forum in comparison to liaising directly with their own medical team: “it’s easier to go on here [online forum] ask questions and get answers”.(272) Their preferences may be related to the speed and ease with which answers can be obtained, given the high rate of engagement by forum users and their readiness to share information. In addition to this, post-operative patients have referred to more readily discussing sensitive issues on the forums as opposed to sharing these in a traditional face-to-face group or clinic appointment: “I think it is easier to talk about them [sensitive issues] in a place like this than face-to-face” and “you can be much tougher on the net, write things that you might not want to say to people because they are difficult to talk about. This becomes easier when you have a screen you can hide behind”.(272)

5.3.6 Facilitating connectedness: peer-to-peer social and emotional support

It appeared that examples of peer support on online forums can take two forms, informational and emotional, with both types offered among pre-operative and post-operative users.(175, 263) Posts containing supportive advice aimed at those awaiting surgery appeared to feature heavily in American and Canadian pre-operative forums.(175, 263, 300, 325, 326) They covered a range of content from advice on managing pre-operative diet plans, to tips relating to medicines following surgery and how to be best prepared for the emotional journey ahead of them: “keep your sense of humour. It’ll all be worth it in the end”.(263)

“you may want to pick up a pill crusher and a pill splitter in the drug store…
I had to crush and mix with drink in order to take [my medicines]”(263)

Koball *et al.* reflected in their mixed-methods study, which analysed content on a bariatric surgery Facebook page, that most pre-operative patients used the forum to solicit answers to nutritional and medical questions ($P<0.001$ for both).(175) Post-operative patients were also seen to post on pre-operative forums, offering their personal support as a ‘buddy’ to someone who would be going on the journey: “I would be happy to make this journey with you”,(263) “I would love to be your buddy”,(263) “Believe me, I’ve been there… feel free to message me with any questions".(325) In their qualitative analysis of post-operative patients, Geraci *et al.* reported the thoughts and perspectives of females who were two years post-surgery. Participants noted that their engagement with online support groups came from a desire to inspire and give hope to the "newbies" (newly post-operative patients).(326)

"I want to give people hope that are just starting out and are thinking, 'Will I ever lose the weight?'"(326)

5.3.7 Enabling accessibility and connectivity with healthcare professionals

This is a smaller, yet significant, theme identified in the literature related to online peer forums connecting patients to healthcare professionals. In their study, Das and Faxvaag evaluated the impact of an online portal on interactions between healthcare professionals and fellow patient-peers.(327) They recognised the benefits in connecting the two groups to allow for easier access to evidence-based advice, as well as offering a convenient and geographically independent platform to promote patient engagement.

"I think it is very positive that you can ask questions that are conveyed to a dietician or a doctor because I must admit that picking up the phone and asking someone is very challenging. That barrier–I think it is difficult. What if it's only me? How ridiculous! You get that feeling. Then, it is easier to write online."(272)

A lower threshold for information seeking by patients was also reported, with questions (including those deemed 'sensitive') being more readily asked online as opposed to in face-to-face settings.(327) Das and Faxvaag reported that growing patient familiarity with online platforms may contribute to this, with one patient disclosing "it's easier to go in here, ask questions, and get answers, rather than calling around and stuff".(272)

The forum also gave the healthcare professionals insight into the 'day to day' lives of bariatric surgical patients that they would not normally see in a traditional, time-limited clinic appointment: "it's obvious that one can capture things in the portal that I cannot capture during a consultation" and "you get more information about them here (online) than on the phone".(327)

4.4 Discussion

This review has synthesised the findings from eight studies focusing on the role and value of online peer forums for bariatric surgery patients. Five distinct themes were developed from the existing data which have enabled the identification of possible roles and opportunities of online peer forums in supporting and empowering elective bariatric surgical patients.

Our findings reflect those from previous qualitative studies in wider health and social care literature. The value of peer-to-peer connectedness has been well-documented in other medical specialities, with authors acknowledging the benefits that peer support and shared experiences can offer to improve the quality of life and care satisfaction of patients with cancer and chronic medical conditions.(297, 335, 336) Qualitative studies have demonstrated how online forums can assist in supporting patients' emotional and informational needs.(337) Not only does connectedness with peers enable the provision of informational support, it also allows patients to share emotional support and reassurance to "those like me".(338) In addition, online forums have been shown to offer the opportunity to engage with a vast community of peers, which was regarded as beneficial for anyone socially- or geographically-isolated.(328) Comparisons can be drawn here with the impact of social-isolation during the COVID-19 pandemic and associated 'lockdowns', social distancing and quarantine.(339-341) In their study, Shah *et al.* discussed the use of digital tools as a means of offering social connection during the crisis. The authors reported that digital technologies were supporting with a myriad of social connections across daily lives (through online and remote business consultations, meetings and learning) as well as those relating to health.(339) The authors postulated that, prior to the adoption of peer technologies and online tools, intervention acceptability and affordability should be assessed.(339)

Pre- and post-operatively, patients acknowledged the benefits and value of peer support in helping to maintain their own responsibility and motivation. This is not a new theme in the literature, where social connectedness and peer support has previously been linked with enhanced health outcomes including post-operative weight loss.(320, 342) Further research should seek to explore digitally-enabled peer support in further depth. Atwood *et al.* discussed that the frequency of informational peer support was higher in post-operative forums.(263) They reported that posters readily shared their personal strategies as topics of information, such as ways to manage physical side effects or symptoms following surgery, and posting nutritional advice for adhering to lifestyle adjustments. The authors hypothesised that this information was likely to be reiterated from information provided at bariatric specialist appointments.(263) Given that previous work has found that patients struggle with retaining information provided at specialist appointments,(343) online peer forums could help to reinforce the ongoing educational messages throughout the surgical pathway.

It is well-evidenced that attendance at post-operative bariatric follow-up assessments is poor, with contributing factors relating to travel burden, geographical isolation, and time commitments.(153, 184, 344) Furthermore, patients have reported not seeing the value in post-operative clinics because the surgery had already been completed,(345-348) and some preferred not to share sensitive information about their surgical journey in front of others.(347) Online peer forums can play a role in complementing traditional care and providing ongoing post-operative support, whilst helping to overcome these challenges. Studies have demonstrated that the content of online forums closely matched that of face-to-face clinics, meaning that patients are seeking support with the same subject areas.(319) Perhaps delivering this support *via* an online forum could be a way of overcoming these barriers, providing patients with the peer support exposure they would be given if it were face-to-face, but ensuring anonymity for information sharing.

Internet-based forums, involving both healthcare professionals and patients also existed in the wider literature, previously termed ‘online health communities’.(334) Patients have reported benefits of utilising these online forums for many health-related conditions, as well as bariatric surgery.(327, 349, 350) In their review, into the ‘empowerment effects’ of online forums and peer support groups, Bartlett and Coulson discussed benefits of promoting active collaboration between the patient and their personal doctor.(333) The authors concluded that online forums increase patient empowerment and positively affect patient-provider encounters, leading to beneficial impacts on health-related outcomes and behaviour change. Patients reported increased feelings of accountability and responsibility to adhere to healthier lifestyles and treatment plans as a result of digitally-enabled connectivity with healthcare professionals.(333) These findings are also echoed in the wider health-related literature.(337, 351, 352) This receptivity towards positive health behaviours has also been associated with the concept of 'teachable moments'.(62, 221, 353) A teachable moment is defined as *'an event that creates an opportunity for positive behavioural change'*.(54) Perhaps digital technologies and online peer forums hold value in this, where engagement with providers can opportunistically exploit patient insight to encourage healthy behaviours and empower patients, so as to achieve improved post-operative outcomes.

Despite the advantages that online peer forums contribute to healthcare, there are notable challenges too, particularly in relation to understanding the digital divide and ensuring the accuracy of content and information being shared.(349, 354) The digital divide refers to a gap in the access and use of technology,(355, 356) but with statistics supporting an unprecedented uptake in internet users to over 90%, it could be better interpreted as 'inequalities in understanding and interpreting the information'.(99, 357) The digital divide has been acknowledged as a threat specifically to disadvantaged, minority, and older patients, as well as those with lower socio-demographic status and educational attainment.(356, 358, 359) In their review concerning the digital divide in healthcare, Lopez *et al.* call for the careful design and implementation of digital health interventions, with the potential to eliminate disparities and bridge the digital divide: *"we should ensure that disparities are not simply an afterthought for"* digitally-enabled healthcare.(358) Despite increases in the integration of digital and online interventions, the digital divide is important to acknowledge in order to best support patients.(357, 360, 361)

Sanders *et al.* identified barriers to using online forums, reporting the main factors to be low health literacy, disinterest, and increased costs.(290) Findings reiterate similar barriers as recognised challenges when it comes to the role of online forums for bariatric surgical patients.(272) We must not forget that there continues to be a population who prefer to use face-to-face contact with healthcare professionals or forms of traditional media (such as leaflets or books) as their primary source of health information.(297, 313, 362) Understanding the reasons behind this could be a pivotal finding in overcoming barriers to usability and uptake. This cohort should not be forgotten when it comes to introducing technology-delivered healthcare solutions; there is a risk of minorities falling further behind and widening the gap. Perhaps this supports the argument for implementing digital technologies (like online forums) to complement traditional care, instead of replacing it.

Given the high acceptability (and engagement) of/with online peer forums, it would be prudent to consider the nature of the information shared, and the credibility and accuracy of the posts.(175, 300, 334, 363) Many bariatric surgical forums are dominated by peer-to-peer communication without professional supervision or involvement. In their review, Li and Suh reported that users associated credibility of posts with certain factors; increased presence of particular users (mainly how often they interact with posts) and posts that share anecdotes of personal experiences are perceived to have higher credibility.(299) In another study, the content and accuracy of nutrition posts in a bariatric surgery Facebook group were evaluated.(300) Authors raised concerns about the fidelity of the information posted, and encouraged healthcare professionals to caution patients when interpreting forum discussions.(300) They recognised benefits that may come from a greater healthcare professional presence on online groups, referring to potential roles in moderation of posts and provision of evidence-based recommendations.(300) Further to this, Lindsay *et al.* reported that having a moderator in an online peer support group for heart disease meant patients were more likely to adhere to advice, and thus more readily maintaining healthy behaviours.(364) Similar findings were reported by Graham *et al.*, but this time from the perspective of a bariatric surgical healthcare professional.(298) Members of the surgical team specifically acknowledged that information shared, which originates from other countries may conflict with the advice from UK recommendations, and that discussions about dietary intake may not be adequately tailored for those recovering from bariatric surgery.(298)

There are some limitations with this piece of work. Whilst the findings in this work were strong, the researcher acknowledges that the narrative review was conducted from a small sample size of papers (n=8), given the paucity of data in existence within this subject area. The small number of searches returned (n=28) was recognised as a reflection of the under-researched subject area, rather than a failing of the search strategy; this highlights the importance of conducting further work in this under-studied area to gain greater understanding and contribute to the growing literature base. The role and opportunity of peer forums is an area that would still benefit from further research in the future to grow the available evidence. In a patient cohort with notoriously high attrition rates at post-operative follow-up, and vastly changing needs during their surgical journey, the potential of online peer forums may well be an untapped method of support. Online peer forums could offer one solution to improving post-operative success by supporting and motivating patients. Furthermore, building the amount of literature in this area would enable future researchers to systematically review the data and better appreciate the place of digital support, in a modern healthcare system. Involving patients to determine the optimal design and moderation of online forums will help to maximise usefulness and effectiveness. Members of the bariatric surgery multidisciplinary team may consider recommendations of peer support networks to complement care for patients throughout their surgical journey. Surgical team members should consider the availability of digital support, and the possibilities or detriments this could have for patients before and after surgery.

4.5 Summary of Chapter 4

This chapter is based on a narrative literature review, which was undertaken to further explore the roles, challenges and underutilised opportunities of digitally-delivered peer networking. Findings from this review demonstrate the emerging areas where digital peer support can provide further benefit to surgical patients. Timely focus was also placed on building a greater understanding of the challenges associated with using online platforms for surgical patient support. This is of particular relevance when considering the impact and influence that the COVID-19 pandemic has had upon digitally-delivered healthcare (which is discussed in greater detail in Chapter 9).

Furthermore, in combination with the results of the meta-ethnography in Chapter 3, this chapter presents a finding of focus for future research within this PhD programme of work. Digitally-enabled connectivity with healthcare professionals remains an under-researched area within elective surgery. It is logical to further explore this and consider the impact that this form of networking could have on the cohorts of orthopaedic and cancer surgical patients. This will be explored further in Chapters 6, 7 and 8.

4.6 Summary of the thesis introduction section

Chapters 1 to 4 have explored the effectiveness, roles, opportunities and challenges of using digital technologies to support surgical patients. The introductory work thus far has determined the effectiveness of digital technologies to modify perioperative health behaviours, in relation to improving surgical outcomes. The value of the surgical teachable moment and exploration of behaviour change theory have been introduced with focus needed to better understand the optimal timepoint at which to implement digital interventions within the surgical pathway. Findings from the meta-ethnography in Chapter 3 highlighted potential approaches for digital technology optimisation and placed an additional focus on the holistic role of digital tools to provide psychological support within the surgical journey. The work from this narrative review chapter has also helped to gain a greater understanding of the theme of peer support and considered the integration of connective functionalities within technologies, whilst indicating the need for further exploration of the area.

Altogether, these chapters have incorporated the findings from three published systematic reviews and one published commentary piece. Further in-depth evaluation of patient perspectives, desires and suggestions is now needed to contribute to the understanding of how best to optimise these technologies for the intended end-users – the patients undergoing surgery. From the findings of the evidence syntheses undertaken thus far, the researcher specifically aims to (i) understand what further opportunities exist to support healthier lifestyle behaviours in the surgical pathway; (ii) explore views from people who are currently going through the surgical journey (either pre- or post-operative) to gather understanding about lifestyle behaviour change and also what benefits and challenges may exist around using technologies to do this; and (iii) begin to identify whether technologies can be designed in a way that best supports patients, whether it relate to the design, functionality or capability. The researcher also aims to draw on the findings gathered above to begin making recommendations that may inform policy and practice. Overall, the aforementioned goals will shape the clear aims and objectives within the methodology of the empirical work.

The upcoming chapters of this PhD programme of work aim to introduce and deliver patient-informed research that showcases the perspectives of the people at the centre of the surgical journey; specifically, concerning the use, design, capability and optimisation of digital technologies during the pre- and post-operative period to support lifestyle changes, with the goal of improving patient outcomes.

As in previous chapters, this work will consider the three specialities of bariatric, cancer and orthopaedic surgery. However, more specifically for the upcoming empirical studies, the decision was made to focus on lung cancer surgery (rather than a culmination of numerous cancer types). It was deemed important to view 'cancer' more broadly in the introductory work of this thesis to better understand the role of digital technologies across a whole disease spectrum. However, it became apparent to the researcher that, in order to explore the views and experiences of participants in depth and detail, it would be sensible to align with one clear speciality that falls under the umbrella of 'cancer surgery'; doing this meant that the researcher could become familiar with the 'typical' surgical pathway and, thus, findings and recommendations could be made that clearly align with current practice. Therefore, the decision was made to focus on surgery for lung cancer – this choice was influenced by a combination of: (i) clinical evidence (in the knowledge that lung cancer surgery has strong links to lifestyle behaviours, such as smoking); (ii) pragmatism in recruitment during the pandemic (in that Mr Robert Slight, from the PhD supervisory team, was a cardiothoracic surgeon and operated on patients diagnosed with lung cancer), and (iii) personal interest of the researcher.

The next chapter of this thesis will introduce and describe the study design and methodological approach taken for these patient-informed qualitative research studies, which involved 54 patients across the pre- and post-operative period.

Chapter 5: Methodology, methods and study overview for the three patient-informed qualitative research studies

5.1 Introduction

This chapter outlines the aim and objectives of the three patient-informed qualitative research studies in this PhD programme of work. The chapter will begin by stating the rationale, research question, aim and objectives of the studies (which is the same for all three surgical cohort specialities), followed by details on the methodological approach used for the studies. Validity, reliability and reflexivity are also discussed later in the chapter.

The methodology and methods discussed in this chapter will be applied and adopted to the three studies that make up this research project, covering bariatric, orthopaedic and lung cancer surgeries. Each cohort will be treated as an independent study; the results and discussions of each will be examined in the subsequent three chapters of this thesis.

5.2 Rationale

As detailed in the previous chapters, the wider background reading, two systematic reviews, narrative review and commentary piece all considered the role of digital technologies to support elective surgical patients with health behaviour change to improve post-surgical outcomes. By coalescing the key findings of these pieces of work, the following statements remain evident: (i) digital technologies remain an under-utilised resource within the healthcare sector, where the potential for remote support is still unmet; (ii) there remains a lack of evidence concerning the perspectives of surgical patients as end-users of digital technologies; and (iii) there are still unknown elements of what constitutes as 'optimal' digital approaches for differing surgical cohorts, specifically the timing of the technology implementation, continued use, and overall duration.

To develop useful and effective digital technologies and strategies, it is important to first understand how patients want to be supported during their care. The patient-informed research applies qualitative investigation to explore the perspectives of both pre- and post-operative patients, *i.e.,* those who are experiencing, and have experienced, the surgical journey. By doing this, the researcher's intention is to identify key technology use, design and functionalities that would optimise the health and lifestyle behaviours of surgical patients. In doing so, this has the potential to influence and improve surgical outcomes.

Three studies (the results of which are shared in Chapters 6, 7 and 8 respectively) were designed to address and shed further light on the aforementioned statements. The researcher has created a person-centred focus to this research, by producing three patient-informed pieces of work. By identifying and better understanding the perspectives and opinions of surgical patients, this work contributes to the growing body of digital health technology literature and its implementation within a transformative, modern healthcare system.

5.3 Overarching research question

How can the use of digital technologies be optimised within elective surgical pathways to best support patients in making healthier lifestyle changes, to positively influence outcomes?

5.4 Aim and objectives

5.4.1 Aim

To understand how digital technologies can be used within the elective surgical pathway to support patients to make healthier lifestyle changes, to improve post-surgical outcomes.

5.4.2 Objectives

1. To identify what opportunities there may be to support healthier lifestyle behaviours in the surgical pathway;
2. To explore the views and perspectives of elective surgical patients on changing their lifestyle behaviours, and whether these views vary between different surgical specialities;
3. To explore what role digital technologies can play in supporting patients to change their lifestyle behaviours, and what challenges these technologies may also present;
4. To highlight areas of 'optimal practice' in relation to the design, functionality and capability of digital technologies for elective surgical patients;

5. Draw on the key findings above to make recommendations that inform future policy and practice relating to the use of digital technologies within elective surgical pathways.

5.4.3 Research questions

Our key research questions concerned:

What would make digital technologies (more) effective for elective surgical patients? Specifically:

- ***What*** would patients want from digital technologies?
- ***How*** do they want to use them during the surgical journey?
- ***When*** is the optimum 'time point' to implement/integrate digital health technologies within the surgical pathway, to support and promote healthier lifestyle behaviour change?

The following sections within this chapter detail the methodological and analytical approaches undertaken for this programme of work. This also comprises a rationale for the inclusion of each methodology and method, as well as comparisons to alternative methodologies and methods.

5.5 Methodological approach

The findings from the systematic review in Chapter 2, the meta-ethnography in Chapter 4 and the narrative review in Chapter 5, enabled the researcher to further identify clear and distinct gaps in the literature where the PhD programme of work could contribute. To best understand how digital technologies can be better used to improve surgical patient health behaviours, a qualitative methodology was selected to meet the aims and objectives of this research project.

By employing a qualitative methodology, it allowed for detailed understanding of the participants' experiences of, attitudes towards, and opinions on, digital technologies in elective surgeries.(365) The richness and depth of data that can be collected by qualitative research can help inform new understanding and practice when it comes to transforming digital healthcare; the researcher believed this would best answer the *what, how* and *when* research questions. This qualitative methodological approach was decided in contrast to a quantitative one. Quantitative research may have helped to measure outcomes from a hypothesis, but would have failed to offer the sought after, deeper insight and understanding into the perspectives behind patient engagement with digital technologies.

An interpretivist approach was adopted by the researcher. This approach assumes that reality is developed through social constructs and experiences, where meanings and understandings can be influenced and shaped from historical experiences.(366, 367) Rather than beginning the work with an existing theory, this approach enabled the researcher to make sense of meanings within the data.(368) For this research programme of work, two qualitative methods were employed. The following section offers further insight into these methods and the rationale for their use.

5.6 Qualitative methods for data collection

To address the study objectives and answer the research questions, a range of data collection methods were considered for this project. Semi-structured interviews were chosen by the researcher as the primary technique in collecting data. These were complemented with a research journal that was kept by the researcher during the data collection and analysis period. The rationale for choosing these methods, and the advantages and disadvantages of these and alternative options, are described in further detail below.

5.6.1 Semi-structured interviews

Semi-structured interviews were chosen for this research, over structured or unstructured interviews. The reason for this was due to their flexibility. As the name suggests, being semi-structured meant there was still an underlying structure to the interview. However, this structure was based around a flexible interview schedule (Figure 7), which allowed for exploration into other areas depending on the participant responses.(369) This was deemed important for the cohort being investigated as it was likely that the experiences and perceptions would differ between surgical cohorts, pre- and post-operative timepoints, and individual patients themselves. That way, the researcher could use the semi-structured interview guide to adapt the line of questioning to each participant.

During the semi-structured interviews, participants were asked a mixture of open and closed questions, which enabled them to describe their perspectives and experiences in their own words. Open questions allowed in-depth answers to be given and a rapport to be built between the interviewer and the interviewee. In addition to this, using semi-structured interviews allowed for topics to be explored in detail; the participant was able to discuss their opinions freely, whilst not being constrained by space as they might be if using a questionnaire or survey. However, one disadvantage of the semi-structured interview method is that they can be challenging for both researchers and participants, particularly if the subject matter is sensitive or if the interview becomes lengthy or deviates from the topic of discussion.(370)

An interview schedule was created and used in all semi-structured interviews across the three surgical cohorts. The schedule listed topics to cover within the interview and included possible example questions that could be asked or adapted. It also served as a plan for the interview and provided the researcher with a logical order and flow to ensure key areas were covered. This interview schedule was carefully developed by the researcher based on pilot interviews conducted with participants from each surgical cohort, as well as key findings identified in the background/introductory work of this project, including the systematic review (Chapter 2), the meta-ethnography (Chapter 3) and the narrative review (Chapter 4).

The interview schedule covered the topics of: health and lifestyle behaviours; digital technology perceptions; technology integration and timings; and methods of technology support. Specifically, example questions to guide the researcher explored:

- Participants' awareness of perioperative lifestyle behaviour change;
- Perspectives on digital health technology use within the surgical pathway;
- Ideas around what would make an 'optimal' technology for them and other surgical patients in their cohort (*i.e.,* the technology design, features, functionality and when (timing) it should be integrated within the surgical journey).
- N.B. it is important to note that the researcher took time to explore each participants' prior use of technologies when discussing perspectives of using digital strategies during the surgical period; a person who did not regularly engage with technology would not be excluded from this study (in fact, it was deemed an appropriate route of investigation to further explore if a person did not use technology, as this may present barriers or reasoning of great interest which could contribute to the study). Taking this stance was deemed inclusive and appropriate by the Newcastle University

Patient and Public Involvement and Engagement Group (PPIE) and the NHS Ethics Approval panel when considering the potential for variation in access to digital technologies (as discussed later in Section 5.9.3).

The interview topic guide is demonstrated in Figure 7.

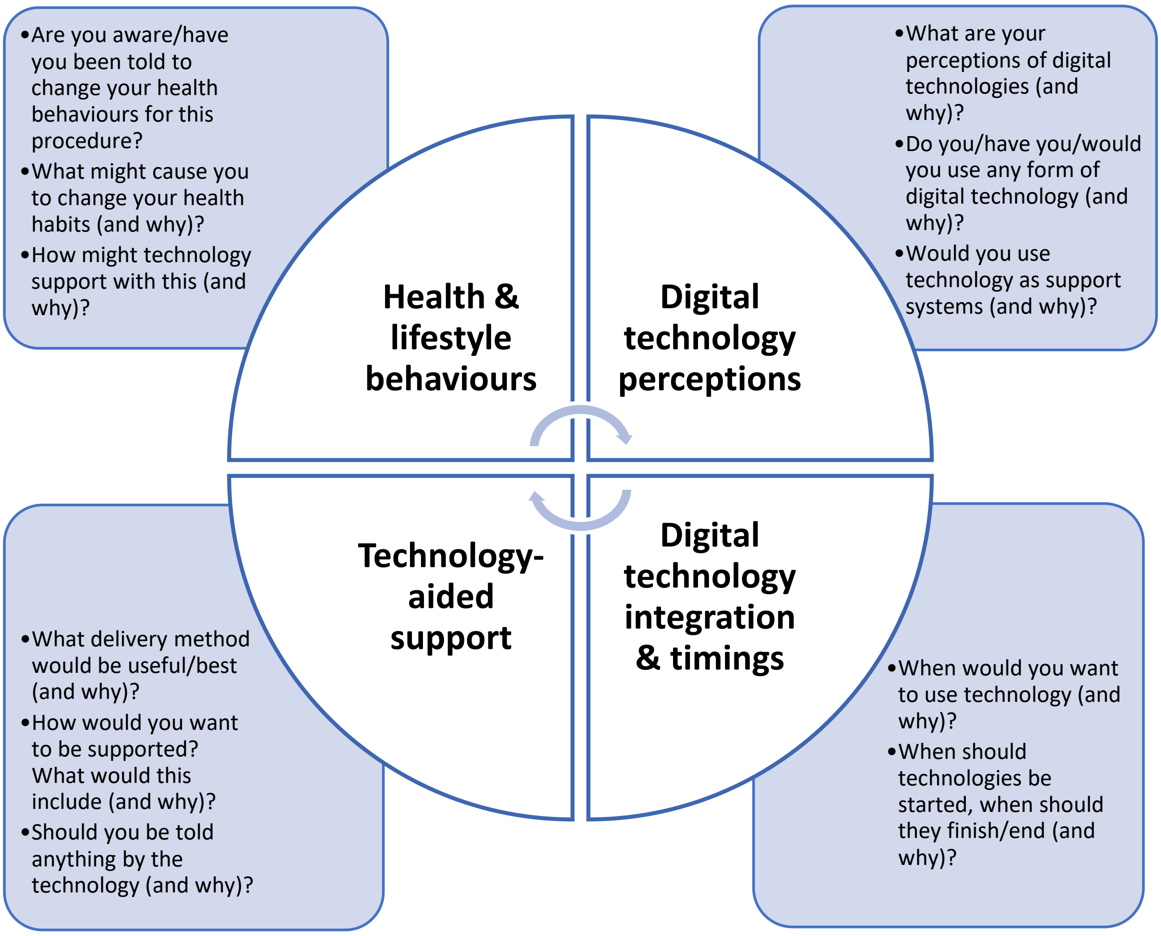


Figure 7: The semi-structured interview topic guide used for all interviews across the three surgical specialities.

5.6.2 Research journal

To complement the data collection achieved through semi-structured interviews, the researcher used a research journal. This hand-written journal, which noted personal reactions, field notes and participant remarks, was kept throughout the data collection and analysis process (see Figure 8). This was done to provide reminders of significant phrases or timepoints within each interview and to note any non-verbal participant reactions. Each entry in the journal included the date and time of the research collection, as well as any contributing bias or factors, which may have influenced the credibility of interview data. The research journal was continually re-read and re-visited during the periods of data collection and data analysis, supporting the in-depth examination of findings from each interview.

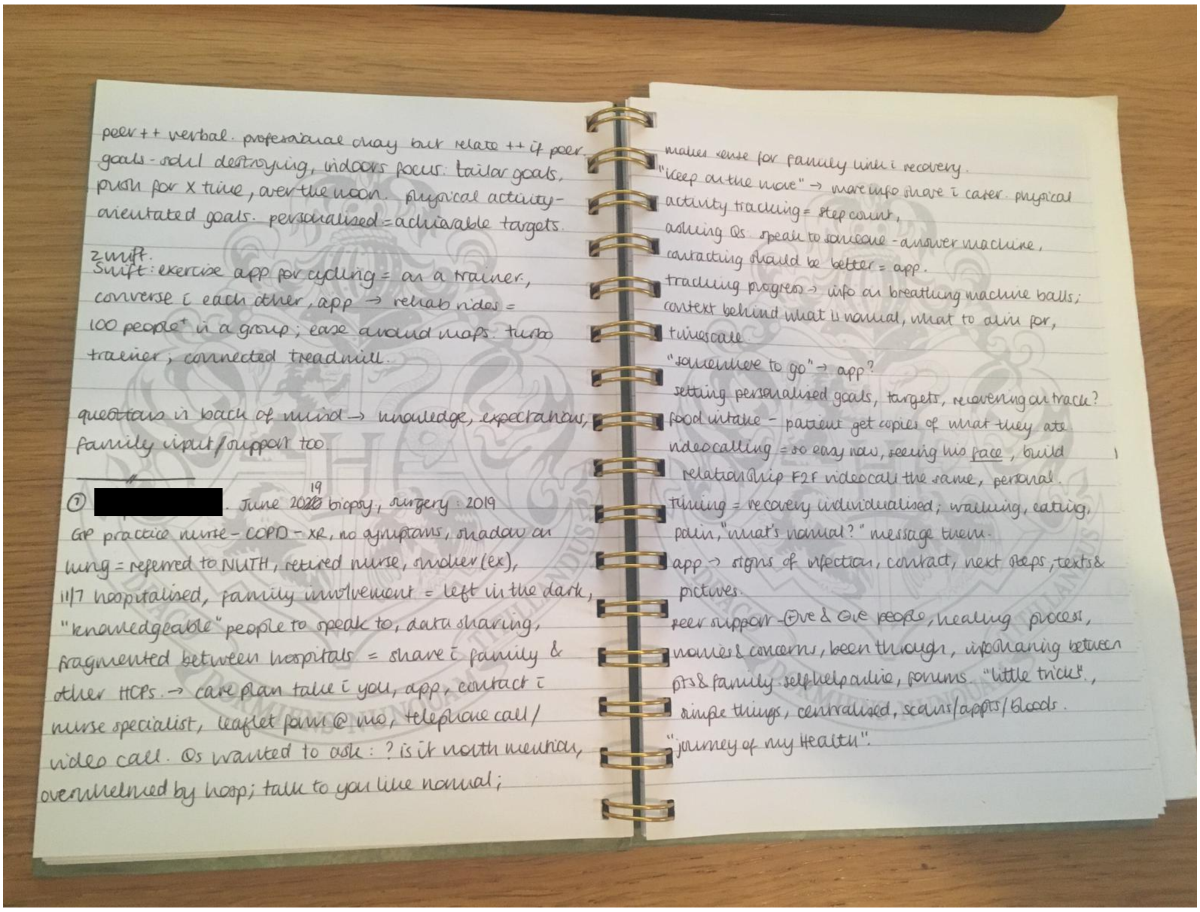


Figure 8: Example of a page from the researcher's research journal following an interview with a patient undergoing lung cancer surgery.

5.6.3 Transcription and use of quotes

The semi-structured interviews were transcribed verbatim by the researcher; this was to ensure thorough familiarity with the data (as detailed in step 1 of the rTA process). The following transcription annotations (detailed in Table 15) were used to produce the transcripts. Any identifiable information was removed at the point of transcription. Recordings of participant interviews were destroyed once transcribed. When it came to using the direct quotes from patients in the results chapters to come (Chapters 6-8) and any associated publications, non-identifiable pseudonyms were used to ensure confidentiality, *e.g.,* participant 1, participant 2 and so forth.

Table 15: Transcription annotations

Annotation	**Context for use**
Square brackets […]	1. To anonymise the transcript if a name is used during discussion, for a person, hospital Trust or identifiable location, *e.g. "…I had my surgery at [name of Trust] ..."* 2. For grammatical correction, *e.g.* if 'had' was used instead of 'have', it would appear in the transcript as *"… had [have] …"* 3. In the use of [sic], the Latin adverb, which is inserted after a quoted word or passage to indicate that the quote has been transcribed exactly as it was spoken by the participant.
Circle brackets (...)	1. To define abbreviations, shortened words, or medical jargon used by participants, *e.g. "… pre-op (pre-operative, before surgery) …"* 2. To provide insight into participant emotions, *e.g.* (laughs)
Ellipsis …	1. To demonstrate a pause in speech, *e.g.* when a participant is thinking before answering

The purpose of this section was to identify the chosen qualitative methodology and methods to underpin the data collection; including the rationale for excluding alternative methods. The following section will detail the analytical approach employed for data analysis.

5.7 Qualitative methods for data analysis

5.7.1 A reflexive account of the researcher

Reflexivity relates to the sensitivity to which the researcher and the research process may shape the data collected. This considers the prior role and experience of the researcher, which may contribute to their subjective data analysis.(371) Within the context of this work, the researcher needed to consider the ways in which her interactions with participants might be influenced by her own professional background, experience, and assumptions. Significantly, researcher subjectivity is grounded within the processes of reflexive Thematic Analysis (rTA). Braun and Clarke state that there is an 'inescapable subjectivity of data interpretation' and encourage appreciation of the researcher's reflexivity within the process.(372) The authors acknowledge that the development of themes requires considerable analytic and interpretive work and thus conclude that the themes 'cannot exist separately from the researcher – they are generated by the researcher through data engagement mediated by all that they bring to this process (*e.g.* their research values, skills, experience and training)'.(372) Thus, it was deemed important to include a reflexive account of the researcher when introducing and detailing the processes of rTA.

For analysis purposes, rTA is characterised by its foregrounding of researcher reflexivity, and encourages reflection on how the researcher's prior knowledge might have shaped her interpretation of the data. For data collection purposes, it was important to consider whether knowing about the researcher's healthcare professional background could have impacted on participants openly discussing their experiences of surgeries. The researcher's previous professional role is of note here, where she has experience of working as a surgical pharmacist and interacting with patients at various stages within their perioperative journey; this experience may contribute additional insight and understanding. The researcher was introduced to the patients as a 'PhD student conducting research, working externally to the Trust and team' where the surgery was performed. There was no prior relationship established between the researcher and participants prior to study commencement or recruitment. To consider this, the research team ensured that processes of data triangulation and peer debriefing (as described in Section 5.8) were employed throughout.

5.7.2 Reflexive Thematic Analysis: the rationale

An rTA approach was adopted for this programme of work. According to Braun and Clarke, the umbrella term of 'thematic analysis' is a research method in its own right.(371) Thematic analysis does not refer to one singular approach to data analysis, but rather to a cluster of approaches, which share common interests in capturing and identifying patterns in the data. rTA can be employed to answer both broad or narrow research questions about experiences, views and perceptions – making it an appropriate choice of analytical approach to address the aforementioned aims, objectives and research questions. rTA differs from most other approaches to thematic analysis, particularly in the procedures for data coding and theme development. Patterns of meaning within and across a dataset can be identified through rigorous processes of data familiarisation, coding, theme generation and development, and continual review.(371) This means that the analytical approach is an interpretative, inductive and continually reflexive process (as the name suggests). rTA is characterised by its acknowledgement of researcher subjectivity, emphasising the importance of embracing reflexivity within the analytic process.(371, 373) A more detailed appreciation of the rTA method and the researcher's reflexivity is included below.

5.7.3 Reflexive Thematic Analysis: the process

Within rTA, the coding process is integral to theme development. Braun and Clarke discuss that 'themes are an 'outcome' of these coding and theme development processes' and that they are developed through coding that is open and organic, without a coding framework.(371) This discounts the view that pre-conceptualised themes are already present within the data, waiting to be found. Instead, the analytic process involves immersion within the data, reading and reflecting,(374) familiarising oneself with the data and questioning the meanings within participant responses: 'time and space with the data help to develop the nuanced analyses that reflexive thematic analysis can deliver'.(371)

When applying rTA to this PhD research, the six-phase process for data engagement, coding and theme development was used to guide the analysis (as seen in Figure 9). This entailed: 1) familiarisation with the data; 2) systematic data coding; 3) generation of the initial themes by collating similarly (descriptively) coded data; 4) reviewing and developing themes; 5) refining, defining and naming the themes; and 6) writing the analysis report. Each phase was conducted sequentially, but the analysis was considered recursive, with movement back and forth between different phases. Time and headspace with the data was needed in order to identify and develop complex themes.(374)

Step 1 of the rTA process was aided through transcription; the researcher transcribed all interviews in this programme of work. In addition to the process of transcription, continual reading and re-reading of the transcripts ensured that the researcher held a close familiarity with the data. To achieve step 2 of systematic data coding, each transcript was printed on A4 paper and handwritten annotations were added (as demonstrated with examples of Figures 10 and 11). These annotations were used to identify the initial descriptive ideas and codes. By no means were these the final codes used, but this was a valuable step for the researcher to recognise the main ideas in each part of the transcript, before stepping back and identifying overarching findings. The researcher worked through each transcript individually, working iteratively and inductively, before conducting the next interview. After identifying the descriptive codes, deeper connecting descriptions between the transcripts were identified by the researcher. Importantly, in their 2020 paper which discussed quality practice in rTA, Braun and Clarke state that 'a code is conceptualised as an analytic unit or tool, used by researcher to develop (initial) themes' whereas themes are 'patterns of shared meaning, united by a central concept or idea'.(371)

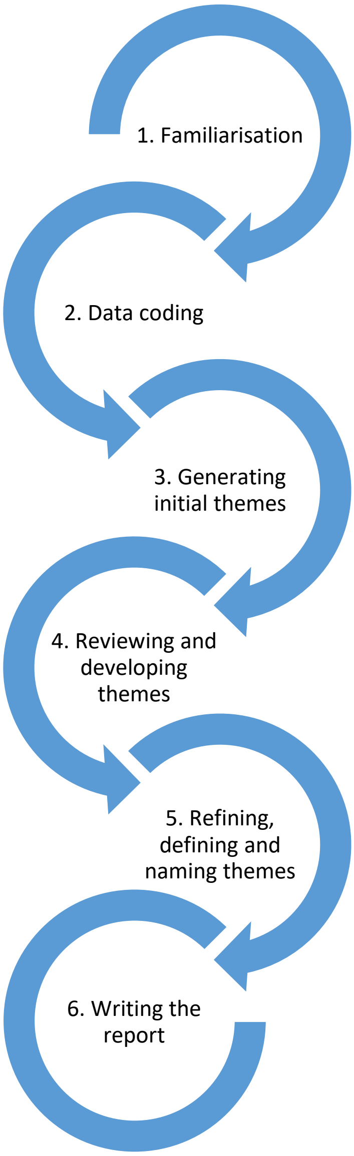


Figure 9: A simplified diagram to represent the six-step approach to thematic analysis, as developed by Braun and Clarke

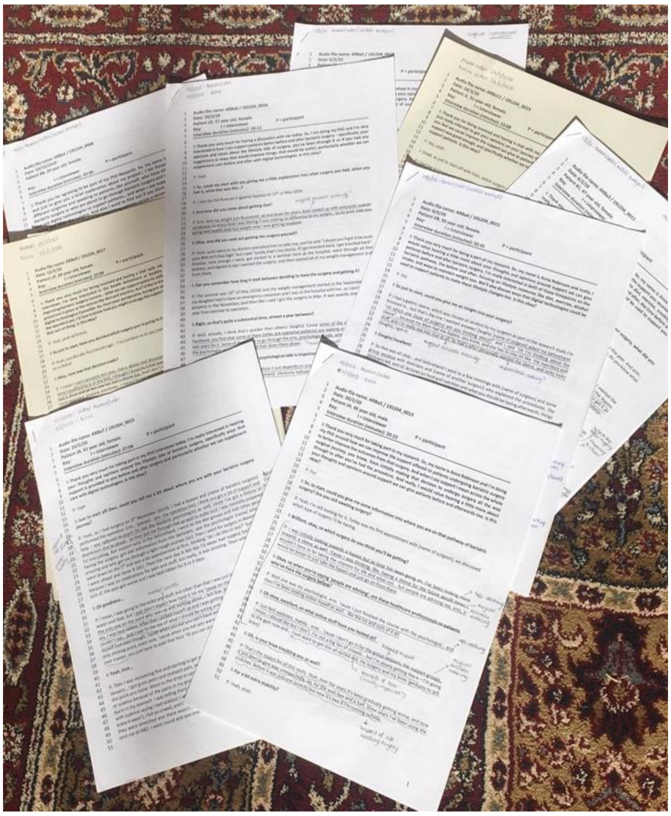
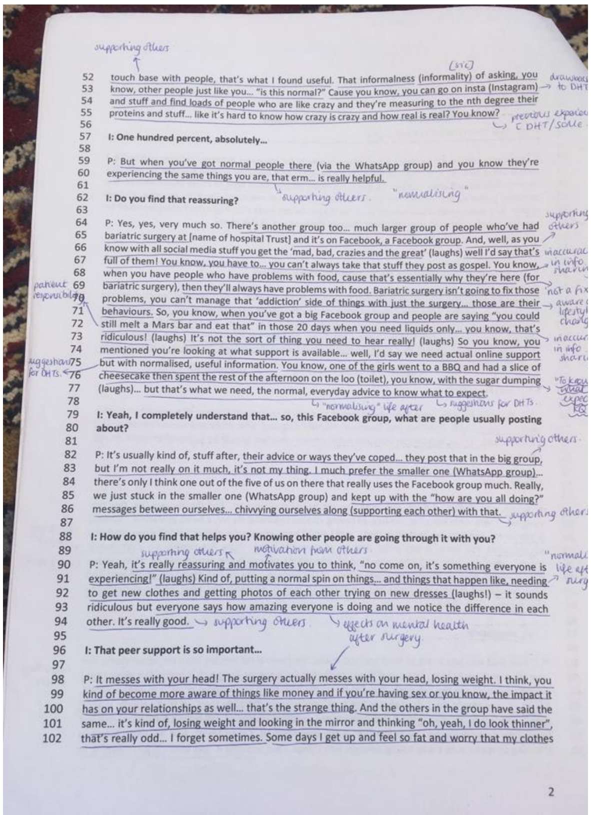


Figure 10: A selection of typed transcripts from patient interviews



touch base with people, that's what I found useful. That informalness [sic] (informality) of asking, you know, other people just like you... "is this normal?" Cause you know, you can go on insta (Instagram) and stuff and find loads of people who are like crazy and they're measuring to the nth degree their proteins and stuff... like it's hard to know how crazy is crazy and how real is real? You know?

I: One hundred percent, absolutely...

P: But when you've got normal people there (via the WhatsApp group) and you know they're experiencing the same things you are, that erm... is really helpful.

I: Do you find that reassuring?

P: Yes, yes, very much so. There's another group too... much larger group of people who've had bariatric surgery at [name of hospital Trust] and it's on Facebook, a Facebook group. And, well, as you know with all social media stuff you get the 'mad, bad, crazies and the great' (laughs) well I'd say that's full of them! You know, you have to... you can't always take that stuff they post as gospel. You know, when you have people who have problems with food, cause that's essentially why they're here (for bariatric surgery), then they'll always have problems with food. Bariatric surgery isn't going to fix those problems, you can't manage that 'addiction' side of things with just the surgery... those are their behaviours. So, you know, when you've got a big Facebook group and people are saying "you could still melt a Mars bar and eat that" in those 20 days when you need liquids only... you know, that's ridiculous! (laughs) It's not the sort of thing you need to hear really! (laughs) So you know, you mentioned you're looking at what support is available... well, I'd say we need actual online support but with normalised, useful information. You know, one of the girls went to a BBQ and had a slice of cheesecake then spent the rest of the afternoon on the loo (toilet), you know, with the sugar dumping (laughs)... but that's what we need, the normal, everyday advice to know what to expect.

I: Yeah, I completely understand that... so, this Facebook group, what are people usually posting about?

P: It's usually kind of, stuff after, their advice or ways they've coped... they post that in the big group, but I'm not really on it much, it's not my thing. I much prefer the smaller one (WhatsApp group)... there's only I think one out of the five of us on there that really uses the Facebook group much. Really, we just stuck in the smaller one (WhatsApp group) and kept up with the "how are you all doing?" messages between ourselves... chivvying ourselves along (supporting each other) with that.

I: How do you find that helps you? Knowing other people are going through it with you?

P: Yeah, it's really reassuring and motivates you to think, "no come on, it's something everyone is experiencing!" (laughs) Kind of, putting a normal spin on things... and things that happen like, needing to get new clothes and getting photos of each other trying on new dresses (laughs!) – it sounds ridiculous but everyone says how amazing everyone is doing and we notice the difference in each other. It's really good.

I: That peer support is so important...

P: It messes with your head! The surgery actually messes with your head, losing weight. I think, you kind of become more aware of things like money and if you're having sex or you know, the impact it has on your relationships as well... that's the strange thing. And the others in the group have said the same... it's kind of, losing weight and looking in the mirror and thinking "oh, yeah, I do look thinner", that's really odd... I forget sometimes. Some days I get up and feel so fat and worry that my clothes

2

Figure 11: An example of a section of transcript with handwritten annotations of descriptive codes.

Step 3 involves examining the codes and collated data to identify significant broader patterns of meaning, *i.e.*, the potential themes. It involves collating the data relevant to each idea of a theme and leads into Step 4 of reviewing the themes. Specifically, to aid steps 3 and 4 of the reflexive thematic analysis process, a technique termed 'One Sheet of Paper' (OSOP) was used (as demonstrated in Figures 12 and 13). This involved using one single sheet of paper to collate similar and connected codes and search over overarching themes.(375) This method enabled the continual development and review of overarching themes from the data. By doing this, the researcher was able to visually appreciate the dispersion of data and closely develop themes. Once developed, the themes were reviewed, defined and refined until they were coherent and distinctive (Step 5).(376) Throughout the data analysis process, NVivo 12 software was used for data management. Within the software, the researcher also utilised the project journal function to log thoughts and ideas as time progressed. Continual review, at all stages of the process, were resolved through regular discussion with the supervisory team.

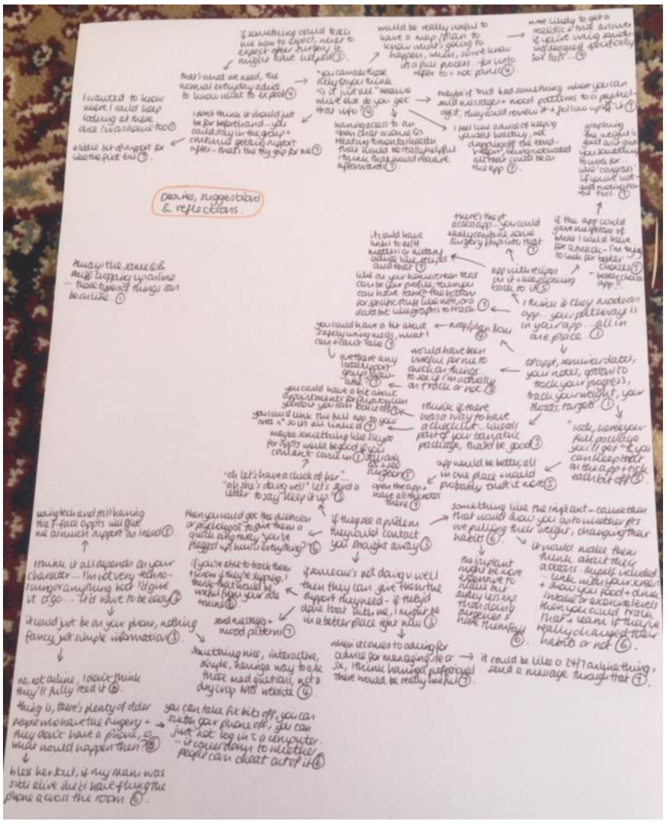


Figure 12: Early stage OSOP for the overarching theme of 'desires, suggestions, and reflections' of bariatric surgery patients. N.B. these are participant quotes followed by the interview number (circled).

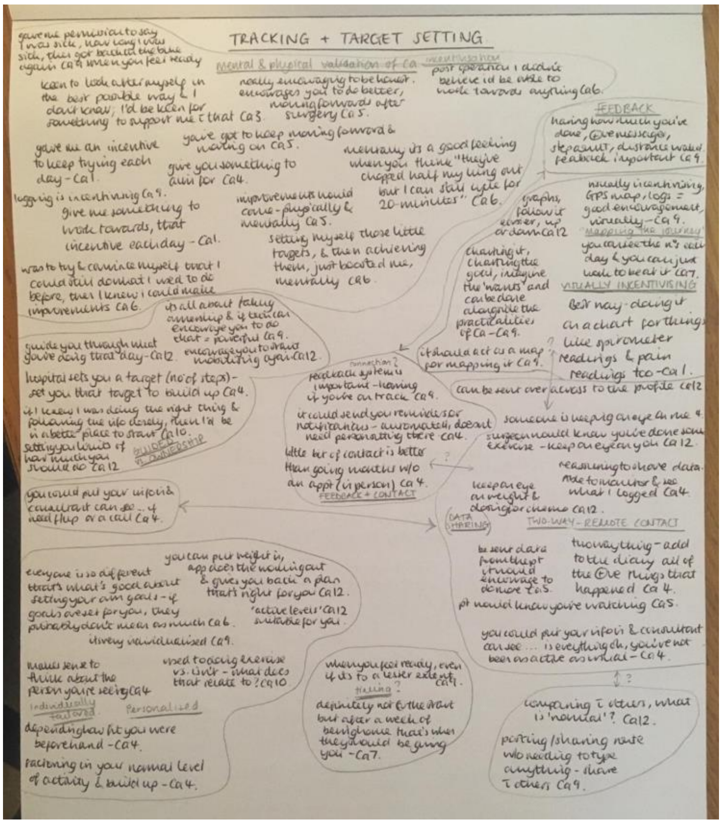


Figure 13: A finished OSOP for the theme of 'tracking and target setting' from interviews with patients undergoing lung cancer surgery. Similar quotes are grouped together to identify common codes and themes.

The researcher conducted, and analysed the data from, each empirical study separately; the way in which this has been presented in the thesis represents the chronological order in which the qualitative studies were performed (*i.e.,* beginning with the bariatric surgery study, then orthopaedic surgery and finishing with the lung cancer surgery study). The decision to conduct the research and data analysis sequentially meant it enabled the researcher to be fully immersed in the 'surgical cohort experience' of each study at any one time; thus, helping to better understand and relate to experiences being shared. Further, the researcher could work iteratively – both in the time between each interview within the study itself, as explained above, but also in the overarching research process where findings and practicalities from the first empirical study informed the subsequent ones. For example, the researcher reflected on her dress code and appearance between the first empirical study to the second and third – postulating whether an informal dress code/appearance may help participants feel at ease, compared to formal dress which they may associate with a paternalistic style of consultation; this is further discussed below.

5.8 Credibility and trustworthiness of the data

5.8.1 Sampling techniques and approaches

Care was taken when selecting the sampling technique for this work to directly relate to the type of study, the research question and the type of evidence sought. As is common in qualitative research, a purposive sampling approach was employed in this programme of work. By applying this approach, it meant that a wide and representative sample of both pre- and post-operative patients, usually treated within each surgical cohort, were included.

Across the three cohorts, the researcher sampled a population of patients deemed representative for that specific surgery type; this spanned participant sex, age, occupation and their timing across the surgical pathway (both pre-operatively and at staged intervals post-operatively). Purposively, the researcher sought to ensure representation across the board.

During the height of the governmental lockdown, in response to the COVID-19 pandemic, the researcher needed to also implement a 'convenience' sampling approach to ensure participants were recruited to the study. This decision to use a convenience sampling approach was one of pragmatism, and specifically applied to the orthopaedic and lung cancer surgical cohorts. For the orthopaedic surgical group, the researchers utilised their personal networks on social media to reach out to eligible people who had recently undergone, or were undergoing, orthopaedic surgery. For the lung cancer surgical cohort, the professional network of the supervisory team enabled the researcher to have access to patients who were attending a surgical lung cancer clinic; this was made possible as Mr Robert Slight (supervisor) was the consultant running this clinic. Both convenience methods of sampling received approval from the HRA Ethics Committee and were viewed as necessary but appropriate work-arounds from the initial planned approach, given the impact of the pandemic.

Across all data collected, and as explained in section 5.6 with regards to reflexive thematic analysis, early codes were descriptive rather than definitive, and after a period of clustering similar coding data, themes began to be refined and defined. This recursive, constant comparative approach maintained the emergent nature of inductive, qualitative research and strengthened the development of themes.(377, 378) During data analysis, the contributions from each speciality was considered as equal (no one group's perspectives were privileged over another). Data analysis occurred iteratively, as part of constant comparison between all participants' accounts. This meant that any similarities or differences between the data were uncovered, highlighted, and subsequently analysed.

5.8.2 Information power and data sufficiency

It then follows that participant sampling and recruitment continues until data sufficiency is achieved – where no new information is added from subsequent interviews.(379) In qualitative literature, thematic saturation has been thought to occur after 12-14 interviews.(380) Lincoln and Guba suggested that '*a dozen or so interviews, if properly selected, will exhaust more available information; to include as many as twenty will surely reach well beyond the point of redundancy'*,(381) and Braun and Clarke recently echoed Malterud in that '*interpretive judgement*' is needed when determining sample size in qualitative interview studies; this is deemed to depend on the subject area, as well as the depth and the complexity of the data.(382, 383) The researcher observed that information power and data sufficiency was achieved at a slightly different points for each of the three surgical patient cohorts; for instance, occurring after 20 interviews with patients in the bariatric surgical cohort, compared to 18 in the orthopaedic surgical cohort and 16 in the lung cancer surgical cohort. Agreements of when information power and data sufficiency was achieved were made between the researcher and the supervisory team through regular supervisory and peer debriefing discussions.(383)

5.8.3 Peer debriefing

Throughout the phases of data collection and data analysis, all emerging and developing themes were discussed with the supervisory team. Peer debriefing is defined by Creswell and Miller as *'the review of the data and research process by someone who is familiar with the research or the phenomenon being explored'*.(384) The aim of the peer debriefing sessions was to identify any unconsidered concepts or highlight areas of bias. The impartial examination of transcripts, reports and methodologies meant that feedback was offered throughout. As well as discussing with the supervisory team, findings from this work were presented to fellow researchers and disseminated at conferences, opening opportunities for review by external individuals. In addition, much of the work for this thesis has been published (including the results chapters), meaning that it has been subject to thorough peer-review processes. These strategies have helped to seek credibility in the analysed findings and to ensure trustworthiness of the data.

Patient and public involvement and engagement groups (PPI/E), including VOICE Global at Newcastle University, provided valuable input into the study conception, design and the language used for all study materials and presentations. In addition, semi-structured interviews were analysed alongside the researcher's journal to validate emerging findings.(385, 386)

5.8.4 Confirming and disconfirming instances

Confirming and disconfirming instances were identified after early stages of data collection and analysis had been conducted. Confirming cases (sections of data that served as additional examples to further support emerging trends) were acknowledged. Disconfirming instances (sections of data which did not fit the emerging trends) were actively sought and examined. Seeking out confirming and disconfirming instances enabled the development of a richer, more in-depth understanding of the participant perspectives, whilst further supporting the credibility of the research.(385, 387)

5.8.5 Transparency: clear account of methods

This chapter sought to clearly demonstrate the methods process for data collection and analysis in this study. The same is said for any papers published from the findings of the study. According to Armstrong *et al.*, '*it has been accepted that different analysists, with different theoretical commitments, will organise codes into themes in different ways'*.(388) Ensuring transparency in research methods means this does not become problematic.(385, 389) A diagrammatic overview of the six-phase process of reflexive thematic analysis was provided in section 5.7.3. Use of this diagram enables the reader to follow the process that led to the development of themes from the research data (see Figure 7). Papers were published in peer-reviewed journals, and findings shared at international and national conferences throughout this PhD programme of work, enabling the dissemination of results to a wider audience in a transparent manner.

5.9 An overview of the programme of work: three patient-informed qualitative studies

This programme of work consisted of three separate studies covering (i) bariatric, (ii) lung cancer and (iii) orthopaedic surgery, respectively.

It is intended that all three of these studies combine under the umbrella of the patient-informed qualitative study component of this thesis. All three studies were approved by the NHS Health Research Authority ethical approval panel (under the same ethical approval application, reference: 19/NE/0318). The three studies were undertaken and conducted at separate times so as to enable the researcher to be fully immersed in each surgical speciality, and the relevant interview data, before moving onto the next. The aim of these research studies was to explore patient suggestions, reflect on their real-time surgical experiences and collect and collate their perspectives of using digital health technologies to support them during the perioperative surgical pathway. The following research was undertaken across two large teaching hospitals in the North of England. The findings of each study within this programme of work have been published in peer-reviewed digital health journals and the results and discussions of each are detailed in full in chapters 7-9.

5.9.1 The study sites

The study took place across two large teaching hospitals within the North East of England, (i) the Newcastle Upon Tyne Hospitals NHS Foundation Trust and (ii) South Tyneside and Sunderland NHS Foundation Trust.

- Newcastle Upon Tyne Hospitals NHS Foundation Trust (NUTH) is the regional lead for cancer surgeries *via* the Northern Centre for Cancer Care (at the Freeman Hospital). The team supporting this study were based in cardiothoracic surgery, where lung cancer operations were routinely performed; it was from this patient cohort that participants were sampled and included in this arm of the study.

- South Tyneside and Sunderland NHS Foundation Trust (STSFT) hosts one of the regional lead centres for bariatric surgery and surgical weight management in the North East. The researcher attended a multidisciplinary team meeting to introduce herself to the members of the bariatric surgery team; the participants included in this arm of the study were sampled from the surgery clinic lists of numerous surgeons working in the team.
- As a consequence of the COVID-19 pandemic, the site for the orthopaedic surgery cohort was moved from in-person to online; initial plans were for orthopaedic surgeons at NUTH to support this study, and for participants to be sampled from the surgical clinic lists from this team. However, due to pandemic-related restrictions within the Trust, and more widely throughout the NHS, participant recruitment was instead conducted through social media (further details on this are discussed in section 6.9.3). NHS Ethical Approval amendments were granted to enable the recruitment of participants undergoing orthopaedic surgery through social media. In addition, NHS Ethical Approval amendments also enabled remote interviewing and data collection to be conducted for the orthopaedic and lung cancer surgical cohorts. Importantly, these amendments meant that the study could continue to run without needing to be conducted *within* the study sites (this is further discussed in section 6.9.3).

5.9.2 Participant recruitment

The qualitative investigation involved semi-structured interviews with patients from three different surgical specialities: bariatric, lung cancer and orthopaedic surgeries. These surgical specialities were chosen with input from the supervisory team at Newcastle University, the Patient and Public Involvement Group (VOICE) at Newcastle University, and knowledge gained from familiarisation with the literature. A decision to limit the study to these elective surgical specialities, and to patients only (rather than including family members and caregivers), was based on the practicalities of research to ensure the project was achievable in the timeframe as a PhD.

Participant recruitment was undertaken by the researcher. A participant recruitment pack, containing a patient information sheet (see Appendix 7) and a consent form (see Appendix 8), was provided to each participant. Each participant was given the opportunity to ask questions about the study and, if they agreed to participate, were asked to sign the consent form. Participants were advised that participation was entirely voluntary and that they could withdraw at any time.

Participant recruitment (and subsequent data collection) was performed for each surgical cohort separately. This enabled the researcher to have uninterrupted 'headspace' for familiarity with each cohort before moving onto the next. The first surgical cohort to be recruited and interviewed were undergoing bariatric surgery; the recruitment of the orthopaedic and lung cancer surgical patients followed.

Bariatric surgical patient recruitment

All patients attending the bariatric clinic first saw their consultant and underwent their usual consultation with them and other members of the surgical team. The bariatric surgeon acted as the gatekeeper for patient recruitment in this cohort. The researcher was allocated a separate consultation room within the clinic to discuss with patients who were involved in taking part in the project. These discussions occurred immediately after their routine clinical appointment. The researcher answered any questions that the participants may have had and provided them with the recruitment pack as described above. If they wished to take part, an interview was then arranged at a convenient time and location for the patient. All individuals who agreed to participate were required to give their written consent, using the consent form as described above. Twenty participants within this cohort were recruited and underwent semi-structured interviews between February and March 2020, until data saturation had occurred.

Orthopaedic and lung cancer surgical patient recruitment

Immediately prior to study commencement for both the orthopaedic and lung cancer studies, COVID-19 restrictions were enforced across the United Kingdom. This meant that the planned face-to-face recruitment and data collection for these cohort groups could no longer be undertaken in-person like the previous. A non-substantial amendment to NHS Health Research Authority (HRA) Ethics was submitted and approval granted. Therefore, participant recruitment was carried out remotely, *via* telephone, email and social media for the orthopaedic surgery cohort – and *via* the consultant clinics for the lung cancer surgery cohort. Data collection also took place remotely, *via* telephone or video-call based methods. All participants were emailed with the same recruitment pack as described above (where electronic signatures were accepted when signing the consent form). Recruitment and interviews were carried out between May – June 2020 for the orthopaedic group and September 2020 – February 2021 for the lung cancer surgical group, where data collection was performed until data sufficiency occurred. The researcher has adapted Figure 14 (originally developed by the Institute for Government analysis)(390) overleaf to demonstrate a timeline of the UK government pandemic lockdowns and measures, between March 2020 to December 2021; this figure provides context to the decisions (and legal implications) that led to some remote data collection methods being used for this work. Further, this figure begins to help the researcher comprehend external factors that may have affected research participants, given the unprecedented nature of the pandemic. The researcher has indicated the interview timelines within Figure 14, using a coloured stars and lines corresponding to the annotated text box in the bottom right corner.

5.9.3 Ethical approval

The study was conducted in accordance with the ethical principles that have their origin in the Declaration of Helsinki;(391) the principles of Good Clinical Practice,(392) and the Department of Health Research Governance Framework for Health and Social care 2018.(393) All study design, protocols and documentation were reviewed favourably by the Newcastle University Patient and Public Involvement and Engagement (PPIE) group. Ethical approval was granted by the NHS Health Research Authority (HRA) and Care Research Wales on 11/11/2019 (IRAS Project ID: 265752, reference: 19/NE/0318, see Appendix 9). The study was also approved and insured by Newcastle University insurance committee. As a result of the COVID-19 pandemic, non-substantial ethical adjustments were required to support remote participant recruitment and remote data collection. By working closely with the HRA and the Newcastle University sponsor, these adjustments were deemed non-substantial and approved in May 2020 (see Appendix 10).

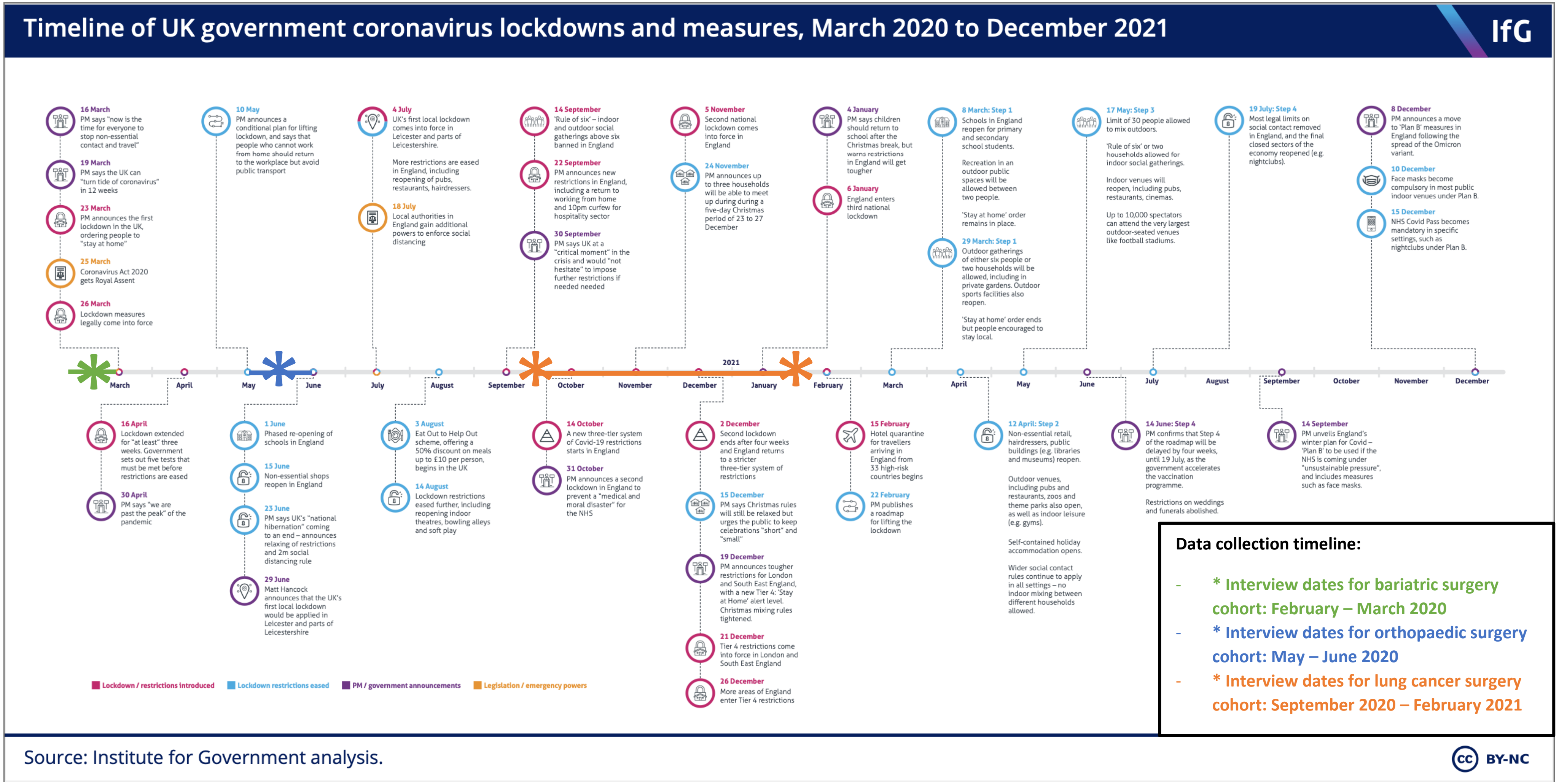


Figure 14: Timeline of UK government coronavirus lockdowns and measures, March 2020 to December 2021.

5.9.4 The impact of COVID-19

Across both of the orthopaedic and lung cancer surgical cohorts, the researcher performed a total of 34 remote interviews; specifically, 21 *via* telephone call and 13 using video call-based methods (Zoom® and Microsoft Teams®). Whilst telephone calls remained the most popular of the two remote interview formats chosen, participants from the orthopaedic and lung cancer surgical cohorts described growing familiarity with the video-based formats due to using them in everyday life as a result of the pandemic.

Telephone interviews were a valuable method for conducting remote interviews with participants during the height of the pandemic. Previously, telephone interviews had been presented as inferior to interviews that take place face-to-face due to the absence of visual cues during conversations(394) and even being critiqued as a method that invites "clinical and methodological scepticism".(395) However, the historic bias around telephone interviewing in qualitative literature has been questioned when it comes to their role in supporting the conduct of research during the pandemic.(396-399) In comparison with face-to-face interviews, the telephone interviews were found to be a flexible method of qualitative data collection as they were scheduled for a day and time convenient to the participant. In addition, the familiarity of conducting interviews over the phone meant that a broader demographic of participant was able to take part, as they did not rely on a participant to travel or use the internet or any unfamiliar software/programmes. This format of interviewing was less resource-intensive for both parties too, as they eliminated the need to travel or have transport to attend.(400) Remote data collection during the pandemic also offered increased opportunities for patients to take part in research who, previously, may not have had the time or chance; the COVID government furlough scheme may also have resulted in participants having increased flexibility to take part. Furthermore, for those who were isolated at home whilst shielding, the interviews may have offered them an opportunity for conversation and connecting with someone. The researcher also experienced the product of the interview to be one full of rich data, as participants were able to talk freely and comfortably in familiar surroundings. When compared to the face-to-face interviews conducted with the bariatric surgery participants, the researcher found that the discussions with orthopaedic and lung cancer surgical patients were longer and more open and in-depth – perhaps suggesting that the researcher-participant power dynamics were easier to balance with telephone-based interviews. The researcher acknowledged that telephone interviews may have also reduced or minimised interviewer bias;(400) this was something which was considered when conducting the interviews in a clinic-based setting for the bariatric surgery patient population.

Online interviews, made possible *via* video call-based software, have been regarded as part of "the new methodological frontier" in social science research.(401) Alike the flexibility explained above for telephone interviews, video call-based interviews also offered benefits for participants in that they can be arranged for a day or time that suits their schedule best. In addition, this format also offered a lesser burden on the participant than a face-to-face, in-person interview would have done, in relation to the removal of travel or geographical barriers.(400) Similar to discussions in section 11.2.1, the video call-based interviews also offered opportunity to a wider range of participants to get involved in research; particularly when many people were in receipt of UK government furloughed schemes during the pandemic. In contrast to telephone interviews, video call-based software offered the advantage of replicating face-to-face contact between the researcher and research participant. This offered the researcher numerous benefits when it came to communicating with non-verbal cues (such as head-nodding, gesturing and body language) which are important when conducting qualitative research.(402-405) The researcher was mindful to ask whether participants felt comfortable in switching their video on in order to do the interview; all participants did this and the majority reported feeling comfortable enough to not hide their camera background.

The use of remote formats meant that data collection could be performed at a location where the participant was comfortable and relaxed (which was often in their own home, due to the pandemic restrictions). Upon reflection, the researcher reported the quality of the data collected to be deep and insightful; participants that were involved in remote interviews openly discussed their experiences and perspectives in a detailed and honest manner. The researcher also reflected on the quantity of data collected from remote interviews, with the average duration being longer than those with the bariatric surgical cohort who were interviewed in-person, in a formal clinic setting within the hospital. The average interview duration for the bariatric cohort was 52minutes (SD ± 18.5minutes), compared with 68-

minutes (SD ± 8.5minutes) and 74 minutes (SD ± 10.5 minutes) for orthopaedic and lung cancer cohorts respectively. The researcher reflected whether this related to participants being more comfortable in their surroundings and thus being able to discuss at greater length and in greater detail. In addition, the researcher also reflected on the possible shift in 'interviewer-interviewee' power dynamics when the researcher and participants were distanced, as opposed to being held in a formal in-person clinic setting. Advantageously, the results from the orthopaedic and lung cancer surgical cohorts included data from patients utilising digital remote methods in real-time as part of their current pre- and post-surgical care, which was a change directly as a result of social distancing during the pandemic. The fact that participants opted to use remote data collection techniques to conduct their interviews provided evidence in itself to add further insight into the acceptability and adoption rates of technologies by patients in a world of modern healthcare.

Alongside the advantages in supporting data collection, remote strategies did not come without challenges for both the researcher and the research participants. Not meeting or seeing research participants in-person meant that the researcher needed to utilise different social cues in order to communicate; a skill which required time to develop. Instead of relying on non-verbal listening techniques and body language, emphasis was placed on the researcher's tone of voice and ability to allow for prolonged periods of silence to ensure that the participants had time and space to think before answering. The researcher also needed to allow for sufficient time in-between interviews, in order to enable decompression and regular discussion with supervisors; there was temptation to schedule a greater number of interviews per day given the ease of remote methods however, in order to ensure proper methodological reflection, this was not done. In addition, the researcher was acutely aware of the potential digital divide and digital exclusion that could arise from utilising remote methods, given that not all participants may have access to a telephone and/or internet connection in order to conduct an interview. As well as this, some participants may not possess the digital literacy skills in order to utilise video call-based platforms; this is a pertinent reflection of addressing inequalities associated with representation of sociodemographic, ageing, and marginalised populations in health and social care research on a whole and has been discussed in numerous chapters of this thesis.

Specifically for the researcher, remote interviewing has been an illuminating experience and encouraged reflection and learning in a number of ways; it has pushed the researcher outside of her comfort zone to explore alternative methodologies and strategies to enable qualitative data collection at a time of great uncertainty. In doing so, she has become adept and skilled at these methods which now means she has gained experience and expertise to undertake future research in this way.

5.10 Participant demographics

In total, 54 in-depth, semi-structured interviews were conducted for this programme of work. Key demographic details of the participants from the semi-structured interviews are outlined in Table 16 overleaf and in each individual results chapter respectively. To summarise:

- Twenty participants were interviewed in the bariatric surgery cohort and of these, 15 were female, 8 were pre-operative and the average age was 46-years.
- Of the 18 participants interviewed in the orthopaedic cohort, 11 of these were male, 12 were post-operative and the average participant age was 52-years.
- The lung cancer surgery cohort involved 16 interviews, of which 9 were female, 6 were pre-operative and the average age was 65 years.

5.11 Chapter Summary

This chapter has provided an overview of the rationale, research question, aim and objectives of the qualitative research project. It also detailed the methodological and analytical approach taken to perform the studies. A qualitative methodology, using semi-structured interviews, has been employed for this work, with a reflexive thematic analysis approach taken for data analysis. Furthermore, this chapter has discussed the processes of ethical approval, patient recruitment and data collection undertaken for this project.

The following three chapters describe the findings obtained from participant interviews; the order follows bariatric surgery (Chapter 6), orthopaedic surgery (Chapter 7) and lung cancer surgery (Chapter 8). Each surgical cohort has been investigated in isolation, with each chapter exploring the key themes, sub-themes, discussion and take-home messages unique to that group of patients. An overall discussion and comparison of findings from these three studies has been conducted following this and can be found in Chapter 9.

Chapter 6: "We need to be told what to do and what to eat" – findings from the bariatric surgical cohort

The work from this results chapter has been published as a qualitative research paper in JMIR Human Factors journal: Robinson A, Husband AK, Slight RD, Slight SP, *"Designing digital health technology to support patients before and after bariatric surgery: a qualitative study exploring patient desires, suggestions and reflections to support lifestyle behaviour change."* JMIR Human Factors, 2022. DOI: 10.2196/29782 (Appendix 11). The findings from this chapter have also been shared at two national research conferences: the Great North Pharmacy Research Collaborative Conference in July 2021 and the Health Services Research and Pharmacy Practice Conference in April 2021.

To develop useful and effective support strategies using digital technologies, it is important to first understand how patients undergoing bariatric surgery *want* to be supported. Much research has previously focused on implementing digital technologies and measuring their effectiveness in various surgical cohorts. However, there is limited work concerning the desires, suggestions and reflections of patients undergoing bariatric surgery and, in addition, there is limited knowledge of what technology functionalities and capabilities are most supportive. The results in this chapter seek to address these current knowledge gaps within the literature.

This chapter will illustrate the perceptions of patients undergoing elective bariatric surgery. Specifically, this arm of the study aims to understand how digital technologies can be used in this patient cohort to better support them across the perioperative pathway and promote healthier lifestyle behaviour change outcomes to aid their surgical weight-loss. The results in this chapter explore pre- and post-operative patient perceptions and the findings intend to identify key aspects of digital technology design, functionality and capability features that best suit and support this patient cohort.

6.1 Introduction

Obesity is a growing global pandemic.(406-408) Weight loss surgery (termed bariatric surgery) is regarded as the most effective method for long-lasting weight loss.(409) Despite a rise in the numbers of bariatric procedures over the past few years, recent literature has suggested that surgery is still an underutilized treatment option, where the number of American adults choosing surgery is approximately 1%.(410, 411) Despite promising weight loss outcomes following surgery, patients can experience challenges beyond the procedure itself in their bid for surgical 'success'.(412) These include facing social-pressures and stigma in relation to the surgery(413) and psychological impacts including negative body image and depression,(414) in addition to adjusting to post-operative lifestyle recommendations to reduce weight regain.(120)

A patient's capability, motivation, and opportunity to change their lifestyle are significant determinants of successful outcomes following bariatric surgery.(85, 415) Healthier lifestyle changes before and after surgery, including improved dietary intake and physical activity levels, have been shown to contribute to greater post-surgical weight loss,(174, 416) maintenance of weight loss,(417) and better overall long-term health.(418) Currently, little is known about the optimal way to support lifestyle changes in patients undergoing surgery with digital technologies; including what form this support system should take, when it should be delivered during the surgical pathway, or the duration of such interventions.(174, 419)

In bariatric surgery literature, recent studies have reported how telemedicine and digitally-supported care have been well-received by patients,(420) and have potentially improved post-operative clinic attendance and patient engagement with surgical care.(421, 422) Utilising digital technologies within the bariatric surgical pathway, both pre- and post-operatively, could form part of a remote strategy to deliver support and behaviour change advice to patients. The key research questions for this work centred on: 1) *what* would patients undergoing bariatric surgery want from digital technologies; 2) *how* would these patients want to use digital technologies during the surgical journey; and 3) *when* is the optimum timepoint to implement digital technologies to support and promote healthier lifestyle behaviour change during the surgical journey? According to the Enhancing the QUAlity and Transparency Of health Research (EQUATOR) guidelines, this study was reported according to the COREQ (Consolidated Criteria for Reporting Qualitative Research) checklist.

6.2 Participant characteristics

Twenty participants were recruited and interviewed as part of this arm of the study. Of these, 8 participants were pre-operative (40%) and 12 were post-operative in their surgical journey (60%). The characteristics of each participant are described in Table 17. The average age of participants was 46-years (SD: 10.63), and the majority had, or were planning to undergo, a gastric bypass procedure (n=11, 55%). There were no refusals to take part, no participant dropouts or repeat interviews. Fifteen of the 20 participants (75%) were female, representative of the common demographic split that is associated with bariatric surgery. All patient interviews were conducted in-person between the months of February and March 2020, prior to the COVID-19 pandemic and governmental restrictions. All participants chose to be interviewed in a confidential room within the bariatric surgery clinic in the hospital.

The analysis revealed that participants undergoing bariatric surgery described support needs throughout the perioperative period, prior to bariatric surgery and beyond. Four overarching themes were developed from the data that related to the *design, capability* and *functionality* of digital health technologies to best meet patient needs and provide pre- and post-operative support. The themes concerned the ability of the digital technology to: 1) provide surgery-specific content and support; 2) facilitate self-monitoring and goal-setting; 3) deliver information in an accessible, trusted and usable manner; and 4) meet information-seeking and engagement needs at timepoints before and after undergoing bariatric surgery (as demonstrated in Figure 15). The remainder of this chapter further explores these four themes in turn to address how best to design and optimise technologies for this patient cohort. Perspectives and suggestions of participants are illustrated throughout this chapter using interview quotes. Non-identifiable pseudonyms are used throughout, for instance following each quote with Participant 1, Participant 2 and so forth.

Table 16: Participant characteristics

Participant Number	Sex (M/F)	Age (years)	Interview Format	Surgical Procedure	Pre- / Post-Operative	Time since surgery (exact) or time until surgery (approximate)[A]	Interview duration (minutes, seconds)
1	F	29	In-person	Gastric bypass	Post	24m	53m 30s
2	F	55	In-person	Sleeve gastrectomy	Post	12m	20m 27s
3	F	54	In-person	Gastric band	Post	18m	61m 36s
4	F	50	In-person	Sleeve gastrectomy	Post	24m	52m 41s
5	M	46	In-person	Undecided	Pre	6w	50m 23s
6	F	52	In-person	Gastric bypass	Post	9m	49m 13s
7	F	61	In-person	Gastric bypass	Post	4m	57m 04s
8	M	51	In-person	Gastric band	Post	24m	42m 45s
9	F	39	In-person	Sleeve gastrectomy	Pre	2w	62m 08s
10	M	40	In-person	Gastric bypass	Pre	8w	57m 24s
11	F	31	In-person	Gastric bypass	Post	24m	63m 08s
12	F	51	In-person	Gastric bypass	Post	24m	52m 24s
13	F	58	In-person	Gastric bypass	Post	24m	46m 54s

14	F	50	In-person	Gastric bypass	Pre	1w	56m 24s
15	F	59	In-person	Gastric bypass	Post	24m	54m 59s
16	F	29	In-person	Gastric bypass	Post	12m	57m 57s
17	M	26	In-person	Sleeve gastrectomy	Pre	8w	69m 57s
18	F	35	In-person	Gastric band	Pre	4w	41m 12s
19	M	50	In-person	Undecided	Pre	2w	65m 50s
20	F	52	In-person	Gastric bypass	Pre	4w	62m 47s
Key:	M = male; F = female; pre = pre-operative; post = post-operative; approximate[A] = given the implications of the COVID-19 pandemic, some surgery dates may have been delayed so these are an approximated date reported by the patients at the time of interview; m = months; w = weeks.						

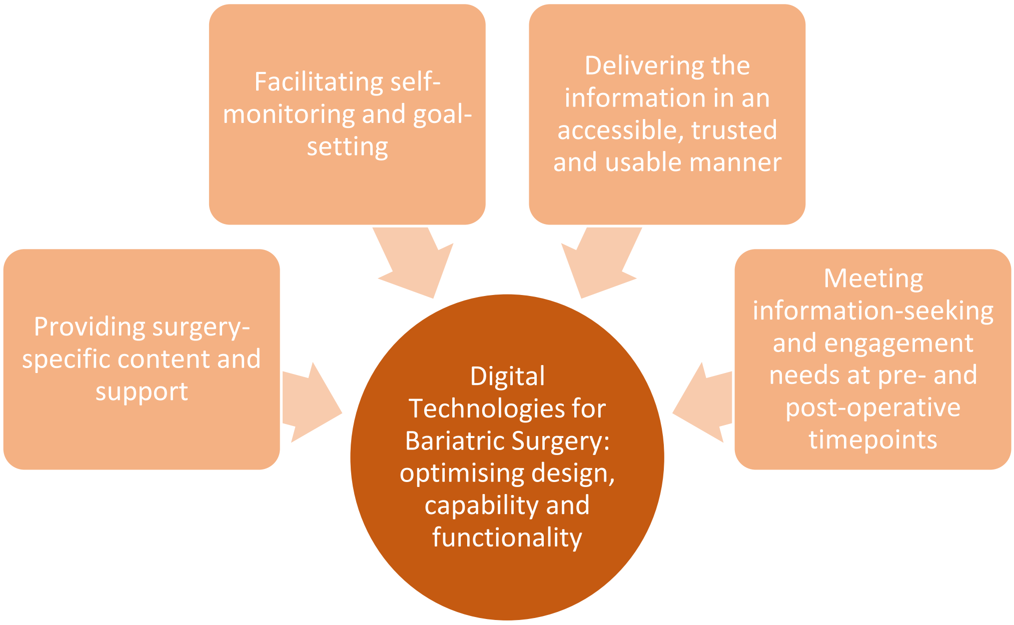


Figure 15: Patient-informed findings: four overarching themes concerning the optimisation of digital technologies to better support patients undergoing bariatric surgery.

6.3 Providing surgery-specific content and support

When asked about *how* digital technologies could be best designed for patients undergoing bariatric surgery, interviewees expressed numerous opinions about the technology's content. In particular, interviewees discussed thoughts around: what information participants want and need to hear when undergoing bariatric surgery (where the most useful information was deemed to have a focus on the reality of undergoing bariatric surgery and recovering and adapting to life, rather than being focused on the procedural side of the operation); and how the technology could be designed so that it offers the most useful content (in particular, relating to prescriptive and directed dietary-based support and wider lifestyle/holistic advice).

When considering how best to get the content right for this cohort, participants discussed a desire for technologies that incorporated *"real and meaningful"* advice (Participant 1, 29-year-old male). It was deemed important that technology for this cohort was specific to bariatric surgery and the 'real-life' experiences that accompany it. This was instead of having content pitched at more of a general-surgical level or based around the specific bariatric surgical procedure that the patient would be undergoing. Participants considered that content based on the *"type of operation or the choices for the operation"* would be less useful (Participant 7, 61-year-old female). Instead, the participants in this group called for the content of the technology to be explicitly focused on *"making it clear about what might happen to me"* (Participant 11, 31-year-old female). To deliver information with the focus of this message, participants discussed designing the content to include advice around potential adverse effects of surgery and changes that they might experience to their bodies before and after surgery. The participants also felt it important to clearly discuss and advise on the common issue of *"how to deal with the excess skin after surgery"* (Participant 1, 29-year-old male).

One pre-operative participant described how "*the support packages should be tailored to the people rather than the procedure"* (Participant 14, 50-year-old female). The same patient discussed preferences to read and have access to content that has *"more of a relevance to what I need as a person"*, explaining how patients *"can lose our hair, end up with excess skin, and need to be on life-long supplements"* (Participant 14, 50-year-old female). These topics were considered to be 'taboo' by participants and were reportedly something that was not always readily discussed by healthcare professionals. Another participant echoed these views and described the importance of hearing *"the good, the bad and the ugly"* messages early in the surgical pathway, so that they were able to *"expect for the reality"* that accompanies the surgery (Participant 6, 52-year-old female). Another patient recognised that *"this is the kind of stuff"* that this patient cohort would likely need support with throughout the post-operative period and beyond, and thus, should be incorporated within the technology content (Participant 4, 50-year-old female). It appeared significant to display the reality behind the lived experiences of bariatric surgery, for both pre- and post-operative patients. One post-operative participant, who underwent bariatric surgery 24-months prior to interview, recognised that *"this isn't the stuff that's just short-lived"* (Participant 4, 50-year-old female); their current lived experiences show that, even 2-years following surgery, the long-term lifestyle information would still be relevant. Furthermore, participants saw value in designing the technology content in such a way that the users could *"learn from it ... and hear the true experiences of others"* (Participant 19, 50-year-old male). Importantly, the technology should seek to disclose the reality of both surgical- and lifestyle-related content, and even seek to normalise matters that may not readily be discussed.

"People need to be more aware of the challenges they will come up against and if you can use this (the technology) to do that, then I'd support it. Things like normalising any weird side effects, like excess skin or hair falling out, those types of things" (Participant 14, 50-year-old female).

Hearing explicit and realistic information was also deemed important in specific timepoints of the surgical pathway, particularly the immediate post-operative recovery period. One participant reflected on their experience of recovering *"without having the specifics (advice)"* (Participant 3, 54-year-old female) and how the content of the technology could be used to address unmet educational- and informational- needs of this patient cohort. They reflected on a previous experience of a different surgery and compared it to the unique experience of recovering from bariatric surgery, where *"after a normal operation you'd be able to eat whatever to build up your energy levels again quite quickly… but you can't do that with bariatric surgery, you physically can't eat things immediately post-surgery so you'd need it specifically to advise on the bariatric recovery in that case"* (Participant 3, 54-year-old female). This participant described the gaps in their own knowledge and highlighted the potential for technology content to be realistic and preparatory in nature. To best support patients across the entire bariatric surgical pathway, messages of general surgical advice should be combined alongside specific bariatric surgical advice to ensure that content is the most useful for the patient population.

"I never knew how different (recovery from bariatric surgery) would be… that should've been something I knew better and it's definitely something I tell people about if I know they're getting it too" (Participant 3, 54-year-old female).

Another remit for designing useful content for this cohort related to dietary support. Participants discussed the benefits of having diet-focused content and perceived it as a useful guide for both the pre- and post-operative periods. The suggestions and desires for this type of content ranged from small snack-based ideas that could be accessed on an *ad hoc* basis (for instance *"options of what I could have for a healthy snack"* (Participant 5, 46-year-old male)), to suggestions of greater detail that may be accessed on a longer-term basis (for instance *"something with a specific meal plan available"* (Participant 9, 39-year-old female)). One participant emphasised that dietary content should be designed to start immediately following surgery, where *"your stomach is just healing because of the operation and your stomach has been changed – you've got to have baby food and blended food until it heals"* (Participant 6, 52-year-old female). Fellow participants also shared this view and discussed the advantages that could come from continuing structured dietary guidance to *"follow you all the way"* along the post-operative period from *"Day 1 until you get discharged"* two-years post-surgery (Participant 11, 31-year-old female). Participants described the value of a long-term strategy to encourage sustained healthy eating habits, where *"an app with recipes on it that you can keep coming back to"* could support patients in choosing healthier meal options over a longer period (Participant 5, 46-year-old male).

When considering the style of technology content to achieve this, participants overwhelmingly favoured a prescriptive and direct approach. Being prescriptive and direct in nature appealed to participants, with some interviewees stating that the intervention should *"tell me what to eat"* and what to *"stick to"* (Participant 8, 51-year-old female). One pre-operative patient suggested that the integration of features such as *"a list of what you're not allowed to eat anymore"* would be most helpful so they could *"easily keep away from it (unhealthy foods)"* in a bid to *"keep on track"* with their anticipated weight-loss and changes in behaviour (Participant 14, 50-year-old female). Some participants stated that immediately following surgery, they wished for stricter support mechanisms delivered *via* digital technologies, especially to support them in adjusting to their new post-operative lifestyle and dietary intake. One participant discussed that *"in the first couple of weeks (following surgery), we need to be told what to do, what exactly to do… like what to eat and what to avoid"* (Participant 9, 39-year-old female). When describing a prescriptive and directed approach to dietary support, participants acknowledged the difficulty in adhering to the dietary information although they may know *"what to have and what not to have"* (Participant 18, 35-year-old female). One participant reflected on her educational qualifications, where she had expertise and knowledge of nutrition from her degree. Even though *"I know the stuff, I know the content of the foods... it's a lot trickier putting that knowledge into practice when I've got busy shifts"* (Participant 18, 35-year-old female). Although interviewees discussed knowing which foods to have or which foods to avoid, they perceived the reality of *"sticking to the list"* as being something that was *"easier said than done"* (Participant 4, 50-year-old female). They felt that the prescriptive direction of the technology could act to *"hold me to account a bit more… where at least there's something there to support you and guide you to make the right choices with your foods"* (Participant 14, 50-year-old female).

> *"Every fat person will tell you what's in everything, what the calories are, what the protein is, you know - it's all stuff they know (laughs). You know what you should be doing and you know how it is done, but actually doing it is really tricky" (Participant 4, 50-year-old female).*

As well as dietary-based support, several participants considered it important that the content of the technology also focused on wider elements of healthy lifestyle support which, in turn, could affect the success of their surgery. When it came to healthier lifestyle choices, participants considered the integration of topics that would be most useful for them, including increased physical activity and reduced alcohol intake. Patients demonstrated awareness that positive behaviour changes in these areas also contributed to bariatric surgery success. One participant remarked that it is important to correctly name and describe the technology to reinforce holistic messages that patients must understand when undergoing bariatric surgery. *"By calling the technology a lifestyles package"* reinforced the *"idea that there's other factors you need to address"* and *"if you described it as a 'lifestyles package' for after bariatric surgery then, yeah, you can mention things like diet but also mention (alcohol) drinking and exercise… cause these interplay in it all too and that's important to get your head around [sic]"* (Participant 9, 39-year-old female). Many participants recognised that there are other modifiable factors that contribute to surgical success, beyond relying solely on the operation or a diet plan to lose weight. This appreciation for 'holistic' change was a shared perception, where participants discussed seeing the surgery itself as *"a tool to help you lose weight"* but that the success of the surgery also *"relies on me making other changes to my lifestyle"* (Participant 1, 29-year-old female). One participant specifically stated how they were *"trying to look for better choices – like a better choices app"* to support their journey and *"to get the most out of it (surgery) and come out of it all a better (healthier) me"* (Participant 5, 46-year-old male). Another participant compared their post-operative lifestyle choices of quitting smoking and drinking alcohol, with that of their daughter who had also undergone bariatric surgery. They discussed their daughter's lower degree of weight loss following surgery and associated her lifestyle choices to be as equally damaging as her poor dietary habits.

> *"I think for her, it's not just the eating. She drinks a lot of those fruity gins so she puts loads of calories in just from the (alcoholic) drink. She'd do better with more encouragement to give that up, and the fags (cigarettes), so maybe it (technology) could mention how (alcoholic) drink is bad and she might start thinking about cutting down" (Participant 9, 39-year-old female).*

One post-operative patient, who was attending for their final follow-up appointment before being discharged from the service (at 24-months post-surgery), reflected on their experience of lifestyle behaviour change throughout their surgical journey. This participant acknowledged that they had failed to consider the significance of lifestyle behaviours prior to surgery. Following their surgery, however, they realised the consequences that come from choosing and maintaining healthier choices; as well as the impact they have in determining surgical success.

> *"If you're not aware that you need to make changes to your diet and that, then it (surgery) is never going to work! It's a bit change for your whole life to be honest, and that's something I had never considered beforehand. But it (surgery) is supposed to be a change to last you for life, not for you to go and eat what you want or do what you want and not think about the consequences. And because I'm now at that stage where I can look back, I honestly think it's vital that it (technology) starts off by encouraging you (that) you've got to act different all round. If you want to lose the weight and keep the weight off and be successful, you've got to make them changes and you will get used to it [sic]" (Participant 15, 59-year-old female).*

Participants described how reminders and prompts could be built into the content of the technology to promote positive health behaviours to achieve successful weight-loss, whilst also encouraging patients to work towards making (and sustaining) healthier lifestyle habits. The timing, tone and content of these prompts were perceived to be important. Participants noted that, in the period immediately following the operation, it may not be appropriate to receive prompts. Instead, in this time, participants reflected that they would likely be *"more focused on recovering"*, than being receptive to prompts to *"start changing my life straight away"* (Participant 7, 61-year-old female). However, in the period following this, where gentle exercise is encouraged as part of surgical recovery, having *"something to just give you little reminders"* was viewed as beneficial (Participant 9, 39-year-old female). One participant discussed their preferences for prompts in this time frame, reporting that they would *"be more ready to hear that stuff and act on it, compared to earlier"* when they were initially recovering (Participant 10, 40-year-old male). It was suggested that prompts include messages relating to physical activity, combined with motivational statements, in a bid to appear more encouraging for patients. For instance, participants discussed examples of prompts such as *"Have you been for a walk today? Don't let yourself slip, keep it up!"* (Participant 10, 40-year-old male) which could be used to encourage physical activity. Following this, a notification of *"well done, you've walked X distance"* could make patients feel *"rewarded for making the right steps"* (Participant 10, 40-year-old male). This was suggested as opposed to anything *"too forceful… not the whole powered gym messages like "get up and move, fatty!""* (Participant 10, 40-year-old male). The same participant appreciated that the lifestyle change may be received differently by other patients, where some may wish for the more forceful messages.

Taking that into account, participants discussed how they should be given control over the technology settings so they could decide on the correct tone of messages for them. When it came to understanding how long the post-operative prompts could continue for, participants stated that they should continue for *"as long as you need them to"* (Participant 12, 51-year-old female). The reason for this came from participants understanding that *"surgery isn't a fix; it's a lifelong change and you've got to be committed on the long-term"* (Participant 1, 29-year-old female). Consequently, the idea of ongoing, long-term engagement with *"constant reminders"* was positively considered by participants (Participant 7, 61-year-old female).

Interviewees viewed this as an ongoing form of encouragement and motivation, which encouraged them *"to remain accountable with my new habits"* and healthier behaviour changes (Participant 6, 52-year-old female).

> *"I think it's got to be constant reminders to change your habits or adjust to the new lifestyle. 'Cause if not, you could easily think "ah well I've had the surgery now so I can still have that bag of crisps" and think you'll still be skinny forever. It's not that simple. If you don't maintain this new lifestyle, you'll always be the same size" (Participant 7, 61-year-old female).*

Alongside the tailored, in-built prompts and notifications to encourage patient post-operative accountability, participants also discussed the integration of psychological-support features within the technology's content. The opportunity for support with patient mental health and well-being were readily discussed in relation to two areas of the surgical journey. Firstly, participants discussed *"needing a bit of mental support"* (Participant 3, 54-year-old female) with breaking and forming of habits (around food, meal choices and dietary intake). One pre-operative participant discussed feeling *"overwhelmed and nervous about going through (surgery)"* and expressed concerns about how *"failing to lose"* weight would affect their mood and well-being (Participant 5, 46-year-old male). Secondly, post-operative patients discussed impacts on their mental health when it came to coping throughout the weight-loss journey, when managing their weight-loss expectations and body changes associated with weight loss. Content aimed at patient mental health and well-being should be integrated to support with both pre- and post-operative patient concerns.

> *"One of the major things with surgery is that you lose a lot of hair and you lose a lot of weight very quickly, your body changes, you're left with skin depending on how regular you exercise… I think mental health could easily be worse after the operation and all dealing with all this" (Participant 1, 29-year-old female).*

One participant reflected on how their mental health was negatively affected during the surgical journey. They viewed their surgery as *"all a bit disheartening… I've beat myself up about it (weight loss) … I felt like a failure"* because their weight-loss was not as great as they had initially hoped (Participant 6, 52-year-old female). This participant saw the importance of integrating *"mental health messages"* within the technology content and notifications from the start of the surgical pathway. In doing so, this participant felt that patients would feel more comfortable knowing they can *"seek help if you're feeling down about it (weight loss)"* and *"speak up for psychological help, because you need to break habits… it's a lot about dealing with the mental challenges"* (Participant 3, 54-year-old female). Many participants reflected that their psychological mindset was influential in determining the success of their surgery; one participant explained their view that *"surgery is an opportunity for you to re-evaluate your mind and get it into the right place"* (Participant 10, 40-year-old male). The integration of psychological messages of support were viewed as significant content, to keep maintaining healthier lifestyle behaviours and putting *"mind over matter"* to achieve surgical success (Participant 10, 40-year-old male).

> *"and it's about maintenance, the things you should be doing, probably the things you weren't exactly aware of before – actually, you need to go out and break those habits. And I think that's why the psychological side of things is really important. A lot of this is mental basically [sic]… I know you've got to change, basically, change your whole lifestyle – you should be using this opportunity to think "what can I change?". You don't have to do loads; you can incorporate things like taking the stairs instead of the lift or escalator or whatever. Just little things that you can do to make sure you actually do something… I think it's you, you've got to do a lot of the work yourself. Like I say, if you have this operation and don't come away from it afterwards and start taking advantage of your new physical fitness, the fact you can walk further and do things, then you're wasting it and you'll fall into those pit falls [sic]" (Participant 10, 40-year-old male).*

6.4 Facilitating self-monitoring and goal-setting

Technologies that support and facilitate patient engagement were perceived as beneficial. When considering *what* patients undergoing bariatric surgery want from digital technologies, participants reflected on the usefulness of self-monitoring and goal-setting functionalities to help track their progress throughout the surgical journey. These views were shared by pre- and post-operative patients, where the benefits of monitoring and tracking both physical- and dietary-based parameters were discussed. In relation to physical parameters, all participants regarded their weight or weight-loss to be a measure of surgical success. As a way of tracking their progress with this, participants described the usefulness of visualisation through self-monitoring. Many discussed the idea of technology-based timelines where *"comparison photos"* can be uploaded and used to visually compare their pre-operative weight to their current 'real-time' weight, to *"see how much of a difference there has been"* with their weight-loss (Participant 15, 59-year-old female). Ideas were discussed around building this photo-timeline feature into an app and using user self-reporting to input their journey. The addition of a photo alongside the *"numbers of kilos"* was perceived to be useful *"because you can't always put the number into a context in your head without seeing it ... you get fixated on the number (weight) and think you need to lose even more, but actually you might be... looking fine after all"* (Participant 4, 50-year-old female). One participant reflected that being able to track their progress through visual form might *"even be kinder than looking at the numbers (on a scale)"*, where an individual's definition of success may rely on *"fitting into that dress again"* and so photographic logging can benefit working towards that goal (Participant 18, 35-year-old female). In the same way, using *"graphs to track"* their weight-loss over time was also widely discussed (Participant 7, 61-year-old female). Similar to self-reporting their weight-loss journey in picture form, participants described inputting self-reported weights into an app, with the output being a graph showing their weight-loss over time. Breaking down the points on the graph *"with facts of your weight or what weight counts as muscle or fat"* could provide further context (Participant 7, 61-year-old female). The suggestions for digital self-monitoring and using *"Wi-Fi scales that send your (weight) results straight to your phone"* (Participant 7, 61-year-old female) supported the determination of this cohort in striving for what they perceived to be the most important measure of surgical success. Another participant drew on personal experiences with the *"NHS Patient Access app"* (Participant 7, 61-year-old female), suggesting the inclusion of specialist-bariatric advice, linking *"the full app to your NHS number so it's all personalised"*, and using the home screen with *"tabs at the bottom for specific stuff… like graphs to track (your progress)"* (Participant 7, 61-year-old female).

"if it shows you on a graph ... and if it calculates your BMI going down as well, I think that would be a really good motivational tool ... to see how much (weight) is coming off week by week" (Participant 7, 61-year-old female).

When it came to monitoring and tracking dietary-based parameters, participants discussed the usefulness of self-monitoring *"the calories and the nutritional information"* in food, particularly when they were adjusting to new meal plans (Participant 14, 50-year-old female). Participants were mindful of the fact that any dietary-based tracking would rely on them *"(being) honest with yourself about what you've eaten and snacked on"* to correctly input the information into an app or programme (Participant 3, 54-year-old female). Like their desires for prescriptive content, participants felt strongly that the dietary-based tracking should be directive. Some discussed that the technology should tell them *"what to do... and what to eat"*, after which, they would self-report what advice they had followed (Participant 9, 39-year-old female).

Self-monitoring features were also discussed in association with each individual patient's motivational- and emotional-investment in the journey towards weight-loss. One participant described how *"seeing how much (weight) you've lost (can) keep people's spirits up"* (Participant 15, 59-year-old female). Another participant explained how automated messages of *"congratulations"* could be incorporated in the technology capability, as push notifications, to facilitate and encourage patient engagement (Participant 7, 61-year-old female). They discussed the motivational *"boost"* that could come from congratulatory notifications and recognised that *"you need to hear those things when it gets tough"* (Participant 7, 61-year-old female). Patients recognised how technology could encourage and 'push' them to adopt healthier behaviours, like physical activity. One participant who was 24-months post-operative described how technology enticed them *"into doing more steps or exercise"* during their recovery following surgery (Participant 1, 29-year-old female). This participant believed that this resulted in better engagement with post-operative lifestyle behaviour change and weight-loss that was maintained over the 2-year period. When sharing their experiences, the participant referred to wearable technology, and used words like *"entice"* and *"motivate"* when describing the digital engagement (Participant 1, 29-year-old female).

Engaging patients through digital goal-setting was also discussed, where the ability to set personal targets to achieve *"your step count or your total distance each week, or even just the fact you get up and move on a daily basis"* (Participant 11, 31-year-old female) was perceived to be helpful and motivational. However, the number of patients discussing goal-setting related to physical activity was far less than those discussing goal-setting solely related to weight. A greater emphasis was placed on the degree of weight loss achieved through surgery-alone. Fewer participants discussed engaging with physical exercise components of healthier behaviour change following surgery, with some giving reasons in relation to pre-existing health problems because of their weight. One participant stated *"the trouble is that my weight is just too much for the joints in my knees right now"* and that *"once the weight has come off, I might be in a better place to start thinking about doing something (exercise)"* (Participant 15, 59-year-old female).

When it came to engaging with the surgical journey, one participant described the common post-operative pitfall of getting *"so hung up on what we're eating and whether it's right or wrong"* (Participant 11, 31-year-old female). Instead, they recognised the benefit that could come from setting *"daily goals about exercise"* to *"give us something else to think about… and work towards"* to achieve optimal post-operative outcomes (Participant 11, 31-year-old female). One participant who acknowledged the importance of physical activity in achieving surgical (weight-loss) success, referred to capitalising on patient-receptiveness with gamification features built into the technology. By having different 'levels' of increased difficulty for patients to work through, this participant believed that *"friendly, competitive"* encouragement and prompts would encourage better engagement with the technology and with healthier behaviour change (Participant 14, 50-year-old female). They perceived that setting gradual targets would *"support me to push on"* to achieve their weight-loss goals following surgery (Participant 14, 50-year-old female).

"I'd want it to have different levels too - like the first month, the second month, unlocking the next bit... Then it's all there for you and you can keep going back and checking on the app… I can know I'm on track then."
(Participant 14, 50-year-old female)

The same participant reflected on how goal-setting would have widened their personal knowledge of *"what to do after"* surgery, meaning they were able to *"recover better"* (Participant 11, 31-year-old female). One participant explained how it *"would be really useful to have a map or plan to know what's going to happen, and when, so we know it's a full process for us to refer to and not panic"* (Participant 4, 50-year-old female). Another suggested designing *"a checklist… like all part of your own bariatric package"* where you could *"tick off each bit"* when it was achieved (Participant 3, 54-year-old female). Patients may find benefit from seeing the phases of the journey and understanding what was going to happen next.

"I think so many people aren't properly prepared going into this, or prepared about what to expect, how much of a shock it all is and how it can affect loads of aspects of your life" (Participant 14, 50-year-old female).

Some participants also discussed the value of sharing their data with healthcare professionals in the surgical team and the increased sense of motivation and accountability that it could bring to keep them engaged with *"breaking those (bad) habits"* (Participant 10, 40-year-old male). Participants discussed that knowing someone else was *"keeping an eye"* would act to hold them more accountable for their healthier lifestyle behaviours to ensure surgical success (Participant 11, 31-year-old female). One participant felt that data sharing could act as a reassurance-mechanism for patients. When discussing the technology facilitating the sharing of data, the participant used terms like *"shared monitoring"* and perceived that there was an element of accountability from the healthcare professionals to ensure surgical success (Participant 4, 50-year-old female). The same participant described that digitally facilitated connectedness would keep them engaged whilst knowing that they weren't being left to *"fend for themselves"* in the run up to surgery or as soon as the surgery was over (Participant 4, 50-year-old female). A sense of shared responsibility for the success of surgeries was discussed when considering healthcare professional-led monitoring. One participant supported the inclusion of shared-monitoring capabilities so that both patients and healthcare professionals can *"notice if they're slipping"* off the post-surgical diet, implying that patients alone may not be able to recognise bad habits re-forming (Participant 7, 61-year-old female).

6.5 Delivering the information in an accessible, trusted and usable manner

All participants offered suggestions on technology delivery methods and how they would like the information to be available to them, including the accessibility of the information, the usability of the technology to obtain trustworthy information, and the empowerment that can come from connecting with patient-peers to gain information.

Most participants discussed that their preferred delivery method would be accessible through their smartphone *via* an app, with one patient explaining *"practically everyone knows how to use a phone for stuff now. Everything's on it... So, if you could put an app on there, I reckon that's the best way"* (Participant 15, 59-year-old female). Other participants also reported how frequently they used their phones and how people rarely "*go anywhere without it"*, offering the potential for ongoing engagement even "*if I'm out for the day or away on holidays or whatever, I can still log in"* to use it (Participant 14, 50-year-old female). Many interviewees desired a delivery system that was *"nice and clear"* (Participant 3, 54-year-old female), to easily process the information. Another remarked that they did not want another *"dry or crisp NHS website"*, instead preferring a *"modernised"* app or discussion page which they could engage with (Participant 4, 50-year-old female).

As an alternative delivery method, some participants reported being members of bariatric groups on Facebook. A few participants reported social media and Facebook to be an acceptable delivery format, offering familiarity and reassurance: *"I use Facebook all the time… it's amazing"* (Participant 9, 39-year-old female). However, participants also questioned the reliability of information posted on Facebook, describing it as *"obviously everyone's own experiences, but it might not necessarily be the safest"* (Participant 11, 31-year-old female). One participant described how some of the posts they had read were *"full of nonsense"* and so they got rid of their account. In their view, *"an app would be better"* as they *"would probably trust it (the content) more than Facebook"* (Participant 5, 46-year-old male). Furthermore, another drawback of Facebook was how one *"need[ed] to scroll back to find the information"*, whereas an app could contain *"a specific folder or tab so you could go back to it (information)"* (Participant 9, 39-year-old female). Other participants described their positive experiences of 'closed' groups with smaller numbers of individuals. One female patient discussed a private WhatsApp group, which contained five other post-operative patients and felt that the *““how are you all doing?” messages”* (Participant 4, 50-year-old female) were helpfully shared amongst themselves. This indicates that some post-operative patients might find it helpful to surround themselves with like-minded individuals.

Many participants highlighted how information needs to be quick and easy to locate, with one participant suggesting it should be kept *“all together in one place”* (Participant 9, 39-year-old female) and another describing how *“that way you can keep coming back to the information any time you wanted to, rather than looking for the leaflets they gave us”* (Participant 5, 46-year-old male). Another participant described organising the information with “*tabs at the bottom (of the screen) for specific stuff”* like *“appointments for follow ups”* (Participant 7, 61-year-old female). Another participant offered suggestions of how to design the technology so that users of all literacy abilities could engage, by using ‘happy’ or ‘sad’ faces, or colours, for instance.

> *“I’ve met a lot of people that can’t read or write... you could do happy face, sad face, whatever… Or amber colour for not advisable, red for bad or danger, green for good” (Participant 12, 51-year-old female)*

Previous technology use was considered alongside accessibility and information provision. One participant described usability as something that depends *“on your character. I’m not very techno-loving or anything, but I’d give it a go (laughs)”* (Participant 6, 52-year-old female). Some participants discussed usability from the perspective of others, particularly older family members. One interviewee considered her 63-year-old mother, describing how *“she can use Google now, but it’s took a long time to get her to do that [sic]. But then again, my husband’s Dad, he’s 73 and he would definitely use digital stuff”* (Participant 9, 39-year-old female). Interestingly, she also appreciated that usability *“is a bit dependent on the person too, not just their age”* (Participant 9, 39-year-old female). Some interviewees viewed usability in the same context as familiarity and referred to strategies to overcome this through the use of patient education materials given alongside the recommendation to use the technology.

A post-operative patient reflected that, regardless of the technology delivery method used, *“the most important thing is that you’re not left alone after the operation… (as) there’s so* *many unknowns [sic]"* (Participant 11, 31-year-old female). Instead, calling for tailored, digital support to be on hand throughout the whole surgical journey to provide reassurance to patients both pre- and post-operatively. Alongside this, participants discussed the value of integrating peer support features into the technology. Ideas of supporting other patients during their surgical journey was discussed by participants – mainly, these participants were post-operative and could reflect back on their insights and *"what we've learnt from... because it's one thing hearing the advice and stuff but it's another thing when you have to do it yourself"* (Participant 4, 50-year-old female). Many reflected on the importance of hearing the advice *"from someone who's been there"* and who could relate to the lived experiences of the bariatric surgery journey, as opposed to only hearing advice from clinicians (Participant 1, 29-year-old female). Post-operative patients also reflected on the benefit that could come from sharing their worries or getting reassurance from others who have experienced similar problems, in a bid to *"normalise those crazy questions"* (Participant 4, 50-year-old female).

Feeling that they could open up and discuss concerns with others who have had the surgery was also important; one participant discussed how they would not routinely *"open up to anyone else"* who had not undergone bariatric surgery, *"because they don't know what you've gone through"* (Participant 16, 29-year-old female). Some participants also discussed the benefits of peer support for pre-operative patients for them to *"know what to expect from it all... it gives you a chance to know what's coming"* when they undergo surgery (Participant 5, 46-year-old male). At the time of their interview, one pre-operative patient discussed their experiences of how online peer support helped to reassure them in making the decision to undergo surgery. They explained *"one of my online friends has actually been through (bariatric surgery) and I was talking to him and he was telling me stories about it all, like how he found it, how other people he knew had been through it... that they hardly had any pain afterwards and that put my mind to rest a bit more"* (Participant 5, 46-year-old male). Some participants expressed caution about the integration of peer support networks within the technology, as it may result in participants drawing comparisons with one another, which may negatively affect their mood and weight-loss progress. However, the consensus was that forms of peer support would help to overcome any loneliness that could result from the major surgical procedure that the patients were undergoing. One participant even described the functionality as having the power to *"empower people... hear people open up and support each other through it"* (Participant 14, 50-year-old female).

> *"I didn't tell anyone else about the operation, only my brother and Mam. It's hard to talk about how I'm feeling when they don't understand it themselves, I mean, they try to but they haven't gone through it. But if I was able to talk to other patients who've actually had the operation, then I could ask them for more advice and that [sic]. And I would probably not feel as lonely in it all too, 'cause it's a big operation and sometimes it can get lonely" (Participant 13, 58-year-old female)*

6.6 Meeting information-seeking and engagement needs at pre- and post-operative timepoints

Participants shared varying opinions about *when* interventions should be offered to be of most benefit to them during their surgical journey to achieve weight-loss. When using a form of digital technology to support their surgical success, two specific timepoints were discussed by patients: firstly, the time when it should be initiated within the bariatric surgical pathway (for example, offering technologies pre-operatively, post-operatively or both) and secondly, the time when patients may wish to cease using it (also referred to as engagement duration).

Considering the initiation within the surgical journey, some participants believed that offering pre-operative technologies would be beneficial. If implemented pre-operatively, participants believed that digital technologies could support their needs around information-seeking to encourage understanding about their upcoming weight-loss surgery. One participant discussed their wish to better learn about the procedure and what is involved during the surgery itself, as *"it's an operation at the end of the day and you're changing your insides so I think it's important to fully know (about) it"* (Participant 10, 40-year-old male). This view was not always shared by other participants, with some reflecting instead that they would *"rather not know the full, gory details"* (Participant 2, 55-year-old female). Instead, many participants wanted to focus on *"finding out about the experience of it all"* (Participant 2, 55-year-old female) to begin familiarising themselves with *"what it's like, what it will be like, what will* *happen"* (Participant 1, 29-year-old female). Participants saw value in this opportunity to build their knowledge and related it to seeking a sense of preparedness for the whole surgical experience, as *"at least you know what to expect, what is coming either before or after the procedure, and what to do"* (Participant 9, 39-year-old female). Through using digital technologies, like apps, patients felt that this preparatory information could easily be provided.

> *"I joined the Facebook group before I had the surgery, so I already had an idea of what I might expect to happen...I'd already read some people's posts about craving chocolate or wanting to eat something unhealthy, so I knew that might happen to me. It just meant that at least I had a head's up to stuff that might happen" (Participant 15, 59-year-old female).*

One participant discussed opportunities where technologies could assist patients even earlier in their surgical journey. This participant discussed the scope for technologies to support with the surgical decision-making process. They remarked on the available options for weight-loss, including non-surgical options, and stated the importance of making the correct decision for everyone. They reported that *"it's always important to give people as much information as possible, before they make a decision even to have the operation"* (Participant 10, 40-year-old male). Participants alluded to being first introduced to the intervention by a healthcare professional involved in surgery, so *"you're hearing about it from someone who knows"* and who they could *"ask more questions to once you've had a chance to familiarise yourself with it and feel ready to decide (on which surgery to proceed with)"* (Participant 1, 29-year-old female). Similarly, the views of pre-operative implementation were also echoed when it came to delivering educational and supportive information to patients. In having this form of digital support, participants reflected they would be better prepared and informed about what the whole journey would entail. Hearing about experiences of bariatric surgery from patients who had already received the procedure was also deemed helpful.

> *"if there was support out there for people who just wanted to hear what it (surgery) was like and what it felt like... and what options they've got for all the different surgeries... you could give them that on the app really*

easily and that's helping them loads before they've even had it (surgery)"
(Participant 16, 29-year-old female).

As well as supporting information-seeking about the surgical experience, participants described other benefits of implementing a technology pre-operatively; one of which concerns the delivery of medicines advice specific to this surgical speciality. Several patients raised concerns in relation to the impact that surgery may have on their medicine regimens. Participants reflected that, through the very nature of bariatric surgery, their body's normal absorption of vitamins would be impaired following the procedure. As a result, they would be commenced on *"vitamins and supplements that I will need to take for the rest of my life... well I want to know more about them and what it means, what options I have, and whether I can decide further down the line to stop them"* (Participant 1, 29-year-old female). Pre-operative interventions can deliver that information prior to the operation to address patient medicine-specific concerns. In addition to this, two pre-operative participants discussed their own personal medicine-specific concerns relating to their ability to ingest more than one tablet at a time. These patients had not received bariatric surgery at the point of interview; however, they displayed knowledge that *"the size of your stomach is reduced after you've had the surgery"* (Participant 8, 51-year-old female). These concerns related to information-seeking needs, with both participants wanting *"to know what will happen if I want to keep on with my tablets as they are now"* (Participant 8, 51-year-old female). Participants saw a gap where this type of information was currently lacking and recognised an opportunity for remote pre-operative support to help them.

"I want to know what's going to happen with my citalopram if I have the surgery... the doctor said I might need to up my dose but I'm worried, I don't know if two tablets would even fit in my smaller stomach… it's the instructions and education we need, but in a non-confusing way"
(Participant 14, 50-year-old female).

After struggling with their own surgical outcomes, one participant acknowledged a potential role relating to pre-operative information-seeking to manage psychological expectations ahead of surgery. They discussed how pre-operative interventions could be used to better educate patients and provide support to manage their expectations concerning weight-loss:

"if something could teach me like how to expect, what to expect after (the surgery), it might have helped… 'cause I thought the weight loss would be much faster and I look no different now and I've spent a long time knocking myself down for it" (Participant 3, 54-year-old female). Other participants also shared similar reflections around weight-related negativity (both in general and following bariatric surgery) and discussed the subsequent effect it can have on a person's mental health, stating *"yeah, they've had the surgery but actually, they're on the borderline of now having something like an eating disorder... expectations, they're too high and it's very much a head game, very much. Like, basically, your weight problem is in there [gestures to head]"* (Participant 6, 52-year-old female). Post-operative participants openly shared personal stories of where psychological support, delivered remotely, may have meant they felt better supported following surgery. One female participant discussed *"(surgery) messed so much with my head that I started to feel really low ... the weight just wasn't shifting off me even though I'd had it (surgery) and I hated me for it, I was dead embarrassed because people expected me to be skinny and I wasn't [sic]"* (Participant 15, 59-year-old female). In turn, they recognised the benefits that could come from pre-operative interventions to better manage any post-operative impact on their mental health. As a consequence, patients may remain better engaged with services, where one post-operative patient discussed how their poor attendance at post-surgical follow-up appointments could have been prevented: *"I'm really disheartened... I've not really lost (weight) and that's why I've not been coming back. I mean, I've got a history of depression anyway but that's all built up... I just thought "I'm not doing it" ... it was all a lot for me to be honest with you. I hit a high after the operation, you know when it was all exciting and I was expecting the weight to drop off me straight away. But that didn't happen and I got really down... then everything just escalated"* (Participant 3, 54-year-old female). Participants reflected that pre-operative interventions could have provided extra, complementary support to better manage their expectations before having surgery. By implementing the technology pre-operatively, patients remarked that they would *"have a chance to get my head in the right setting"* and *"probably be in a place where I could easily ask things if I started to get ahead of myself in expecting a miracle"* (Participant 11, 31-year-old female). Having remote input pre-operatively meant that patients felt they would be in a better position, and have acquired better knowledge, to manage their expectations post-operatively.

"I think they (healthcare team) really need to tap in with people more beforehand, especially people who have had histories or depression, because it (surgery) can just play with your mind. You're thinking "I don't feel well so I want to eat to pick myself up" but then you can't eat, and you worry about what to eat – you're all over the place" (Participant 7, 61-year-old female).

Participants also considered the long-term role that technologies can have within the immediate recovery period following surgery. Interviewees recognised that engagement with technologies would likely be higher in the initial post-operative period *"once you've had it (surgery), you're in that space, and probably will need to use it for finding out the information there and then…"* (Participant 10, 40-year-old male). However, there was also reflection around each participant's engagement needs and how they will likely change, the further the person is along their journey of post-surgical recovery. Being able to engage with the technology again, when needed, was deemed important: *"it might be something where it (intervention usage) tails off a bit, once you start getting the hang of things, what to eat, how much you can tolerate and stuff. But also, if anything happened and I wanted to ask questions, then I picture being able to use it as and when"* (Participant 14, 50-year-old female).

Beyond this initial recovery period, most participants felt that technologies could support them in a multitude of ways. Two participants (one pre- and one post-operative) acknowledged that technologies could play a role in complementing current practice to improve patient support between annual follow-up appointments. One post-operative participant explained that *"once you got a few months in it was more "well, I'll see you in 12 months unless you have problems" and that's not supportive enough"*. They believed there to be benefit from continued technology-enabled engagement throughout this time, specifically linking with a healthcare professional for *ad hoc* advice: *"if I'd had more contact with the dietician, digitally, I could maybe have stayed on track better"* (Participant 11, 31-year-old female). Recurring messages of prescriptive and descriptive approaches, where post-operative participants appear to cede complete control over their journey and outcomes, perhaps demonstrates a lack of belief that they can make and sustain positive behaviour changes on their own. One pre-operative participant perceived the value of ongoing support from technologies in a more self-determined manner: *"I want to make sure I get it (dietary intake) right. I want to avoid any complications and give myself the best chance of success"* (Participant 5, 46-year-old male). They went on to describe their ideal technology-enabled support system, combining technology alongside face-to-face appointments, stating: *"I think using tech and still having the (face-to-face) appointments will give me as much support as I need"* (Participant 5, 46-year-old male).

Of all the participants interviewed, only one recommended implementing an intervention that spanned both the pre- and post-operative periods. This patient was 2-years post-surgery and their views combined those of pre- and post-operative patients, as discussed above, and described how supportive 'boosts' from the technology continued on a long-term basis could help to promote positive behaviours: *"from the minute you decide to go through with it (surgery), you probably would benefit from having something there just for peace of mind… definitely (implementing) from the start, but also so they can keep using it after (surgery) too for those little boosts and support"* (participant 16, 29-year-old female).

In addition to the timepoints of when to start and stop digital interventions within the surgical pathway, participants also discussed their ideas around engagement by comparing 'real-time' with *'ad hoc'* use. Interviewees recognised the value of real-time information seeking in the initial post-operative period, for instance: *"'cause, say you were standing in the supermarket and you thought "oh I could really fancy that, but I don't know if I'm allowed it", then you'd be able to look it up and see if you can have it or not. That would be really practical and handy"* (Participant 14, 50-year-old female) and "*I think if you could make something that had a meal plan we could access straight after the surgery… rigidly… what to stick to for the first few weeks, then that would be good [sic]*" (Participant 5, 46-year-old male). In a cohort required to change their lifestyle behaviours, even before having the surgery, perhaps technologies delivering short-term descriptive support would be beneficial.

6.7 Discussion: contextualising the findings into current literature

This patient-informed study highlighted the desires, suggestions, and reflections of bariatric patients in the context of using digital health technologies as support tools during surgery. By collecting both pre- and post-operative patient perspectives, we highlighted *how* digital support strategies could be delivered, *what* content is perceived as useful, and *when* technologies could be implemented within the current NHS bariatric surgery pathway. From these results, four key themes were developed which related to the *design, capability* and *functionality* of digital health technologies to best meet patient needs and provide pre- and post-operative support. These findings can be used to enable the design, production and implementation of better tailored and targeted digital health technologies for bariatric surgical patients.

Study participants described a range of potential technology suggestions to meet their pre- and post-operative needs. Patients discussed how digital health technologies should enable easy access to specialist and tailored information, located in one place. Comparable with findings in wider digital health literature, patients undergoing bariatric surgery also highlighted how technologies should provide them with individualised feedback and reviews on their post-operative progress.(423) Personalisation of feedback has previously been associated with positive health behaviour change and increased patient engagement with care.(424-426) The inclusion of this feature could better support this patient cohort to manage with the number of lifestyle-related changes expected following weight-loss surgery, such as dietary intake and physical activity.

Strategies to deliver individualised care were discussed by this patient cohort. One participant suggested connecting the digital technology with health system identifiers, such as an individuals' NHS number. In doing so, the patient could have electronic access to their own personal patient records, clinic letters and follow-up care plans. This functionality could form an integrated, personalised health record that acts as a rich source of information for various purposes(427) – as well as supporting the patient in understanding and experiencing their surgical journey. Having the functionality and capability within the technology to support the joined-up delivery of personalised care plans has been associated with remote data-sharing exchanges in existing literature.(427, 428) Telehealth (the remote exchange of data between patients and healthcare professionals) and telecare (the remote monitoring of a patient's condition) has been acknowledged as key to promote and maintain long-term health in patient populations.(429) In the same way, findings from this cohort echo the important role that remote data-sharing can play, before and after bariatric surgery. Previous literature supports the usefulness of this technology capability in the management of long-term conditions such as diabetes, coronary heart disease and chronic pulmonary disease (COPD).(430-433) In the context of bariatric surgery, the benefits of digitally-shared outcome measures (like weight and physical activity levels) could benefit both patients and clinicians. Combining these functionalities, alongside others that encourage patient engagement with dietary intake and physical activity, may better support the goal to achieve improved lifestyle behaviours and greater post-operative weight-loss outcomes.

Participants shared their perceptions and beliefs of the benefits that could arise from certain technology functionalities; in particular, those which encouraged engagement with each stage of the surgical journey. To achieve this, ideas of implementing technology-enabled checklists to enable the creation of digitalised, stepwise 'packages of care', which covered each patient's journey from pre- to post-operative, were discussed. Digitally 'ticking off' key milestones has been previously discussed in behaviour change(434) and digital health literature(435) as being associated with both short-term and long-term intervention effectiveness; this feature may also prove beneficial for the bariatric surgical patient cohort to guide them through their journey through recovery and support them with lifestyle changes thereafter. A novel finding from this work related to the potential to share the achievements of patients reaching these milestones. By integrating data-sharing functionality alongside the digital checklists, patients and clinicians would be able to monitor progress and milestone achievement. The two-way value of telehealth data-sharing has been acknowledged in previous literature as a technique that promotes patient empowerment; (436) however, it also requires active patient involvement and engagement throughout to paint accurate pictures of progression. Specifically, participants envisaged this functionality to be of best use in the post-operative period, where they could work towards milestones once they had recovered from surgery. The digital checklists were perceived as a functionality that offered patients a structured plan for their post-operative period. For this cohort, this could result in better engagement with their recovery, weight-loss and dietary changes, as well as providing them with a better understanding of the next steps in their follow up care.

When discussing their desired measures of success, this cohort focused on the monitoring of post-operative progress, primarily the ability to track surgically-induced weight loss. Previously, interactive health technologies with monitoring capabilities have been credited as transformers of healthcare by supporting engaged self-care and promoting positive health behaviours.(437) As well as individualised feedback, the potential for individualised goal-setting may further support a generation of digitally engaged patients with bariatric conditions. Working towards achievable targets has been deemed an effective strategy to successfully motivate behaviour change.(185) Wider literature echoes that individualised goal-setting has demonstrated improvements in sedentary behaviour,(273, 274) personalised feedback and messages of encouragement have provided breast cancer patients with a sense of accomplishment,(253) and visual tracking of physical activity (*e.g.* daily step-counts) has been reported as motivational.(274, 438) Perhaps the same approach could be used for patients undergoing bariatric surgery, with a focus on achievable targets of weight loss combined with dietary intake and physical activity.

Uniquely, one participant reflected on aspects of gamification when designing health technologies (in a game format) to support staged surgical recovery. Similar findings have been reported in existing literature that explored health technology design with a cohort of participants following a number of different cancer surgeries.(439) This study focused on the role that digital technologies could play in delivering physical activity-based support to participants in the post-operative period, in order to aid recovery. The authors of this study also identified that personalised difficulty settings in the 'game' boosted patient satisfaction and engagement with the intervention. The use of game-like rewards and incentives has been seen to motivate and sustain health habits over time.(440, 441) In wider public health initiatives, incentive-based health apps and activity tracking programmes have been associated with positive physical activity behaviour change in Canada(442) and the United Kingdom.(443, 444)

Creating a culture of connectedness through the technology was also perceived to be important. Findings from this work echo that of Athanasiadis *et al.*, who investigated the feasibility and effectiveness of Facebook® to deliver peer support to pre- and post-operative bariatric surgical patients.(445) The authors shared that digital forms of social support, in particular those that include the sharing of post-operative success stories, were seen to motivate positive health behaviour change. Feelings of belonging and connection between peer-members of the group were also discussed. Numerous studies exist in digital health literature focusing on the role and success of remote interventions supporting patients with mental health care.(446-450) In particular, digital interventions that combined peer-peer networking alongside evidence-based practice, have been associated with positive changes in body weight outcomes.(451) The same consideration can be transferred to support patient well-being and recovery during bariatric surgical care, and beyond.

There appeared to be value in implementing technologies both pre-operatively and post-operatively. Echoing participant reflections in this study, pre-operative interventions have previously been linked with promoting positive behaviour change culture.(195, 198, 452) This is closely linked with theories of surgical teachable moments, arguing that patients are highly susceptible and motivated to change following the initial decision to undergo surgery.(221, 302) Highlighting the perspectives of participants in this study, digital health technologies may present a promising opportunity to prepare patients prior to surgery, as well as provide continued support between routine post-operative follow-up appointments. Participant responses also highlighted a desire to engage with the technology on an *ad hoc* basis. The benefit of being able to engage 'when required' seems logical, particularly for a patient cohort with changeable post-operative needs over time. Participants in this study also considered that intervention usage and engagement rates would likely be higher soon after surgery, but reduce over time once they better adjusted to post-surgical life. These thoughts echo similar findings within the literature that support engagement decline, however these were previously related to a novelty phenomenon associated with digitally supported care,(453, 454) rather than a result of reduced patient support-requirements. This draws attention to the importance of finding optimal 'engagement balance' with any digital health technologies implemented for patients. Currently, there is insufficient evidence to state the optimal initiation point of digital technologies within the bariatric surgical pathway.

Participants raised contrasting views that suggested a fine balance also existed between them accepting and abdicating responsibility over their recovery and subsequent surgical 'success'. Prescriptive and descriptive approaches to technology content were desired by some, where they wanted the technology to provide them with regulated and specific advice, like directed post-operative meal plans. Yet, previous studies have noted this approach to have questionable success when it comes to motivating and sustaining behaviour change.(455) Instead, authors have cited the importance of empowered patient-health provider strategies.(456, 457) Self Determination Theory (SDT) provides a theoretical framework through which to understand participant motivations and behaviours.(458) When SDT has been applied to other health behaviour contexts (such as programmes for smoking cessation(459) and weight-loss(460)), findings have suggested that the more autonomously motivated participants were, the more successfully they implemented behaviour change. Reflecting on these findings from the literature, it could be suggested that patients with higher levels of independent motivation and acceptance of responsibility are more likely to have successful surgical weight loss; both in the short-term, as well as sustained over the longer-term. Technology-enabled monitoring has also been recognised to boost autonomous motivational levels;(458) however, it may be considered unsustainable to have long-term monitoring done by healthcare professionals as patients desire. Monitoring opportunities and timescales should be considered when it comes to digital technology design and functionality to support and motivate these patients in their surgical journey. The value of digitally-enabled peer-networking within the bariatric surgical journey could be considered as an area for future research; in particular, *how* and *when* digital health technologies could support with, and facilitate, this.(461)

In-line with current research, perspectives of becoming ‘digitally engaged patients’ were considered by many of the participants.(462) Echoing previous digital health research,(287) themes of usability centred around the participant’s existing familiarity *vs.* unfamiliarity with technologies. Many participants discussed being familiar and confident with using technology in their social lives, and open to using it for healthcare too; however, some shared concerns about the ability- and engagement-levels of older participants. Although the cohort demographics of patients undergoing bariatric surgery commonly reflect those of younger ages,(97) it is still important to consider this potential barrier to digital health implementation in modern healthcare settings. Digital literacy and generational bias may remain a challenge to address in this patient cohort.(288, 289, 438) Individuals with poorer digital health literacy tend to be older in age, and as a result, may suffer from more complex chronic health conditions.(463) In addition, those with lower educational attainment and those impacted by social determinants of health may experience disparities in engaging with digital health interventions.(464) Medical jargon and specialised language can persist as barriers that impact engagement.(465) Whilst technologies are now implemented more readily within healthcare, it cannot be discounted that some patients may still prefer traditional, face-to-face encounters with clinicians, rather than virtual ones.(462) In their study evaluating acceptability of mobile health apps in recovery following cardiac surgery, Abelson *et al.* reported that whilst older age was associated with lower likelihood of having smartphones to use the apps, it was not associated with willingness to engage with the technology.(466) Determining a patient's digital health literacy and skills should be done on a person-by-person basis. Suggestions of implementing technology to complement existing care pathways, rather than replacing them, were shared by the participants in this work as well as previous studies.(467-469) Technology designers and policy makers should remain mindful of achieving an optimal balance and, as suggested by participants undergoing bariatric surgery, work to integrate technology alongside educational support materials for those who might need them.(470, 471)

This work has important implications for the design, capability and functionality of digital technologies that could be implemented to provide optimal support to patients undergoing bariatric surgery. Uniquely, this work collates participant desires, suggestions and reflections that span the entire bariatric surgery pathway; including pre-operative participants who were about to undergo surgery and those who are at the 2-year post-operative timepoint who were about to be discharged from NHS 2-year follow-up care. The findings from this work could be used to shape co-design discussions between bariatric surgical patients and healthcare professionals, to refine the best way that digital technologies can be implemented into the bariatric surgical pathway.

The results of this qualitative study have important implications for the design, delivery, usability and implementation of digital technologies for patients undergoing bariatric surgery. This study is one of the first to incorporate pre- and post-operative participants, building evidence on the optimisation of technology-based support to span the perioperative journey when undergoing bariatric surgery. The researcher acknowledges that there were some limitations with this work. Firstly, the research predominantly focused on a small sample of patients in the North of England and, secondly, as is common amongst candidates for bariatric surgery, this sample included more female participants than male. Participants included in this study were purposively sampled from attendees at bariatric surgical clinics (including pre-operative assessments and post-operative follow up appointments); thus, the results do not include patients who were under hospital care, but were non-compliant with appointment attendance. Further research is needed that specifically focuses on the experiences and perceptions of participants from ethnic minority communities undergoing bariatric surgery, given that 75% of this sample self-reported British or White British ethnicity. Finally, our study also focused solely on the desires, suggestions and reflections of bariatric surgical patients, and thus the results may not be generalisable to other elective surgical procedures. Future studies may wish to deepen the insights gained from this work to consider the patient journey and changing mindsets more closely from pre- to post-surgery, which may affect rates of patient engagement with technologies. The study limitations are explored in further detail in Chapter 10.

6.8 Conclusion of results and take-home messages for the bariatric surgery cohort

The integration of digital technologies within the bariatric surgical pathway was viewed favourably by pre- and post-operative patients. By collecting patient perspectives, the results in this chapter were able to highlight important findings relative to the *design, capability* and *functionality* of digital health technologies to best meet this cohort's needs. These findings can be used to enable the production and implementation of better, tailored and targeted digital health technologies for patients undergoing bariatric surgery.

Technologies could offer enhanced connectedness and support to patients across all stages of their bariatric surgical experience, with participants discussing various opportunities where digitally-delivered care could support them to achieve surgical success. Digital strategies should consider the incorporation of content tailored to the pre- and post-operative needs of bariatric surgery patients and their lifestyle choices (such as diet and physical activity) which affect weight-loss outcomes. In addition, the implementation of self-monitoring and goal-setting functionalities support patient engagement with their surgical recovery and long-term lifestyle changes that impact on weight-loss. To address specific unmet support needs of this patient cohort, digital health technologies should enable the provision of a digital 'package of care' to offer care follow-up and support. Finally, consideration should be given to the timing of implementing these technologies within the current bariatric surgical pathway, where use before and after the surgery may prove beneficial in supporting patients to achieve best outcomes.

As considered in the introduction to this programme of work (Chapter 1), in the two systematic reviews (Chapters 2 and 4) and in the narrative review (Chapter 5) written thus far, there are wide-ranging implications and positive outcomes for patients undergoing bariatric surgery who make positive changes to their health behaviours, pre- and post-operatively. Healthier lifestyle changes before and after surgery, including improved dietary intake and physical activity levels, have been shown to contribute to greater post-surgical weight loss,(174, 416) maintenance of weight loss,(417) and better overall long-term health.(418) Prior to this work, little was known about the optimal way to support lifestyle changes in patients undergoing bariatric surgery with digital technologies. Now, because of this patient-informed qualitative study, the researcher has identified key features to support this surgical patient group. The next chapter examines the results from participant interviews conducted with the second patient cohort included in this thesis – those undergoing orthopaedic surgery.

Chapter 7: “All I was after was some indication of what to do to safely push on” – findings from the orthopaedic surgical cohort

The work from this chapter has been published as a qualitative research paper in the Journal of Medical Internet Research (JMIR): Robinson A, Husband A, Slight R, Slight S. *Designing the optimal digital health intervention for patients' use before and after orthopaedic surgery: a qualitative study.* JMIR, 2021. DOI: 10.2196/25885 (Appendix 12). The findings from this chapter have also been presented at a national research conference: the Great North Pharmacy Research Collaborative Conference in July 2021.

This chapter will explore the perceptions of patients undergoing elective orthopaedic surgery. This arm of the study aims to understand how digital technologies can be used in this patient cohort to better support them across the surgical pathway. This cohort of patients experience a period of physical rehabilitation following their surgery, during which, lifestyle behaviour change can improve post-surgical outcomes. This work intended to identify the optimal technology design and functionality features to best support this patient cohort – both, pre-operatively in preparation for surgery, as well as post-operatively through rehabilitation and beyond.

7.1 Introduction

In recent digital health literature, there are various interventions that have successfully supported patients in the management of long-term health conditions(122) and medicines adherence,(150, 151) as well as supporting positive lifestyle behaviour change before and after surgery to improve post-operative outcomes.(16, 472) Health behaviour changes made during the perioperative period can be fundamental in determining the outcomes and success of elective surgeries. The same applies in the context of orthopaedic surgery; increases in pre-operative physical activity levels, and behaviours such as smoking cessation, have been associated with improved post-operative bone healing,(155) wound healing,(156) quicker recovery times, and reduced pain scores.(157) Physical rehabilitation after orthopaedic surgery is an essential component of treatment as it helps to improve functional outcomes and patients return to their daily activities.(158) There remains a limited understanding of how best to support patients undergoing orthopaedic surgery, during both the pre- and post-operative period. There is a lack of evidence on the use of patient-focused digital interventions to support orthopaedic surgery outcomes.

Previously in orthopaedic digital health literature, research has focused on the clinician's use of digital technologies,(473, 474) for instance in supporting their educational development,(475) guiding clinical decision-support,(476) managing care referrals,(477) and building the patient-clinician relationship.(478, 479) Little has been done with the patient at the centre of focus. Recognising and understanding the potential unmet needs of elective orthopaedic surgery patients is central to motivating healthier behaviour change, improving their recovery, and optimising overall surgical success in both the short- and long-term.(480-482) The optimal design, functionality and capability of digital solutions to best aid this cohort is yet to be recognised; therefore, this is where the focus of this work lies.

In order to develop useful and effective digital technologies and strategies, it is important to first understand (i) *how* patients want to be supported on their care pathway; (ii) *what* aspects of technology functionality may support the maintenance of long-term healthy lifestyles following surgery; and (iii) *when* is the optimum timepoint to implement or integrate technologies within the surgical pathway in order to support and promote healthier lifestyle behaviours which lead to a greater likelihood of surgical success. The focus of work in this chapter aims to explore the perspectives of pre- and post-operative elective surgical patients to identify key technology features that they would find most supportive. According to the Enhancing the QUAlity and Transparency Of health Research (EQUATOR) guidelines, this study was reported according to the COREQ (Consolidated Criteria for Reporting Qualitative Research) checklist.

7.2 Participant characteristics

Eighteen participants were recruited and interviewed as part of this research study. The characteristics of each participant are described in Table 18. The average age of participants was 52-years (SD: 16.7), and the most common elective orthopaedic procedure was a total hip replacement. The majority (n=11, 61%) of participants in this sample were male, which is representative of the demographics of elective orthopaedic surgery. Interviews took place between May and June 2020. Participants chose their preferred method of interview, with a total of 11 being conducted over the telephone and 7 conducted using video call–based software (including Zoom® and Microsoft Teams®).

Four themes were developed from the data that addressed the research questions. These themes centred around an intervention's ability to incorporate interactive, user-centred features; direct a descriptive and structured recovery; enable customisable, patient-controlled settings; and deliver both general and specific surgical advice in a timely manner (demonstrated in Figure 16). These four themes are further explored in the remainder of this chapter to understand how best to design and optimise digital technology functionality and capability to support orthopaedic surgery patients. Perspectives and suggestions of participants are illustrated throughout this chapter using interview quotes.

Table 17: Participant characteristics

Participant Number	Sex (M/F)	Age (years)	Interview Format	Orthopaedic Procedure	Pre- / Post-Operative	Time since surgery (exact) or time until surgery (approximate)A	Interview duration (minutes, seconds)
1	F	83	Telephone	TKR	Post	12m	66m 48s
2	M	63	Telephone	TKR	Post	6m	70m 12s
3	M	63	Telephone	TKR	Post	24m	50m 39s
4	F	41	Video call	THR	Post	22m	63m 24s
5	F	42	Video call	THR	Post	14m	65m 56s
6	M	61	Telephone	THR	Post	20m	67m 44s
7	M	70	Telephone	THR	Post	16m	72m 55s
8	F	50	Telephone	THR	Post	8m	64m 54s
9	F	69	Telephone	THR	Post	24m	41m 28s
10	M	50	Video call	THR	Post	10m	74m 07s
11	M	66	Telephone	TKR	Pre	2w	59m 03s
12	M	26	Video call	Hip FAIS	Pre	4w	62m 42s
13	F	62	Telephone	WL R	Pre	6w	75m 58s
14	M	26	Video call	ACL R	Post	6w	69m 49s
15	F	30	Telephone	AR	Pre	1w	59m 50s
16	M	24	Video call	ACL R	Post	6m	67m 12s
17	M	56	Telephone	TKR	Pre	3w	74m 39s
18	M	54	Video call	THR	Pre	8w	68m 23s
Key:	TKR = total knee replacement; THR = total hip replacement; Hip FAIS = hip femoral acetabular impingement surgery; WL R = wrist ligament reconstruction; ACL R = anterior cruciate ligament reconstruction; AR = ankle reconstruction; approximateA = given the implications of the COVID-19 pandemic, some surgery dates may have been delayed so these are an approximated date, reported by the patients at the time of interview; m = months; w = weeks.						

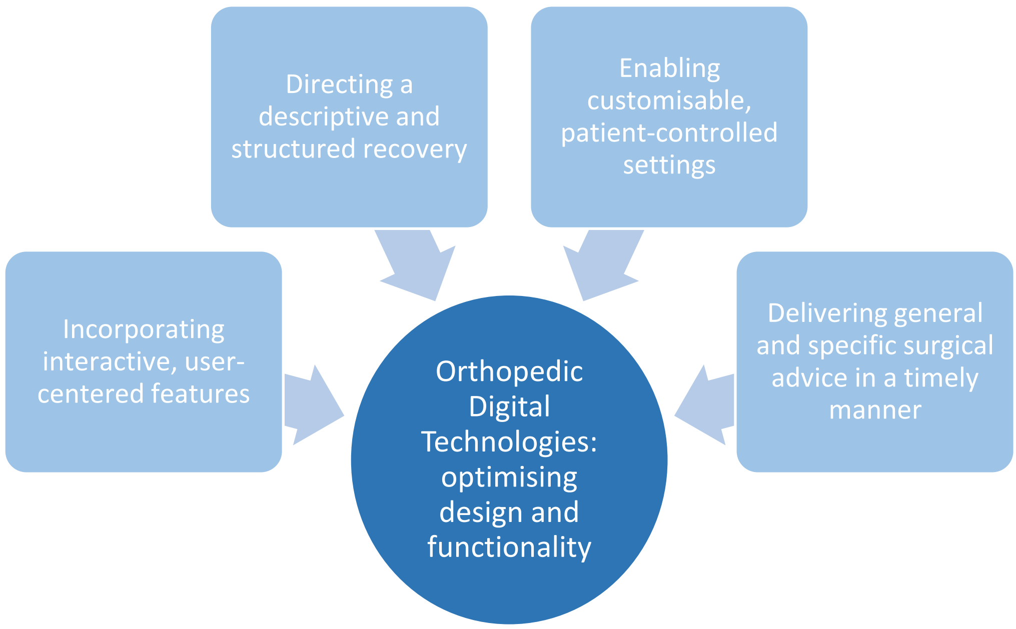


Figure 16: Patient-informed findings: Features contributing to the optimisation of digital technologies to best support patients undergoing orthopaedic surgery

7.3 Incorporating interactive, user-centred features

When considering *what* orthopaedic patients wanted from digital technologies, it appeared key that the technology should include features that were interactive and centred on the needs of each user. By doing so, these features would (i) enable the logging and tracking of a person's recovery; (ii) provide visual and instructive information (using videos); and (iii) facilitate peer-to-peer connectivity (through messaging platforms). Each of these interactive, user-centred features will be discussed below.

7.3.1 "Logging and tracking recovery"

Interviewees perceived numerous benefits from keeping logs during the perioperative period. In the first instance, they recognised personal benefits from *"logging and tracking (their) recovery"* (Participant 5, female, 42-years-old) to visually *"see your progress"* (Participant 16, male, 24-years-old) and *"gauge where you are and how well you're doing"* (Participant 4, female, 41-years-old). This was viewed as something that would *"give you the drive"* to continue with the physical rehabilitation and *"to benefit yourself further"* (Participant 9, female, 69-years-old).

> *"Things that record what you've done so you can see and say "ah, I've achieved that, I've done that" ... I have the incentive to go further"*
> *(Participant 11, male, 66-years-old)*

In addition, participants also discussed benefits in allowing members of the multi-disciplinary team, like surgeons and physiotherapists, to also view the information from their recovery logs. One participant discussed it as beneficial from both sides, where it could give the healthcare professionals an opportunity to *"get an idea of when you're starting to improve"* (Participant 13, female, 62-years-old). Others expanded on this, perceiving shared access to offer patients an opportunity to obtain further medical expert advice, if required. Examples of this included seeking advice on *"pains or swelling… and problems with the scar like any bleeding or signs of infection"* (Participant 13, female, 62-years-old) and finding *"reassurance"* from practitioners in relation to the wound-healing process, as *"(the wound) can look a lot worse before it starts to look better ... I didn't know that but once I did, I felt more settled about it"* (Participant 10, male, 50-years-old). Participants also reflected on the accountability that can arise from having shared access to their recovery logs. They discussed this from the perspective of both intrinsic accountability to keep *"helping yourself at home… to give yourself the best chance"* in the recovery period and beyond (Participant 15), but also as a way of *"proving that you're doing what you're meant to"* to their surgical team (Participant 13, female, 62-years-old).

Keeping a log of wider experiences during their perioperative journey, beyond physical activity, was also considered useful. A pre-operative log of *"mood, sleep deprivation and pain-management"* strategies were considered important for participants in the run up to surgery. One participant discussed how this could have been used to *"validate (their) mental-side"*, which was negatively impacted prior to undergoing surgery (Participant 5, female, 42-years-old). This participant openly discussed how pre-operative joint pain and poor mobility negatively impacted their quality of life prior to surgery. Other participants also reflected on their personal experiences of poor mental health during their surgical journey. They discussed how *"meditation or soothing-type app"* features could have supported them *"through particularly tough periods of pain"* both pre- and post-operatively (Participant 10, male, 50-years-old). In addition, another participant reflected on their recent experience of how their *"mental health has took a bit of a dip recently [sic]"*, whilst recovering and isolating alone at home due to COVID-19 pandemic restrictions (Participant 14, male, 26-years-old). Another participant called for the integration of an interactive *"diary on the app… where you could type in how you feel… if there's any problems"* alongside *"logging the pain and the level of pain"* (Participant 13, female, 62-years-old).

Alongside the logging features, patients described detail about the information they wished *"to be told by the technology"* (Participant 5, female, 42-years-old). Participants felt that being able to *"compare your times or distances"* (Participant 5, female, 42-years-old) through *"a graph or a visual"* comparative feature (Participant 11, male, 66-years-old) would be useful, particularly if it was personal to them. One pre-operative participant discussed wanting to track their *"personal progress"* as a way of celebrating their *"personal wins"* following their total knee replacement (Participant 11, male, 66-years-old). At the time of interview, they described limited physical activity levels due to their knee condition. However, upon discussing tracking their progress following the upcoming surgery, already the participant desired to log their recovery to improve the likelihood of surgical success to *"get the most out of my new knee"* (Participant 11, male, 66-years-old).

> *"I know I will think to myself "can I do it quicker, can I go further?" … which I think are all the correct messages one needs to hear after (surgery) ... and when you put it in the context of general healthy living" (Participant 11, male, 66-years-old)*

Emphasis was also placed on supporting *"the specific tracking… of any (form of) activity"* to be truly personalised and user-centred; this was opposed to only tracking walking or running-based activities like some current fitness trackers. One post-operative participant who had a total knee replacement discussed being recommended to *"swim or cycle instead because it's less impact on my knee"* (Participant 2, male, 63-years-old). Ensuring that the technology tracking features were compatible with swimming or cycling-based activities was deemed important to support user-centred rehabilitation advice. Other participants described having previously high levels of physical activity prior to requiring their orthopaedic surgery, where they regularly engaged in skiing and horse riding. These participants discussed similar requests to enable compatibility to track their specific sporting activities, so that their individual desires were met as *"that's what I want to get back to doing as soon as I can after my operation"* (Participant 16, male, 24-years-old).

Furthermore, enabling real-time functionality was deemed important so that participants could *"track (their) progress accurately… like keeping track of reps and weights"* without relying on retrospective data-entry (Participant 16, male, 24-years-old). In line with this, one participant drew comparisons to an app that they had previously used for cardio-exercises at the gym; they discussed having in-built countdown timers, which you could set to *"count down your last 20 or 30 seconds ... and then they counted out your specific break time too, before you started on the next (exercises)"* (Participant 16, male, 24-years-old). This participant felt that something similar could exist for tracking recovery exercises, where participants can interact with the technology and set their own countdowns. This was perceived to take away some pressure from the individual, so they could focus solely on completing the rehabilitation exercise without needing *"to worry about counting how long you've done the reps for; it's keeping you on track and counting down for you"* (Participant 16, male, 24-years-old).

Similar to the idea of shared access with healthcare professionals, participants also discussed the potential to add 'share' functions when it came to their logged activity achievements. For example, participants discussed being able to share their activity *"maps and times"* with their wider network of peers (Participant 11, male, 66-years-old). The integration of motivational features based on competitions, such as *"leader boards with friends"*, were also discussed (Participant 12, male, 26-years-old). This functionality appeared to add an incentive for patients to engage with their physiotherapy-based recovery plans. Combining these with *"rewards and badges"* (Participant 4, female, 41-years-old) for logged activity appeared to reinforce patient motivation and engagement, whilst keeping the technology interactive and user-centred. One participant described connecting with people who have had the same surgery so that *"you can compare to others and see their maps and times"* and draw comparisons between recovery rates (Participant 11, male, 66-years-old). However, this participant also recognised the importance of avoiding *"pushing oneself too much when you see someone else has gone further or faster ... you've got to remember it's all relative"* (Participant 11, male, 66-years-old).

7.3.2 "I want something to show me"

Video features were discussed by all participants. They were viewed and described as an interactive method, which allowed them to engage with physical activity during the surgical pathway, both pre- and post-operatively. Prior to undergoing surgery, participants reflected that video features could be integrated into the technology and used for educational purposes. Participants discussed how videos could be purposively designed to demonstrate *"exercises they'll be expected to do"* following surgery (Participant 5, female, 42-years-old), or to build awareness around *"the limitations, physically, that you will feel after the surgery"* (Participant 8, female, 50-years-old). In both instances, the participants desired having the ability to watch and re-watch videos in the run up to their surgery with the intention of *"fully educating myself"* in preparation (Participant 5, female, 50-years-old). Participants discussed the obvious value of preparation to *"know what to expect"* (Participant 18, male, 54-years-old) but also the less obvious value of managing their own expectations of what will happen following the surgery. The idea of understanding the likely physical limitations that will be experienced post-operatively was felt to be important, with one participant describing it as *"necessary to get a realistic vision of what I need to deal with"* (Participant 4, female, 41-years-old). One pre-operative participant, currently 6-weeks prior to having their surgery, described the value and usefulness of seeing *"the real side"* so they could learn about what will come next (Participant 13, female, 62-years-old).

> *"I want something to show me... how to do the exercises and what's coming next... the real side of it all" (Participant 13, female, 62-years-old)*

Video-based features were felt to be an interactive and engaging platform through which to deliver these types of preparatory and educational messages. Drawing on their personal lived experiences of the surgery, some post-operative patients reflected on how valuable they would have found videos if *"I had to go back through it all again"* (Participant 2, male, 63-

years-old). Being able to watch videos to practice rehabilitative exercises in the pre-operative period, would have given them *"confidence and reassurance"* to better engage with the recovery process from an earlier stage (Participant 2, male, 63-years-old). One participant discussed this as a way to optimise future strategies through involving digital technologies across *"the entire recovery process, to give myself the best chance of making a good job of it (recovery)"* (Participant 1, female, 83-years-old).

Whilst pre-operative video content was perceived to be useful from an educational and preparatory basis, overall, participants felt that video-content would be of the most value during the post-operative period. Specifically, participants discussed the benefits that could come from interacting with instructional, surgery-specific rehabilitation advice *via* videos that were in-built within the technologies. The patients viewed post-operative rehabilitation to be important to ensure longevity of use from their newly replaced joint, and in this way, they believed videos to be the most useful way to relay physiotherapy content. When discussing this, participants described the integration of instructional videos that demonstrated information including *"which exercises to do, how many reps, how to do them, how long for"* (Participant 16, male, 24-years-old). Interviewees discussed using these videos to inform them of their own rehabilitation and viewed the potential for content to be personalised and user-centred depending on their own recovery plan. The idea of using the digital technology to deliver personalised content, tailored to the stage of recovery, was viewed as supportive and something they could easily interact and *"get on board with as opposed to having it written down on a piece of paper for you"* (Participant 12, male, 26-years-old). One participant who was 24-months post-operative since a total hip replacement described the interactivity of video content as novel and engaging, something that would have *"kept me more engaged with it being different"* (Participant 9, female, 69-years-old). This participant compared the methods that she experienced (where exercise instructions were provided in a leaflet) and discussed the *"lack of appeal in doing them"*, compared to digital, video-based delivery (Participant 9, female, 69-years-old). One participant discussed how watching *"user-friendly video tutorials with people doing"* the exercises could support them in adhering to their own recommended exercises (Participant 16, male, 24-years-old).

> *"With each exercise there could be a video tutorial with people doing them so you can go on, click, watch the video… it could help you understand the*

exercise the physio(therapist) recommends… and learn how to do it properly so it's of most benefit" (Participant 16, male, 24-years-old).

Participants discussed how videos could be used as motivation for those going through various milestones of their recovery process. Post-operative *"success stories"* were discussed, with participants wanting to see video content from *"people who have gone through it, come out of the other side and are thriving"* (Participant 6, male, 61-years-old). The video success stories were defined as empowering and participants recognised the power of them in helping *"visualise what you can achieve"* (Participant 6, male, 61-years-old) – particularly if patients were going through a tricky time with their recovery. Other participants described how the videos could *"push me further with recovering"* (Participant 16, male, 61-years-old), as *"if they can do it, I can do it"* (Participant 4, female, 41-years-old).

Along with using videos for instructional and educational purposes, participants reflected on their *"changed views"* (Participant 9, female, 69-years-old) of integrating video call features in digital technologies for support during the perioperative period. For many, these views were linked to, and influenced by, the global COVID-19 pandemic. Participants described the usefulness of video calls, accepting them as a valuable and convenient form of communication whilst *"getting used to a new normal, a different way of doing things with technology"* (Participant 13, female, 62-years-old). When discussing an upcoming pre-assessment appointment, one participant remarked that their preference for the consultation would be a video call in comparison to a proposed telephone call: *"I'd be more than happy with Skype to 'see them' for my appointment… I think it's more personal, phone calls aren't personal… I'd much prefer to Skype now instead"* (Participant 13, female, 62-years-old). Two post-operative patients reflected on their current experiences of undergoing video-based physiotherapy sessions, considering COVID-19 measures. These participants remarked that the content of the sessions *"doesn't differ that much from actually being in-person – you can see everything well, the resolution is good and the picture is clear, I can hear clearly"* (Participant 10, male, 50-years-old) and *"everything we done the week before with the physio, we replicated on the Zoom call… everything that had been done in-person was quite easily done on the Zoom call"* (Participant 14, male, 26-years-old).

7.3.3 "Messaging someone to settle your nerves"

Participants felt that the inclusion of message-based features within a digital intervention would offer several benefits to the user. Specifically, participants discussed that the integration of functionalities which enabled communication, could be grouped into two forms: (i) peer-to-peer messaging, between themselves and other patients and (ii) patient-to-professional messaging, between themselves and members of their multidisciplinary surgical team (including the surgeon, the specialist nurse and physiotherapists for instance). Both forms of message-based functionalities were perceived to provide patients with ongoing support no matter their stage within the perioperative period, and both of which will be explored in turn.

Pre-operative participants expressed value in communicating with other people going through the same surgery as them. This appeared to relate to information-seeking and educational support – where messaging and communicating with their peers could provide additional support throughout the surgical journey. Two pre-operative participants discussed how they already *"have looked for blogs and posts from other people going through the operation"* (Participant 12, male, 26-years-old) to learn more about their upcoming surgery. Another participant described how they searched and found an online forum, which they used to *"mainly ask for advice and to find out what it's like, what the surgery is like"* from patients who have already gone through the process (Participant 13, female, 62-years-old). Both participants described wanting to seek out further support about the surgery in a bid to educate themselves. Coupled with searching for educational-support, other pre-operative patients reported how they have sought reassurance and emotional-support from others during the whole surgical pathway. One participant discussed doing this even before undergoing the surgical procedure; when it came to making the decision to undergo surgery, they described how they purposefully searched and connected with peers to hear *"stories off people who've done it (undergone surgery) successfully [sic]"* to decide if the surgery was what they wanted to undergo themself (Participant 17, male, 56-years-old). In doing so, they felt supported in their decision-making and opted to be put on the waiting list for a total knee replacement. Post-operative patients also reflected on the lack of peer-support when they were in the pre-operative period and discussed the benefits that could come from connecting peers.

> *"definitely speaking to other people – putting patients in touch with other patients, other people who have experienced it, would be really valuable ... because I just did it all myself when I was going through it. Speaking to others would have helped with that, I think ... I know I would have felt more at ease" (Participant 4, female, 41-years-old).*

Peer-support was deemed particularly important for younger participants undergoing elective surgery. One interviewee described how they felt *"really low that I even need this surgery... I thought hip replacements were only for older people... I'm thinking "is there anyone even like me who's had this before?" because I thought I'd be the only one. It turns out I wasn't and actually, there's loads of people like me having hip replacements (laughs) so thankfully I was able to connect and ask them for advice"* (Participant 4, female, 41-years-old). Other participants echoed similar thoughts and described how they wished to discuss with patients of similar ages to them to ask questions, particularly gauged around physical activity. One patient, who described being extremely active and playing sport to a high level prior to needing an elective anterior cruciate ligament repair, wished to use peer-messaging functionalities to ask questions to find out *"how quick their recovery was... what effect it's had on them getting back to (sport)"* (Participant 14, male, 26-years-old). Drawing parallels between peers of similar ages and previous levels of physical activity could be facilitated through digitally enabled peer support. Another young participant described the role that physical activity played in their life prior to requiring ankle reconstruction and explained their pre-operative nerves about not knowing *"what my life is going to look like after my surgery"* (Participant 15, female, 30-years-old). Concerns about being young and wishing to return to playing competitive sport may have been eased by *"having a conversation or messaging someone to settle your nerves if you know they've been through something similar"* (Participant 15, female, 30-years-old).

> *"being able to speak to other people in that situation would be really valuable. There's no point speaking to someone in their mid-70's, you*

know, their recovery is going to be totally different to how mine is"
(Participant 4, female, 41-years-old).

Post-operatively, participants also discussed the value of sharing message-based support and *"experiences on a forum"* with their peers (Participant 7, male, 70-years-old). One participant suggested that the integration of a patient-led *"discussion area"* within an app may offer a chance to connect with *"people who've gone through similar surgeries – whatever question it may be, they can put it on there and receive feedback"* (Participant 16, male, 24-years-old). The messaging platform would mean it were possible to give and receive feedback, as well as support and encouragement, from peers. However, in doing so, participants demonstrated an awareness for *"mis-information or mis-interpreting the information"* that may be shared (Participant 16, male, 24-years-old). Participants expressed caution in *"believing in it 100% about what it says"* (Participant 17, male, 56-years-old) and discussed the importance in understanding *"every person's experience is going to be different... because everyone recovers at a different rate"* (Participant 2, male, 63-years-old). Also, they acknowledged how one could become easily *"disillusioned"* by comparing or *"judging yourself on other people's recovery"* (Participant 2, male, 63-years-old). Careful interpretation of posts would be needed, even alongside *"maybe needing someone to manage it (the forum) to make sure no-one's writing anything negative or abusive or being like inappropriate in any way"* (Participant 8, female, 50-years-old).

Participants also discussed another messaging feature that they were readily familiar with – Facebook®. Many drew on the similarities that Facebook® groups and peer-support groups have and acknowledged the capability of the networking site to facilitate peer-to-peer support. One participant described the potential to use the social media site by creation of a *"special group, just for that surgery, where you can join up using your personal account and link with others who have had that same surgery as you"* (Participant 13, female, 62-years-old). They described the benefits of it as being familiar and easily used *"because something that I use all the time anyway and so does pretty much everyone I know so you could guarantee that people would sign up for it"* (Participant 13, female, 62-years-old). Another participant echoed these thoughts and discussed the flexibility and usability of the platform as being something that *“everyone knows how to use it already so you wouldn’t need to get a new app or be teaching anyone about how to use it”* (Participant 5, female, 42-years-old). The same participant also described the functionality benefits of using Facebook® for posting pre- and post-operative updates with pictures, videos or text and where other peers could comment.

> *“I would be able to post up and say how well I was walking and stuff like that. I had the benefit of people writing back and commenting on saying “well done” and stuff, which felt really good and encouraged me”*
> *(Participant 5, female, 42-years-old).*

Both pre- and post-operative participants considered the encouragement and morale boost that can come from communicating with their surgical peers. Participants described this feeling regardless of the stage of their surgical journey, whether it be pre- or post-operative. One post-operative participant reflected on their own experience of engaging in peer-support before they underwent surgery, by *“asking them (surgical peers) how quick their recovery was and what it felt like, and stuff. So, I kind of took some comments off them before I had mine”* (Participant 5, female, 42-years-old). This patient went on to describe their engagement with peer-support again following their total hip replacement, where they were *“able to post up and say similar stuff – how well I was walking and stuff like that. I had the benefit of people writing back and commenting on saying “well done” and stuff, which felt really good and encouraged me more”* (Participant 5, female, 42-years-old). They also reflected that surgical peers supported them during their period of rehabilitation, describing that *“it’s harder when you’re on your own, but when you’re doing it alongside other people, having them to just be there as a point of reference or just to ask daft things to – that’s much easier”* (Participant 5, female, 42-years-old). One participant reflected on the encouragement that came from speaking to peers (older than themselves) who shared sporting interests. They described the motivation that they felt from speaking to those with the lived-experience and who continued to remain physically active post-surgery: *“I’d spoken to a guy who had 2 joint replacements and he was cycling well into his early 70’s and seemed to be doing really well. So that was really encouraging and I think that’s a big one for me – seeing what people can do, and do do [sic], after their surgeries”* (Participant 6, male, 61-years-old). Another post-operative participant discussed the motivation that it could have provided them with during their immediate recovery period when aiming for post-recovery activities.

> *"You see people who are post-op, you see that they are able to do X, Y, Z… I think that's why it (peer-support) would have helped me the most by giving me something more to aim for" (Participant 4, female, 41-years-old).*

"Messaging features" (Participant 10, male, 50-years-old) could also enable two-way interactivity between the patient and a member of the multi-disciplinary team. Participants discussed feelings of reassurance when considering possible interactivity with members of the surgical multidisciplinary team. Coupled with the functionality of video call features (as discussed in Section 8.3.2), participants saw value in two-way interactivity with healthcare professionals to aid clinical decision making. Examples of this were discussed such as *"how is your wound healing?"* (Participant 10, male, 50-years-old) or *"sending a photo to them so they can identify any signs of infection"* (Participant 3, male, 63-years-old). It was perceived as a user-centred feature that provided participants with reassurance that, despite being remote, there was a connection with a medical professional during their perioperative period.

> *"Even the idea of (clinicians) saying "we're here, even though it's through technology" … it gives you a bit peace of mind" (Participant 9, female, 69-years-old)*

Participants considered various methods in which to enable this type of two-way, health-seeking conversation to take place. The use of real-time *"live-chat boxes"* (Participant 10, male, 50-years-old), akin to those on websites, where participants and professionals can message back and forth. This form of instant messaging was felt to hold a level of professionalism and formality, with one participant describing its use as being *"a bit more official if you're doing it through a proper chat like that... just setting it up on your phone or on a computer so you can be typing in your questions and have someone answer it and there could be a bit of back-and-forth"* (Participant 10, male, 50-years-old). Another participant described their experience of using chat-box messaging for their car insurance and home insurance matters, believing it to be *“straightforward and quite quick really... you just typed your message in and pressed send and someone got back with their answer”* (Participant 11, male, 66-years-old). The same participant described transferable features that could be used and implemented to support their health, viewing that asking questions about their surgery, as opposed to their insurance, was *“totally do-able, it doesn’t matter as much as long as you were speaking to a medically trained person and you got the answer you needed”* (Participant 11, male, 66-years-old). Overall, real-time messaging was perceived to be a useful and supportive user-centred feature however, some participants raised concerns about making sure it addressed confidentiality requirements. An interviewee suggested one way to provide reassurance to the user by “*asking you some security questions first before you start telling them your issues, just so you know it’s legit and you’re talking to the right person [sic]”* (Participant 8, female, 50-years-old). An alternative method of messaging features linked back to earlier discussions about Facebook®, where the social media platform (or an equivalent) could be used to create a personalised account from which messages could be sent. Participants discussed designing the technology so that it was user-centred, personalised and remained active from pre- to post-surgery.

> *“(could have my) own profile, own log in, own history of messages – who I’ve sent them to and what their answers were – and some sort of record of the op I’m having and what stuff, information, I get told before or after I get it (surgery) [sic]” (Participant 18, male, 54-years-old).*

Regardless of the method of messaging feature offered, it appeared important to participants that response times were clearly specified when it came to seeking-information in this manner. Some participants desired an *“instant reply from someone”* (Participant 10, male, 50-years-old) while others deemed 1-2 working days as a suitable response time; the main driver for this appeared to be in relation to the urgency of the patient queries. When it came to pressing questions or emergency concerns around *“wound healing or infections in the site where you’ve had the surgery”*, participants desired an instant response (Participant 4, female, 41-years-old). One participant suggested quantifying ‘instant’ as being a matter of *“minutes, say up to 60 minutes wait time for getting a response”* (Participant 16, male, 24-years-old). However, another participant suggested *“urgent stuff... well, I would probably be* *calling 999 instead if it was that pressing"* (Participant 13, female, 62-years-old). One pre-operative participant discussed their experience of having a wound infection after a previous surgery (for an unrelated condition). They described *"it (the wound) was going a bit oozy and got really, really sore. I was thinking straight away if that happened again for getting this surgery, I'd be wanting to know "is it another infection again?" because I know now that as soon as I spot anything, I should be asking 'cause the sooner it's spotted, the better"* (Participant 17, male, 56-years-old).

Participants discussed being agreeable to seeking relatively urgent information *via* digital means, coupling messaging-features with video call features could support remote strategies to provide urgent, follow-up care. For other needs, participants considered that a *"response within 24 hours… or a defined period of time"* for generic questions was appropriate. Interviewees acknowledged that response times should be appropriate to meet their needs, but also to *"fit around the (professional's) workload"* (Participant 16, male, 24-years-old); they were conscious of the added workload that these features would cause for the already-stretched NHS professionals. They referred to recognising and experiencing care *"when the staff are so stretched"* and discussed how urgent pre- and post-operative questions could easily be managed through remote means (Participant 17, male, 56-years-old). One participant believed that *"the doctor could give you a short response, like type it and send it and for them, it might actually take less time than having to pick up the phone, ring you, put up with the chit chat and all of that"* (Participant 4, female, 41-years-old).

> *"(messaging) might actually end up being quicker for them (healthcare professionals) and reducing their workload in the longer-term... like, with the shifts that I work, I might not be able to pick up the phone and it might waste everyone's time trying to get back in touch or leave voicemails. Whereas, me dropping in a message and them getting back to me in a day or so might mean it's using both of our times in a better way [sic]"*
>
> *(Participant 4, female, 41-years-old).*

7.4 Directing a descriptive and structured recovery plan

Another important consideration of *what* this cohort wants from digital technologies related to content that was directed, descriptive and structured in its purpose. Perioperative participants expressed their desire for a digital intervention that could support them in *"making the best recovery"* from the surgery (Participant 16, male, 24-years-old). It appeared that patient intentions for this were centred around the provision of 'programme', delivered by the technology, which was designed to offer a formalised structure for their recovery. Participants discussed that this structure should focus on providing *"suggestions of what you should be doing at each stage"* (Participant 16, male, 24-years-old); starting with advice in the pre-operative period and guiding through the perioperative journey to the post-operative recovery.

Numerous post-operative patients reflected on their experiences before and after surgery and described an apparent *"lack of direction"* during these times (Participant 16, male, 24-years-old). They discussed "*not really knowing the full ins and outs"* in the pre-operative period, before undergoing surgery (Participant 4, male, 24-years-old). As well as this, they remarked on there being extended periods of time between post-operative follow-up appointments where *"you were left on your own really... not much guidance for months"* (Participant 4, female, 41-years-old). During the post-operative time, participants felt that they lacked *"the necessary, ongoing support"* from members of the surgical multidisciplinary team (Participant 2, male, 63-years-old). One post-operative patient, who was two-years post-total hip replacement surgery at the point of interview, described gaps in their care where *"I was just winging it, really"* (Participant 9, female, 69-years-old). When clarifying this, specific examples were given in relation to them *"winging"* and *"trying to do my own thing"* with their physiotherapy exercises because *"there was no kind of updates with stuff when I was at home"* (Participant 9, female, 69-years-old). Another participant, who was 22-months post-operative at the time of interview, also discussed similar experiences in their recovery following a total hip replacement. Along with sharing thoughts about feeling *"unsupported"* and *"not knowing what to do"* during the time when they were in rehabilitation, this participant reflected on the vulnerability that some patients feel in that period (Participant 4, female, 41-years-old). They discussed that they did not have any medical knowledge themselves, and had never undergone surgery before, which meant they were experiencing *"something totally unusual"* (Participant 4, female, 41-years-old). This participant shared their perspectives around finding it difficult to know *when* and *how* to progress with their recovery. Thus, they felt strongly that the technologies could provide them with *"some indication"* to help guide and support them, in the form of a structured recovery plan (Participant 4, female, 41-years-old).

> *"All I was after was some indication of what to do to safely push on… having some indication of "this is what you need to do in this week, then move onto this" … I wanted something to show me like that". (Participant 4, female, 41-years-old).*

Participants also expressed views on the delivery of a technology-based recovery plan to support them in a *"safe and appropriate"* manner (Participant 18, male, 54-years-old). One pre-operative participant discussed their nerves and fears about the recovery period, specifically wanting to make sure they did not *"rush and ruin it and be back to square one again"* (Participant 17, male, 56-years-old). This participant viewed the technology as a way to guide them through their total knee replacement. In addition, they acknowledged that an element of individualisation should be incorporated into the technology as *"everyone will recover at different speeds but I reckon everyone will agree, it's got to be at the right speed for them... it's not worth rushing it"* (Participant 17, male, 56-years-old). During the interviews, many participants described their personal experiences that led to undergoing orthopaedic surgery. Many discussed periods of intense *"pain, pain that was just totally debilitating"* which affected them being able to *"go out and live my life"* (Participant 3, male, 63-years-old). Participants perceived the surgery to be a *"life-changing operation"*, which offered them a *"new life"* (Participant 9, female, 69-years-old) and *"more opportunities to keep going"* (Participant 3, male, 63-years-old). On this basis, many felt the need to *"proceed with caution"* (Participant 3, male, 63-years-old) when it came to their recovery and rehabilitation. They described not wanting to *"push it too fast"* when they were in that *"risky period of time... 'cause you're just getting your strength back but at the same time you're thinking "I don't want to rush this" because why would you possibly waste that new joint?"* (Participant 2, male, 63-years-old). It appeared that a form of digitally delivered recovery plan would provide orthopaedic patients with guidance and a structure to their recovery, as well as giving them some form of *“reassurance (that) you’re doing the right thing at the right time”* (Participant 2, male, 63-years-old).

Participants reported knowing *“within each stage of recovery, you should be pushing a little bit more”* (Participant 15, female, 30-years-old). However, participants discussed feeling unsupported enough to be able to do this in the current format of their ‘usual care’ delivered by the hospital. Many viewed this as a potential role that the technology could play, assisting and ‘bridging’ current care in a manner that better supported their surgical outcomes and recovery. Descriptions of structured and directed programmes were given by participants spanning all age groups in this study. However, this view was especially apparent in previously physically active patients and those of a younger demographic. Participants from these groups reported that they wanted to be challenged further, post-operatively, to restore their physical ability. These patients openly shared their past levels of engagement with physical activities including skiing, running, cycling and horse riding. When it came to them discussing their hopes for recovery, they discussed wanting to hear the *“best way to make sure I get back”* to their idea of normality (Participant 4, female, 41-years-old). Importantly, this focused on regaining their *“functionality in the joint after surgery”* (Participant 12, male, 26-years-old).

> *“I feel like the whole process, the whole support from having the surgery was all geared around older people... I was finding myself thinking that the exercises were just “Urgh!” (sighs)... I found myself ringing the hospital saying “have you got anything more for me? Have you got any other exercises I can be doing?” ‘cause they were far too easy. I spent all day thinking about pushing myself more to be able to get back to where I was previously with my sport and it just wasn’t challenging... I had a list of questions: ”will I still be able to do things like snow board and ski?” (Participant 4, female, 41-years-old)*

Recommendations to provide this structured recovery programme stemmed around designing *“milestones… in terms of where you could expect to be after Week 1, Week 2”*, with the inclusion of *“physiotherapy messages”* (Participant 12, male, 26-years-old) and *“general healthy living messages”* (Participant 11, male, 66-years-old). Tailoring the intervention to support a structured recovery would mean starting with *"simple exercises to start the recovery and build on from there"* (Participant 16, male, 24-years-old). In addition, participants described the integration of gamification features and *"progression-based exercises"* throughout the recovery where, over time, the programme recommended *"trickier exercises… working towards that final goal of being recovered"* (Participant 16, male, 24-years-old). Both pre- and post-operative participants viewed the capability of setting *"targets and goals to work towards"* as an important feature of creating a structured and directed recovery programme (Participant 4, female, 41-years-old).

Combining goal-setting with gamification-features to break *"(rehabilitation) down into small chunks at the start and then advancing through each level"* (Participant 15, female, 30-years-old) and real-time messages of support like *"well done, you've completed this level, next it's…"* (Participant 4, female, 41-years-old) were deemed motivational in giving *"more people focus for what to achieve after the surgery"* (Participant 5, female, 42-years-old). Having a directed rehabilitation structure with set 'milestones' to unlock over time also allowed participants *"to feel some independence that it's up to you to advance through the levels or reach a certain target, but with the comfort of knowing it's still safe, you're not pushing too hard"* (Participant 12, male, 26-years-old). Incorporation of safety-netting features to recover at *"a safe speed"* also provided reassurance for pre-operative patients that they will not be pushed to *"do too much too soon"* (Participant 12, male, 26-years-old) and compromise their outcomes following surgery.

7.5 Enabling customisable, patient-controlled settings

When it came to addressing our research question of *how* patients wished to use these technologies, the benefits of having in-built, customisable, *"patient-controlled features"* to enable elements of control were widely discussed (Participant 4, female, 41-years-old). This included wanting to *"set myself my profile, choose my name…"* (Participant 14, male, 26-years-old) when creating their own login and account on an app. While some participants were agreeable to creating a personalised profile, others discussed the potential to make this optional, instead preferring to keep their accounts anonymised and private *"without having to put my picture on or put my name on... I don't think I'd want people to know that, I'm quite* *private really"* (Participant 6, male, 61-years-old). Enabling the option for patients to control and select their desired privacy level may support increased engagement across all groups, no matter their usual level of technology use.

Participants also described their desires to customise the app, beyond creating their own personalised profile and account. Having the ability to *"build your own workout"* (Participant 16, male, 24-years-old) within the app was sought after by participants who were previously physically active, and who had familiarity with exercises that may be incorporated in their rehabilitation. Participants discussed being provided with a selection of exercises (tailored to their surgical type) and being able to select several of them to create a customised workout. Integrating the functionality which allowed patients to *"preference certain exercises to make it individualised to each person"* was viewed positively (Participant 12, male, 26-years-old). The same participant referenced their experience using digital technologies like exercise apps, and specifically discussed the layout features of one, explaining how it was possible to *"toggle the home-screen settings"* (Participant 12, male, 26-years-old). This meant that the participant could select which exercises featured as their 'favourites' and include these in an easy-to-access place on the app. Enabling customisable, patient-controlled features, such as toggling and selecting favourites, were discussed in a similar way when it came to integrating *"practical things that would support you when you're doing the exercises... (like) stopwatches or countdown timers"* to ensure exercises are being done for the correct amount of time *"and it stops you from shaving any time off and cheating (laughs)"* (Participant 4, female, 41-years-old). Interviewees perceived that customisable functionality would encourage a greater sense of accountability, which, in turn, would encourage them to better *"connect with the (recovery) process"* (Participant 4, female, 41-years-old).

> *"It's going to need a personal approach – but if you were able to toggle certain settings to make it individualised to each person, then you'll get more successful outcomes with it and impact different people in different ways" (Participant 12, male, 26-years-old)*

Accompanying the ability to customise aspects of their physical recovery, participants recognised benefits in having the capacity to preference functionalities, which focused on the holistic experience of surgery. Specifically, features relating to the mental- and motivational-experience of undergoing orthopaedic surgery were perceived to be useful, as was the ability to customise the settings to make them personalised. Participants discussed choosing a *"more personal way of setting reminders or getting messages"* (Participant 7, male, 70-years-old) in relation to any notifications they might receive from the technology. This patient-controlled functionality was deemed to be more constructive and supportive than other technologies participants have had experience with. One patient discussed a connected wearable technology and app that they used previously which sent automated push-notifications *"without a personal touch"* (Participant 10, male, 50-years-old). They were described as instructional and informal, such as "move!", whereas encouraging messages were perceived to enhance user-experience and the likelihood of better engagement with rehabilitation recommendations. The same view was shared by other participants, who described that the tone of notifications was important to encourage participant interaction. Examples of notifications that participants perceived to be user-friendly included *"have you done your physio yet?"*, rather than *"automated "do your physio" notifications"* (Participant 12, male, 26-years-old).

Granting patients the capacity to tailor preparatory and recovery information to meet their own personal requirements was widely discussed. This was viewed as crucial by participants who described high levels of physical activity prior to surgery and a wish to continue this post-operatively: *"it completely depends on who you are as an individual and what you want from it (surgery)"* (Participant 4, female, 41-years-old). Being able to *"advance at a pace suitable for you"* (Participant 12, male, 26-years-old) during recovery was perceived as imperative to best restore previous *"functionality of the joint"* (Participant 6, male, 61-years-old). By doing this, customisable features may enable individual post-operative expectations to be met. When discussing their experiences, some post-operative participants viewed the rehabilitation exercises that they were provided with as being *"rather pedestrian"* (Participant 8, female, 50-years-old). Another felt that *"the whole process, the whole support… was geared around older and less mobile people"*, instead calling for the capability to preference and customise their own rehabilitation, whilst remaining within the surgical guidelines (Participant 4, female, 41-years-old). From the experiences discussed by some post-operative participants, it appeared that rehabilitative exercises were not designed with a younger or more active patient in mind. When it came to using technology to manage this, participants expressed desires to be able to *"choose your own difficulty… to make the recovery challenging enough"* (Participant 16, male, 24-years-old).

> *"(recommendations) should be determined by how active you already are… it's no good telling me "walk 1 mile" when I'm used to walking 20! It's the same for someone perhaps less active when they can't functionally do it"*
> *(Participant 4, male, 24-years-old)*

7.6 Delivering general and surgical-specific advice in a timely manner

In addressing the research question around *when* digital technologies would be of most benefit during the surgical pathway, the *timing* of the intervention appeared crucial; this not only related to the time at which the intervention was offered to participants, but also the time for which they could use the technology. From discussions with participants, it appeared that the 'initiation point' of the intervention was significant. Participants described that the technology should be initiated *"at a proper time for you to get use out of it before you go for the op"* to meet the pre-operative needs of participants (Participant 3, male, 63-years-old). Getting the 'initiation point' right meant that participants were able to seek information and be provided with advice relative to the surgical stage they were at, as soon as they desired.

Closely related to optimising the timing of the intervention, the delivery of advice at key timepoints within the surgical pathway was also perceived to be key. Particularly this related to the delivery of both general and surgery-specific information. Specifically, pre-operative interviewees wished for explicit *"sections for before surgery"* to seek-information about the surgical procedure itself (Participant 11, male, 66-years-old). Several participants reported that they had done their *"own research about it and what the surgeon would be doing"* (Participant 11, male, 66-years-old) and *"read up about what it'll entail just so I have an idea"* (Participant 18, male, 54-years-old). Going into the surgery with an element of understanding about the procedure was a shared consensus for many participants. It was important that the delivery of this information happened at the right time for participants to *"do the reading up* *of it"*, digest the information, and have *"time to ask any questions if I think of some"* (Participant 3, male, 63-years-old).

Many participants shared the view that pre-operatively, they needed time to process the information prior to undergoing surgery and many placed emphasis on initiating the technology to do this at an early stage within the elective surgical pathway. However, when it came to the nature of this information, particularly relating to how in-depth they wanted to learn about their procedure, participants seemed to have very individual views. Some participants discussed wanting to understand the *"basics, the majority of what's going on"* but without learning about *"all the gory stuff"* (Participant 15, female, 30-years-old). Whereas others reported that *"I want to know everything, I like to know everything like the pros and cons and risks"* (Participant 18, male, 54-years-old). Careful technology design and initiation could enable the delivery of surgical advice and provide insight to participants who wished to learn more about the procedure pre-operatively. However, the idea of making this *"not a mandatory thing, more of a thing if you were intrigued to know more then you could"* would be an important consideration (Participant 15, female, 30-years-old).

"Implementing it as early as possible, I think, would be really good. Implementing an app with all of the pre-op information... it just makes it a consistent approach for people and allows them to get used to using it and integrating it in their routine" (Participant 16, male, 24-years-old)

Alongside this, participants recognised the benefit of having a pre-operative initiation point, to become familiarised not only with the surgical procedure itself, but with the process of *recovery*. One participant discussed the value of understanding and learning about the recovery period in advance, so they could be *"already in that mindset"* when approaching the operation (Participant 17, male, 56-years-old). This patient went on to point out the importance of optimising the initiation point to maximise participant engagement with the surgery itself. They described perceptions of *"approaching (surgery) with the right attitude"* and how important it is for patients to have an *"idea of the time and energy we need to invest in order to fully recover"* (Participant 17, male, 56-years-old). This view was shared by other post-operative participants when they reflected on their own surgical experiences; they discussed how their recovery benefitted having the right mindset and understanding about the surgical recovery, prior to undergoing the operation. When considering the optimal initiation point of the technology for elective surgical patients, it appeared that the pre-operative period could represent a time where patients could capitalise and prepare for their upcoming recovery and rehabilitation.

> *"I was ready for the off, straight away… I had it in my mind that that's what I needed to do… you don't want to be waiting 'til you're post (-operative) to hear those things" (Participant 5, female, 42-years-old)*

In combination with ensuring the technology was initiated at the correct time, the post-operative 'continuation point' of intervention-use was also deemed significant. Many participants discussed preferences to continue the use of the technology beyond the pre-operative period, seeing benefits for using it post-operatively too. The post-operative use was perceived in two forms: firstly, to support the initial post-operative period to *"give me some pointers on that initial getting up and moving straight after (the surgery)"* (Participant 5, female, 42-years-old); and secondly, to be used as a means of continued advice throughout the entire surgical pathway until the participant had fully completed their recovery rehabilitation. One participant (who was 10-months post-operative) shared their perceptions of using the technology to support them in adjusting to immediate post-operative life. When sharing their personal experiences after undergoing a total hip replacement, they described struggling with post-operative pain in the immediate weeks to months following surgery. They reflected that the technology could have been of most use *"when I landed post-op, with all my new aches and pains and new experiences after the surgery"* (Participant 10, male, 50-years-old). They described that it was within this early post-operative timepoint that people would *"want the most support because physically you're in pain, but mentally you're needing to adapt to the pain and the limitations"* (Participant 10, male, 50-years-old). Other participants echoed similar opinions, seeing post-operative technologies as a means of offering an input that *"extended from the hospital team right back to you in the house"* (Participant 1, female, 83-years-old). One participant described the benefit of post-operative input from the hospital physiotherapist following a total knee replacement. This participant discussed how the email-exchanges they had with physiotherapists could have been made easier with contact *via* a video-call app *"where you could still send text(-based) messages to them in a chat, but also they can watch me doing the exercises visually in front of them... so they can be doing checks as to whether you're doing them right or wrong and get their advice there and then (rather than waiting for an email response)"* (Participant 1, female, 83-years-old). Ideas of real-time exchanges with members of the surgical multi-disciplinary team were shared by many participants; when delivered through technology, these exchanges were described as timely and *"going the extra mile"* to *"ensuring we make a good recovery"* (Participant 14, male, 26-years-old).

Other participants shared their opinions about receiving real-time post-operative advice as they advanced through their recovery too. One participant reflected on *"still needing to hear these messages"* relating to physiotherapy and rehabilitative exercises throughout the journey (Participant 4, female, 42-years-old). When comparing with their own experience, one participant emphasised that *"hearing (advice on rehabilitation exercises) once, right at the start before I'd even had the surgery – well that's going to be no good to someone when it gets to them being 3- or 4-months down the line and them actually needing to hear it at that point when they're ready to hear those messages"* (Participant 4, female, 42-years-old). Instead, they remarked that 'drop-in' rehabilitative exchanges delivered by the technology at various points of the post-operative journey could act as a means of providing necessary information.

> *"You still need these messages post-op too. Things like "when should I go out and climb a mountain? When is too soon to be walking out or starting to do some real exercise?" Things like knowing when you can get out and about again – that should come afterwards" (Participant 4, female, 42-years-old).*

One participant was using an app already during their surgical pathway and they acknowledged the potential to continue the use of it beyond their rehabilitation time too;

they perceived that the digital strategies could offer benefits to participants in their continued use.

> *"I think, to be quite honest with you, I'll keep using it long-term now, just as a means of curiosity really, to see how my new joint does on a longer term... (and) to track how far I'm getting (with cycling)" (Participant 10, male, 50-years-old).*

Participants also discussed the importance of *"staggering the information"* provided by the technology (Participant 10, male, 50-years-old). They described a gradual build-up of information, with ideas of *"drip-feeding what we need to know"* during the pre-operative period so that post-operatively, they would be better prepared (Participant 10, male, 50-years-old). Another participant described that *"you can't expect everyone to take it all in at once... so staggering the information, it needs to be do-able"* (Participant 8, female, 50-years-old).

> *"I think having access to (technology) fairly long-term would be useful. I'm not sure I could put an exact timeframe on it, but I can't see any reason why that information access would have to stop. You could link it all to the NHS app so you can get that information at any point, if you happened to be further down the line... for example, a year down the line my hip starts to hurt and I'm wondering "is this normal?" and I still have access to that information. I think the information-needs would decrease as time goes on, but certainly, for as long as you're living with the new joint, then I think you need access to that information" (Participant 12, male, 26-years-old)*

Participants also recognised the need to deliver both general and surgery-specific advice during the elective orthopaedic surgical pathway. They discussed the initiation of digital interventions with a sense of 'generalisability' between surgical procedures, so that patients undergoing any form of elective orthopaedic surgery may find the pre-operative information beneficial. Participants described the need for *"a generic advice"* hub (Participant 15, female, 30-years-oldf) for all orthopaedic patients to use. For instance, one participant who underwent a total hip replacement remarked *"well I'd never had an operation before so some stuff about what to expect about the sedation would have been helpful... that would probably be helpful across the board to be honest"* (Participant 3, male, 63-years-old).

They also believed that information pertinent to their type of orthopaedic surgery would be helpful, suggesting that technology designers should consider timing the delivery of surgical-specific information in a tailored, patient-by-patient (or procedure-by-procedure) capacity. When it came to this capacity, participants described how the technology content and layout could support them, where *"different tabs for different surgeries"* could mean they find surgery-specific information whenever they wanted during the pre- or post-operative periods (Participant 8, female, 50-years-old).

> *"When it came to advice more about the operation I was having, then I reckon I'd only need to read up on the stuff for my hip... I wouldn't have expected to be needing to read anything if it was about a knee replacement instead of my hip if that makes sense, 'cause that's just not relevant for me" (Participant 3, male, 63-years-old).*

Two participants discussed the feasibility of having one *"centralised database"* (Participant 12, male, 26-years-old) of exercises, breaking *"the exercises down to different body parts"* and being able to easily find ones that they could do to aid their recovery (Participant 16, male, 24-years-old). In addition, interviewees called for holistic *"general health and recovery"* sections, integrating *"positive health advice"* that would be useful to hear throughout the perioperative process of any surgery (Participant 6, male, 61-years-old). This included pre-operative advice on preparation for surgery and *"building muscle strength beforehand"* (Participant 15, female, 30-years-old), reassurance on post-operative physical rehabilitation, and *"short- and long-term messages"* around overall healthy living (Participant 11, male, 66-years-old). Overall, the consensus of pre-operative initiation and post-operative continuation of technologies to support elective orthopaedic patients appeared to bring numerous benefits.

> *"There are generic exercises that would be recommended for most joint surgeries, just to build up the muscle strength again… (and) if you had an*

app where you could select 'hip replacement' and it provided you with 'this is what exercises you should do'… it could give you more specific information when you actually needed it" (Participant 4, female, 41-years-old)

7.7 Discussion: contextualising the findings into the current literature

This patient-informed study underlines the importance of obtaining patients' perspectives in relation to the design and functionality of digital technologies to best support their recovery following elective orthopaedic surgery. Prior to this work, the optimal design, functionality and capability of digital solutions to best aid orthopaedic surgical patients was not known. By collecting both pre- and post-operative patient perspectives, it was possible to identify specific features and functionalities that appear to be of most benefit in supporting this cohort across specific timepoints along the surgical pathway. The reflections and experiences shared by interviewees provided additional understanding of the surgical pathway as a whole, at a person-centred level. This also meant that key areas of focus were identified when it came to considerations of this specific patient cohort.

A consistent finding across interviews was that participants saw value in having a digital technology to direct them through a structured plan to achieve a successful recovery. In relation to the technology design, both directed and descriptive content were desired by participants. Like the findings from the bariatric surgical cohort in the previous thesis chapter, orthopaedic surgical patients described the benefits of having directed and specific advice in the perioperative period. This appeared to relate to knowledge-building and psychological preparation within the pre-operative period, and the cautious guiding and increasing difficulty of physical activities as part of their post-operative rehabilitation. Participants described the feeling of "being directed" as a way of building their self-confidence during the surgical pathway – a period of time during which, ordinarily, they have reported being "out of their depth" and placing trust in a surgeon.(483) Wider literature also echoes these findings of benefits in directed recovery; studies have demonstrated that participants felt that having the ability to take ownership over their own recovery was an important aspect of surgical rehabilitation.(483-486) This has also been noted by Doyle *et al.* in their systematic review, when considering wider factors that impact patient experience and patient empowerment within their health care.(487)

In addition, participants described the benefits of having content that provided regular digital milestones to guide them and measure their journey towards recovery. Previous studies have demonstrated the benefits of continuous measurement within the recovery process of patients following cardiac and neurological surgery.(488) Quantifying surgical rehabilitative progress has been seen to motivate patients and cause them to take more active roles in their own recovery and rehabilitation.(489) In their recent study, Lyman *et al.* evaluated the role of smartphones to collect daily step counts following total hip or total knee replacements.(490) The authors reported the feasibility of tracking post-operative recovery using mobile technologies, particularly with regular engagement in the form of daily logging of patient reported outcome measures, for instance by using numeric rating scales for pain levels when a patient is mobile and performing rehabilitative exercise. This finding, as echoed by the participants of this study, demonstrates that regular logging and reporting (of both physical and psychological measures/aspects involved in surgical recovery) could complement the idea of following routine digital milestones generated by this study cohort. Consideration should be given to integrate this feature into technologies associated with orthopaedic surgery.

Mehta *et al.* aligned this idea with reports of positive reinforcement through setting and meeting individual recovery goals following hip arthroplasty.(491) Goal-setting is a well-recognised behaviour change technique that supports self-regulation skills in the change process.(492, 493) In previous orthopaedic studies, digital goal-setting facilitated personal fulfilment and gave patients a sense of control and accomplishment during the perioperative period.(268, 494) In their review, Argent *et al.* demonstrated that home-exercise programmes that involved wearable sensors provided patients with value, measured in patient satisfaction and adherence to achieving specified goals.(494) The authors suggested that using the wearable technology alongside the exercise programme contributed to an increased sense of routine for the patient when experiencing the post-operative rehabilitation journey. Likewise, in their mixed-methods study of participants following knee surgery, Lee *et al.* described that virtual reality-based rehabilitation which incorporated the challenges of goal-setting, were perceived as motivational by patients.(268) Combining goal-setting alongside performance feedback and the review of goals (akin to milestones within the recovery journey) have been associated with both short- and long-term intervention effectiveness.(434) By integrating digital strategies to help define goals within recovery, orthopaedic patients may feel better supported and motivated to engage in health behaviour change.

Participants also highly valued the integration of video-based features in digital interventions, whether as a visual aid for rehabilitative exercises or to facilitate remote telemedicine consultations. Our findings supported the growing popularity for video-based consultations reported in other areas of global health and social care,(495-497) with participants reporting feelings of connectedness, empowerment and reassurance through image- and video-based sharing.(117, 498, 499) Similar findings have also been shared by patients undergoing treatments for a range of non-surgical health conditions including heart failure,(124, 499) chronic obstructive pulmonary disease,(500) diabetes and cardiovascular disease,(501) and Parkinson's disease.(117, 502) The incorporation of video call features within digital health technology is gaining attention, particularly as a consequence of the global COVID-19 pandemic.(496, 503) It appeared that more prominent use of video call features, both in participants' work- and social-lives, has led to greater acceptance and adoption of their use within the world of healthcare.(503) In their recent study, Rush *et al.* reported growing evidence of patient preference for video-calls over telephone-based follow up appointments.(118) In particular, patient reported satisfaction scores were higher among those using video compared to telephone calls ($M=4.18$ vs. $M=3.79$ respectively, $p=0.031$).(118)

All participants in this cohort discussed the impact of the global COVID-19 pandemic on the UK NHS. At the point of interview, three participants were undergoing technology-enabled follow-up appointments with their physiotherapist and two had used video call-based software to conduct their pre-operative assessments with members of the surgical multi-disciplinary team. The responses from these participants meant that reflections and perceptions of the subject of digital healthcare were timely. However, in addition to these participants who reported active use of technologies, this study also included participants who had not previously engaged with technologies in any capacity. This was done to ensure a rounded collection of opinions and highlight any challenges that may accompany the implementation of technologies within surgical patient care. Participant views echoed those discussed in current research on ‘digitally engaged patients’ and recognised the multitude of ways in which technologies can be embedded within the NHS to transform surgical patient support throughout the entire perioperative journey.(503) Interactive digital health technologies have been credited as transformers of healthcare by supporting engaged self-care and promoting positive health behaviours.(504) The global pandemic has presented a unique opportunity for creative delivery of healthcare. It is important that this momentum gained to adopt and utilise digital technologies is not lost, with the focus being continued provision of innovative surgical patient care, monitoring and follow-up spanning the whole perioperative period.(505)

Another promising strategy of digital intervention design, ‘gamification’, was discussed in the results of this study. Digital gamification has previously been linked with increased user-engagement with technologies.(506, 507) In this study, participant suggestions to incorporate leader boards and collecting rewards during the post-operative recovery process echoes recent findings from adult and paediatric patients undergoing orthopaedic, dental, and ophthalmic surgeries.(508, 509) The use of game-like rewards and incentives has been seen to motivate and sustain health habits over time.(440, 441) In the paper by King *et al.*, the authors discuss the use of active video games as a source of motivation to achieve physical activity goals.(440) This paper also coined the phrase ‘games with purpose’, where health aspects and behavioural insights can be targeted in partnership by clinicians, behavioural scientists and software developers alike. In the systematic review conducted by Lister *et al.*, gamification was recognised as a common feature in health and fitness apps, spanning cohorts mainly invested in tracking aspects concerning physical activity and dietary intake;(441) other health behaviours such as smoking cessation were also reported. Features that relied on social- or peer-pressure were the most common element of gamification employed in the current digital strategies; where features such as competitions, digital rewards and leader boards were seen to be less common. In wider public health initiatives, incentive-based health apps and activity tracking programmes have been associated with positive physical activity behaviour change in Canada(442) and the United Kingdom.(443, 444) In their experimental study, Mitchell *et al.* evaluated a rewards-based app that rewarded Canadians with loyalty points for engaging in healthy behaviours.(442) The loyalty points were exchangeable for groceries, retail goods or travel rewards. The authors reported small, but significant increases in daily step counts, especially for individuals who were previously physically inactive, and postulated that the combination of rewards alongside digital strategies to improve health behaviours provided a measurable improved result. In the UK-based study by Elliott *et al.*, similar results were reported in relation to using an incentive-based app that converted physical movement into virtual currency, which could be exchanged for goods and services.(443) The authors propose the potential role in which gamification can be tailored to individual patients; similar to the findings from this orthopaedic cohort.

This study contributes further evidence to support gaps in the literature, which relate to the timing of intervention use. This gap has been recognised in recent systematic reviews by Jansson *et al.*(158) and the research team involved in this conducting this PhD work (as discussed in Chapters 2 and 4 of this thesis).(472, 510) Pre-operative initiation of interventions, and post-operative continuation, were sought after by this elective orthopaedic cohort. In addition, captivating the pre-operative patient mindset and making use of the surgical teachable moment appears to be significant in encouraging perioperative behaviour change and optimising post-operative outcomes.(221) Being granted a sense of control and responsibility over their recovery, starting pre-operatively, was valued by participants; this links closely to work conducted in Chapter 3 of this thesis.

Prior to surgery, interviewees described desires to customise their technology and its content to best suit their needs, thus encouraging better engagement with the upcoming recovery process. The individualisation of care pathways has been discussed in medical and surgical literature,(4, 25) however our study also presents the importance of individualisation of the *technologies* to support with care-delivery. Technologies that incorporated customisable features, which the patient could control and toggle according to their personal preferences, was considered another motivator for successful recovery. Participant autonomy has been shown to positively impact motivation levels and user-experience, thereby improving experiences of patient care.(511-513) This study also highlighted the specific desires to create challenging rehabilitative content for participants who were more physically active prior to surgery. These patients sought the ability to customise the difficulty levels of physiotherapy-based exercises to regain their previous levels of physical activity with their new joint. These participants recognised the need for guided post-operative input in the initial post-operative period, but also reported the value in building confidence and physical ability in their rehabilitation by taking ownership over their recovery, in order to achieve higher-level functioning with the hip or knee arthroplasty. In existing literature, technology-enabled, preference-based care has improved patient and healthcare professional outcomes.(512-514) In their recent randomised controlled trial, Hamilton *et al.* discussed the lack of rehabilitative guidelines for total hip replacement patients based in the UK.(515) In addition, uniform post-operative physiotherapy for all patients following total knee replacement (when compared to no treatment) were seen to offer only short term benefits, which were deemed ineffective for improving patient outcomes 12-months post-surgery.(516-518) Hamilton *et al.* recognised the need for targeted interventions for certain patient subgroups in order to challenge and improve patient outcomes, with their results demonstrating enhanced satisfaction with the ability to undertake physical activities. The authors also recognised the lack of consensus as to the optimal way to delivery rehabilitation to participants undergoing total knee replacement; a knowledge-gap that this research fills. Technology creators may consider implementing customisable features to grant patients autonomy over aspects of their recovery.

The researcher acknowledges there were some limitations with the work within this results chapter. The virtual call-based software enabled the researcher to replicate features that usually accompany face-to-face interviews (*i.e.,* enabling the researcher to respond to verbal and non-verbal cues and build rapport).(519, 520) However, there were some disadvantages to this remote interview technique that may have impacted this study. All participants were asked which format of interview they would prefer; established familiarity and participant comfort of use may have contributed to the higher number of interviews being conducted over the telephone. Despite this, video-calls enabled a unique snapshot into life as a patient recovering at home during the crisis and provided a fuller-picture with more context than a telephone call may have done.(521) Participants currently experiencing remote consultations with members of the surgical team offered timely insights to this study. In addition, because of the COVID-19 pandemic and the pressures placed on healthcare settings, many elective orthopaedic surgeries were cancelled during the time that this research was being conducted. This meant that fewer pre-operative participants could be recruited and interviewed in comparison to those who were post-operative (n=6 vs. n=12 respectively). This research predominantly focused on a sample of patients in the North of England and, as a result, the experiences shared by participants may not be representative of all persons experiencing the orthopaedic care pathways across the UK. Given the focus of this study arm, the perspectives of elective orthopaedic surgical patients are explored in this chapter thus, the results may not be generalisable to other elective surgical specialties or acute surgeries. The limitations of this study are discussed further in Chapter 10.

7.8 Conclusion of results and take-home messages for the orthopaedic surgery cohort

Results of this study have important implications for the design, functionality, application and use of digital technologies for patients undergoing elective orthopaedic surgery. By collecting patient perspectives, the results in this chapter were able to highlight important findings relative to the *design, capability* and *functionality* of the digital health technologies in order to best meet the needs of this cohort.

By integrating digital goal-setting strategies within their recovery, patients feel better supported and motivated to engage in health behaviour change to optimise surgical outcomes. The use of game-like rewards and incentives has been seen to motivate and sustain positive health habits over time. The integration of video features was acknowledged as an interactive method of engaging with physical activity during recovery, as well as being regarded as a more personal strategy to enable follow-up consultations. This work contributes to the limited amount of existing digital health literature in this patient cohort, and provides much needed evidence relating to the optimal timing of digital interventions for elective orthopaedic surgical patients. These findings should be employed in future co-design projects to enable the design and implementation of patient-focused, tailored and targeted digital health technologies within modern healthcare settings.

Prior to this work, little was known about the optimal way to support lifestyle changes in patients undergoing orthopaedic surgery with digital technologies. Now, because of this patient-informed qualitative study, the researcher has identified key features to support this surgical patient group through digital health technologies. The following chapter is the final results chapter for this programme of work and considers the results from interviews conducted with participants undergoing surgery for lung cancer.

Chapter 8: “We are all individuals and the technology should reflect that” – findings from the lung cancer surgical cohort

At the time of thesis submission, the work from this results chapter has been submitted as a qualitative research paper to the Journal of Medical Internet Research (JMIR), under the citation: Robinson-Barella A, Husband AK, Slight RD, Slight SP, *Designing a digital health support tool for lung cancer patients requiring surgery: a qualitative, patient-informed exploration of digital technology capability, functionality and design* (under-review). The findings from this chapter have also been presented at a national research conference: the Royal Pharmaceutical Society Annual Conference in November 2022.

This chapter will describe how digital technologies can be used to support patients undergoing lung cancer surgery, and in adjusting their lifestyle behaviours, to consequently benefit their post-operative outcomes. The results in this chapter explore pre- and post-operative patient perceptions and the key aspects of digital technology design, functionality and capability features that best support this group of patients.

8.1 Introduction

When it comes to supporting healthier lifestyles and behaviours amongst patients with lung cancer, there are key associations between good physical activity, psychological wellbeing and improved post-operative outcomes.(522-526) A number of existing reviews have focused on interventions aimed at increasing the physical activity levels of lung cancer patients,(527-531) and have studied these across both the pre- and post-operative periods. Pre-operatively, maintaining recommended levels of physical activity led to increased pulmonary function and decreased risks of post-operative pulmonary complications, as well as shorter durations of stay in hospital.(532) Post-operatively, interventions based on the promotion of physical activity demonstrated increased exercise capacity, increased muscle strength and improved health-related quality of life.(533) Yet, despite the possible benefits that could be gained from increases in physical activity, existing evidence demonstrates low levels of exercise being reported by lung cancer surgical populations during the perioperative period.(534) Supporting patients to integrate a form of physical activity into their perioperative journey could be one mechanism to improve surgical outcomes, aided by digital technologies.

In addition to the benefits that come from incorporating physical activity, there is also evidence highlighting the value of integrated psychological support during the perioperative period. Receiving a cancer diagnosis can result in a variety of psychological challenges for patients;(535, 536) approximately half of all people diagnosed reported significant psychological distress relating to their diagnosis and treatment plans.(537-539) Patient with lung cancer that have reported psychological distress were also associated with poorer adherence to their recommended treatment and overall worse outcomes following surgery.(540, 541) Further, depression and anxiety in surgical lung cancer patients are associated with increased levels of post-operative pain,(542-544) poorer wound healing,(545) and increased durations of hospital stays.(546, 547) Psychological care has become an established domain of quality cancer care,(548-550) and a recent study by Grimmett *et al.* recognised the pre-operative period as a timepoint within the surgical journey where complementary supportive treatments could potentially improve a person's surgical outcomes.(547) For example, studies have demonstrated the benefits of implementing meditation and mindfulness coaching alongside mental health consultations during the treatment pathways for surgical cancer populations, including breast, prostate, head and neck, and lung cancer.(551-554) Continued psychological support, including the integration of mindfulness-based interventions post-operatively, may also be of benefit for this cohort.

Research has begun to explore the potential supportive strategies available to patients during the perioperative period.(523) However, there remains a paucity of knowledge relating to the delivery of patient-centred support strategies to focus on lifestyles and wellbeing, *via* digital technologies. There is a lack of in-depth qualitative work in this area, which includes the voices of the people at the centre of care during the surgical lung cancer pathway. To develop potentially effective digital interventions for this cohort, it is first important to understand how patients undergoing lung cancer surgery want to be supported. The key research questions for this work centred on: 1) *what* would patients undergoing lung cancer surgery want from digital technologies; 2) *how* would these patients want to use digital technologies during the surgical journey; and 3) *when* is the optimum timepoint to implement digital technologies to support their physical and mental health during the surgical journey? The results in this chapter seek to address these knowledge gaps. According to the Enhancing the

QUAlity and Transparency Of health Research (EQUATOR) guidelines, this study was reported according to the COREQ (Consolidated Criteria for Reporting Qualitative Research) checklist.

8.2 Participant characteristics

Sixteen participants were recruited and interviewed for this study. The characteristics of each are described in Table 19. Nine participants were female and 7 were male, with an average age of 65-years (SD 8.29). Ten of the 16 participants (62.5%) were interviewed post-operatively; they had their surgical procedure between two and 12-months prior to interview. All patient interviews were conducted between the months of September 2020 and February 2021; this was during the COVID-19 pandemic and so all were held over the telephone (n=10) or *via* the video call-based software, Zoom® (n=6).

Table 18: Participant demographics

Participant Number	Sex (M/F)	Age (years)	Interview Format	Surgical procedure	Pre- / Post-Operative	Time since surgery (exact) or time until surgery (approximate)[A]	Interview duration (minutes, seconds)
1	F	59	Video call	R upper lobectomy	Post	6m	77m 57s
2	M	68	Telephone	L lower lobectomy	Post	7m	73m 37s
3	M	74	Telephone	R thoracotomy and bi-lobectomy	Post	4m	67m 27s
4	M	61	Telephone	L lower lobectomy	Post	7m	50m 51s
5	F	61	Video call	L open wedge lobectomy	Post	12m	81m 22s
6	M	57	Telephone	R upper lobectomy	Post	10m	79m 45s
7	F	67	Video call	L lower lobectomy	Post	12m	67m 20s
8	F	80	Telephone	L upper lobectomy	Pre	2w	65m 33s
9	M	64	Video call	R lower lobectomy	Post	11m	76m 38s
10	M	83	Video call	Upper bi-lobectomy	Pre	3w	75m 10s
11	F	56	Telephone	L upper lobectomy	Pre	6d	84m 27s
12	M	59	Video call	R lower lobectomy	Post	5m	71m 24s
13	F	60	Telephone	R thoracotomy and lower lobectomy	Post	2m	80m 45s
14	F	55	Telephone	L upper lobectomy	Pre	3w	74m 15s
15	F	74	Telephone	R wedge resection	Pre	1w	70m 68s
16	F	64	Telephone	R thoracotomy and upper lobectomy	Pre	2w	74m 33s
Key:	F = female; M = male; R = right; L = left; Pre = pre-operative; Post = post-operative; approximate[A] = given the implications of the COVID-19 pandemic, some surgery dates may have been delayed so these are an approximated date reported by the patients at the time of interview; m = months; w = weeks; d = days.						

Figure 17: Patient-informed findings: features contributing to the optimisation of digital technologies to best support patients undergoing lung cancer surgery

8.3 "Getting the technology to tell me, guide me and encourage me"

All patients recognised the importance of listening and adhering *"to the guidance from the professionals to see me through"* their surgical journey (Participant 4, 61-year-old, male) and thus, some participants described whether this guidance could also be provided through the use of digital technology during the pre- and post-operative period. Many discussed how the technology could support them in *"steering through the whole (surgical and recovery) process"* (Participant 15, 74-year-old, female). Participants perceived the technology to be an extension of the support from the healthcare professional team.

To achieve this, participants viewed the technology as a tool with two mechanisms; the first being a prescriptive tool providing instructions and advice, where it *"tells me what to do"* (Participant 1, 59-year-old, female). For example, the technology could help participants manage post-operative symptoms or side effects from their chemotherapy and/or surgery, with one participant highlighting how *"it's important to know what to do if something goes wrong, like if my temperature was starting to read high or I felt unwell"* (Participant 12, 59-year-old, male). Another example related to monitoring *"wound infections after the* *operation, like if anything was indicating the wounds weren't closing up properly or if the stitches had become infected"* and the technology being designed to *"clearly (include) the contact details of who you need to ring or what steps you need to take to act quick on it"* (Participant 6, 57-year-old, male). When considering the management of side effects following surgery and any other associated cancer treatment that they may require, participants reported benefits in being able to *"watch out for signs my immune system is low"* (Participant 1, 59-year-old, female) and *"measuring my temperature and checking for infection signs"* (Participant 3, 74-year-old, male). It appeared that medical support and advice was regarded as vital information, given that participants may not have the expertise to manage it themselves. Further, it may act as a repository for information that participants could access at any point. While the *"strict things you need to know... stuff with more of the medical focus"* was deemed as essential to include, participants viewed that any other content need not be as formal and prescriptive (Participant 11, 56-year-old, female).

One participant discussed the importance of having *"quite a relaxed tone from the technology"* which could be *"more personal to me, instead of being just a generic strait-laced package for everyone to use"* (Participant 6, 67-year-old, female). Alongside the prescriptive guidance for the immediate post-operative period of recovery, participants also described the technology acting as a guide for their longer-term recovery. In this way, there was emphasis placed on aspects of holistic care that patients regarded as important to support their personal outcomes, such as encouragement to exercise more and improve their diet, as well as supporting their mental health and wellbeing to recover from their diagnosis and treatment. In this way, participants used terms such as *"guidance"* and *"guide me"* to describe the technology as a tool to support "*choices"*, as opposed to supporting the delivery of instructions (Participant 14, 55-year-old, female).

> *"I think if you can make it so I'm having the technology guide me around things like what I could be doing so that I can move forwards best for the future, then that would be very useful indeed" (Participant 1, 59-year-old, female).*

Regarding this guidance on exercise and dietary intake, comparisons were made to technologies that participants were aware of or had previously used to *"count my steps and my distances for the walks I've done"* (Participant 14, 55-year-old, female) and *"tracking my foods and meals, like on the diet app my son uses"* (Participant 9, 64-year-old, female). Participants recognised ways in which existing technology could be included or applied to specifically support their perioperative journey; with participant describing how it would help them *"look after myself in the best possible way after I get over the cancer"* (Participant 3, 74-year-old, male). When considering approaches for technology to support and guide with a person's physical activity, a number of participants discussed their uncertainty around exercising, given their lung cancer diagnosis. Some participants questioned whether they should do exercise or physical activity post-surgery, and if so, how much they should do, when they should begin to reintroduce it and what form it should take. There were perceptions that *"any kind of exercise, post-operative, probably would be a good thing (but)... just gently, it's reintroducing it, but I don't know what's the best way to do it"* (Participant 9, 64-year-old, male). Another participant described the post-operative phase as being a period of time when they were *"moping around thinking "what can I do?" because I didn't know if exercising was necessarily safe then. I mean, they said "move around when you feel able" but I didn't know to what extent"* (Participant 6, 57-year-old, male). In this way, digital technologies were acknowledged as a potential tool to provide guidance on physical activity, particularly with suggestions of how to reintroduce it and at what stage of the journey.

"I do think, if there's something there just to guide people and encourage them to take that path of doing a bit exercise, mixing it in to help them recover and grow stronger. Coming from a pretty active lifestyle beforehand, I didn't know whether I'd be able to get back to any level of fitness that was 'normal' for me, so to speak. So, I kind of feel like that's when something would have been helpful" (Participant 6, 57-year-old, male)

Suggestions were made regarding the functionalities that technologies could employ in order to deliver physical activity-based guidance. One participant discussed the use of push notifications for reminder messages to appear, where they could *"prompt me, encourage me to get up and do a little walk, get myself stronger"* (Participant 3, 74-year-old, male). Another participant described how they may feel motivated if they were to receive text or instant *"messages from the physio reminding me it's time to get moving in the early days, when you really want to just sit and rest a bit"* (Participant 7, 67-year-old, female). This initial post-operative period of uncertainty, coupled with knowledge gaps about safe levels of exercise to undertake whilst recovering, may lend itself to receiving structured guidance from the technology in combination with motivating individuals to act on the guidance. The idea of forms of encouragement coming externally from the technology could indicate a desire for this patient group to somewhat cede control in the initial post-operative period, and be guided by the technological prompts. Particularly in the early post-operative period, one participant considered how realistic it would be to receive digitally-delivered prompts of this nature, and whether such support would be favoured more or less than in-person prompts. They described that *"any form of encouragement is useful to keep us going (post-operatively). That's more supportive than I think you'd ever get, realistically, from the NHS – with all of the staffing pressures and the pandemic too. It could just be an automatically generated (prompt) – that little bit of contact is better than going months without an (in-person) appointment"* (Participant 4, 61-year-old, male).

The participants also acknowledged the importance of the technology creating a gradual, guided approach in terms of activity, which was perceived as useful when recovering from surgery. This was preferred over something that reintroduced activity at a level close to a person's normal pre-operative baseline. One participant perceived using such an approach would "*help me recover and grow stronger... to prevent anything from returning"* in reference to recurrence of lung cancer or other disease (Participant 10, 83-year-old, male). Guided post-operative interventions were viewed as a strategy to *"recover in a better way"* on both a short- and long-term basis (Participant 3, 74-year-old, male). The findings timings and implementation of this advice is further discussed in section 8.6 of this chapter.

"Something where it gradually builds up with how much activity it recommends – because you can't be expected to go straight back to the level you were at before the operation or before the cancer. I think you might be able to get back to that level over time, but certainly not at any

great speed. I don't think that's wise. I think something that gradually builds you back is much more important" (Participant 10, 83-year-old, male)

The integration of technology features that could put participants' "*mind at rest a bit"* was also discussed (Participant 14, 55-year-old, female). Participants believed that psychological support strategies, in-built within the technology, had potential to support and guide patients through the lung cancer surgical journey. Some participants made expressive links between their physical and mental well-being with one describing how the technology could encourage walking activities, and potentially distract them from thinking about their upcoming surgical procedure.

"People who are unprepared for surgery, especially cancers, I think… well, personally speaking, I was frightened, I was anxious, I had no idea what to do or what was coming up. It wasn't a good place to be in. And I think if nothing else, if someone said "here, use this app... you can do some steps, get your fitness level up" it would have taken my mind off things – even if just for a little bit while I was waiting for it all to happen" (Participant 5, 61-year-old, female).

One post-operative patient reflected on their lived-experiences of lung cancer surgery 12-months prior and acknowledged their personal challenges associated with their mental health. They described awareness of there being *"anxiety that can be felt when undergoing any form of surgery"*, but that *"it was even worse... times that anxiety by a thousand... because of the fact I had cancer. I had cancer, that's a significant source of worry, for me and for anyone else I would imagine and that side of (the digital support) shouldn't be forgotten"* (Participant 5, 61-year-old, female). Designing the technology to include psychological support features was viewed as one way *"to feel like your worries were being addressed"* (Participant 5, 61-year-old, female). Other post-operative participants echoed these views and reflected on their own experiences of feeling *"lost and without much help really, when it all came to that (psychological) side of me"* (Participant 3, 74-year-old, male). Instead, participants recognised and discussed how *"ways to map your mood... even a button you could press with a smiley face, a sad face, a worried face so you could document how you were feeling"* could be an *"easy but simple and effective way of feeling like that (psychological) side is being recognised"* (Participant 13, 60-year-old, female).

Acknowledging the individual at the receiving end of the digital support was deemed significant when it came to achieving a *"personalised approach"* (Participant 12, 59-year-old, male). Participants recognised that the technology should be tailored to the person using it and discussed designing the technology in a way where one could choose which particular 'areas' one may need support with. This was felt to be important, as it *"is probably more likely to be of use to someone when they've had a say in it and what they want to focus on... and as a result, is probably going to make more of a difference for that someone using it"* (Participant 12, 59-year-old, male). Another participant described there was a higher *"likelihood of me using it better and actually engaging more with it when I've chosen it myself, as opposed to it being a set-in-stone, one-size-fits-all, thing"* (Participant 10, 83-year-old, male). This view was echoed by a second participant who described *"well, I think I know what means more to me, I know what I'd probably want more guidance with because I know myself"* (Participant 11, 56-year-old, female).

"It certainly makes sense to think of the person you're treating first, what they need most support with, "is it the diet? Should they get some more advice on exercise? Should their step target be 2,000?" and then go from there – get the technology to tell me, guide me and encourage me..."
(Participant 4, 61-year-old, male).

8.4 "Tracking me and supporting me to reach my goals"

Continuing in the desire for individualised support from the digital technologies, this cohort of patients discussed the importance of incorporating the functionality to support (i) the delivery of personalised care and (ii) the achievement of personalised outcomes throughout the perioperative period. Reflections were made about the significance of recognising that each person's disease prognosis and post-operative outcomes will likely be different, whether they have the same lung cancer diagnosis or not. Participants explained their thoughts on the importance of factoring this into the design and functionality of the technology; in particular, one participant described that *"we are all individuals and the technology should reflect that"* (Participant 13, 60-year-old, female). As such, it was deemed significant that the technology should support each user to reach their own, individualised goals before and after surgery.

> *"If it's not individualised, it's pointless doing it. Everybody is different. Everyone's operation will go differently to everyone else's – hopefully it all goes well (laughs) but realistically speaking, sometimes it might not, and so some different mechanisms might be needed to be built into (the technology) for that reason" (Participant 2, 68-year-old, male).*

Ways to achieve and support with this were widely discussed, including the ability to use the technology to set personal goals and support in the tracking of *"one's progress in achieving"* them (Participant 4, 61-year-old, male). Participants described digital goal-setting as a form of motivation that was physically- and mentally-incentivising, both pre- and post-operatively. One participant described the goal-setting functionality as a form of *"extended connection"* from the advice and encouragement received from the hospital (Participant 4, 61-year-old, male). Others also recognised the benefits that goal-setting functionality could bring within the surgical journey; it was described both as a way of driving and supporting patients by *"giving you something to aim for"* in the recovery period (Participant 4, 61-year-old, male), and as a means of encouraging them to *"keep moving forward and moving on"* during their treatment and thereafter (Participant 5, 61-year-old, female). One participant reflected on their own recent experience of technology-enabled goal setting and the *"mental boosts"* that came as a result (Participant 6, 57-year-old, male), showing the benefits that can arise from this functionality, both physically and psychologically. They discussed using digital applications such as Strava® to track their cycling activities and spoke of setting their own goals in *"wanting to go out (cycling) further next time... so then if I challenge myself and do it, press save, it would give me a message saying "you've achieved the furthest distance" for that activity or something... which is something you want when you're in recovery from the op because you want that, sort of, proof to know you're going on alright with it and you then go* *onto the next one... and set a goal for a bit longer each time and so on*" (Participant 6, 57-year-old, male). They recognised *"obviously it's good 'cause it's getting me out for my (physical) fitness but it's nice to know it's probably improving me mentally too"* (Participant 6, 57-year-old, male). As well as supporting their physical and mental recovery, participants saw goal-setting as a means of facilitating them to work towards life following lung cancer. One participant perceived goal-setting in the perioperative period as a method of achieving his longer-term aims in *"supporting me to reach my goals in what I want to achieve for life after (recovering from the operation and the disease)"* (Participant 12, 59-year-old, male). Reflections of this participant indicated a potential desire for longer-term support that is unique to this surgical patient cohort – where participants described wanting to look forwards in their surgical journey to focus on life after the underpinning disease of cancer.

> *"The reason I set goals was to try and convince myself that I could still do what I used to do before all this (the cancer diagnosis) … then I knew the improvements would come (following surgery) and they did, physically and mentally... and it was nice to see it written in black and white on the app to prove it to myself" (Participant 12, 59-year-old, male).*

Participants also recognised the benefits that could come in tracking their progress throughout the pre- and post-operative period when working to achieve their personal goals. The interviewees considered how the ability to track their physical activity post-surgery could be an important factor to help them physically and psychologically *"move on with my life"* post-diagnosis (Participant 6, 57-year-old, male). Specifically, in relation to the functionality and capability of the technology, enabling participants *"to map and chart"* their physical activity (Participant 9, 64-year-old, male), through the integration of in-built features such as *"GPS trackers to create maps"*, were methods that were readily discussed (Participant 11, 56-year-old, female). Using a variety of digital tracking tools to not only log the physical but the psychological recovery goals of participants was deemed significant by the lung cancer surgery cohort. Examples of progress-trackers discussed by patients included features like step trackers, map tracking and *"general health trackers to see like my heart rate counts and things so I can actually see myself getting that little bit fitter each time"* (Participant 7, 67-

year-old, female). A number of interviewees also discussed their perceptions of fitness milestones that they wanted to aim for in their recovery journey; one participant spoke of their aims to *"get back out on the bike again... clock up the miles"* and saw progress-trackers as being one support method that they could use to achieve this (Participant 6, 57-year-old, male).

"Everyone is going to have their own goals, aren't they? Some might be happy with just walking up and down, moving about the house, driving their car, things like that. I mean, I'm happy with those things too but I don't think I'd want to stop there… I've got other things I want to do" (Participant 4, 61-year-old, male)

The integration of digital charting tools to measure wider aspects of their surgical experience were also discussed as a way of monitoring and tracking an individuals' progress through the perioperative pathway. Participants discussed the usefulness of measuring *"pain scores, mood levels and my spirometry readings day-by-day"* (Participant 1, 59-year-old, female). Having access to this type of functionality meant that patients perceived that the technology could provide them with a fuller picture of their health outcomes during the perioperative period. They described wishing to have access these tools to *"see the numbers and readings"* as it could help them to *"work towards beating"* their goals and achieving improved post-operative outcomes (Participant 7, 67-year-old, female). Specifically, one participant described wanting to track their spirometry readings on a daily or weekly basis in order to *"see my lungs improving and functioning more, going off the numbers... as you're improving, your lungs are improving too"* (Participant 1, 59-year-old, female).

"The best way I think would be documenting it all on a chart – either on an app or online. You could use the chart for spirometer readings and pain readings too. Then you can track what you're scoring, see where you're improving, see when pains might be worse and link it to what pain relief you're taking at the time. That way it's all in one place for you to view and analyse" (Participant 1, 59-year-old, female).

A number of participants discussed possible remits where the technology could support them to track their progress in their lung cancer journey. Having access to charting the data seemed important for individuals to look back on and *"feel good about myself 'cause when I look back, I've overcome all them (goals), where I never appreciated it at the time"* (Participant 2, 68-year-old, male). Participants also discussed sharing these achievements with a wider network including peers or with members of their healthcare team. They described thoughts on combining these charting tools alongside an integrated data-sharing functionality. In doing so, interviewees described the potential for further encouragement and motivation to support them in achieving their goals of recovery and rehabilitation.

Being able to seek feedback on goals from healthcare professionals, as well as share achievements in reaching them, was perceived as desirable. One patient discussed wanting to *"chart my goals and imagine my wants"* in conjunction with their specialist nurse and surgeon to ensure they *"can be done alongside the practicalities of cancer"* (Participant 9, 64-year-old, male). Patients described that a technology-enabled *"feedback system is important"* and that it would be *"reassuring to share that data with the surgeon"* (Participant 12, 59-year-old, male) and members of the wider multidisciplinary team. In doing so, participants described the data-sharing capability as a mechanism of comfort and reassurance, acting *"as a way for them to keep a closer eye one me"* before and after surgery (Participant 6, 57-year-old, male). Participants viewed their recovery and goal-setting successes as achievements that they might want to share with the healthcare professional team. One participant remarked *"it might even be good for them (surgeon) to see their own success through me ... the only reason I'm living and doing this is because of them and their skills!"* (Participant 5, 61-year-old, female).

Some participants believed that the technology could act as an extension of face-to-face follow-up care provided by the multidisciplinary team. It appeared that long-term support strategies were desired for this patient cohort, very much underpinned by the nature of the disease that they were diagnosed with. Participants discussed the potential for the two-way feedback system to act as a mechanism for healthcare professionals to provide them with ongoing personalised support, where interventions could be made if the data was not showing a 'normal' recovery pattern. The option of sharing data with healthcare professionals and enabling them to view and track progress was perceived to be a choice that many participants found as *"really logical"*, in a way of *"following up, putting us at ease, showing us that we've not been forgotten about and they're with us for the journey, not just to cut it out and then that's it"* (Participant 4, 61-year-old, female). These perceptions appeared to validate the significance of personalised elements of digital care, implying that the technology had the potential to extend as a form of empathetic support throughout the perioperative period.

> *"If they (healthcare professionals) were able to monitor and see what I'd logged, they could get in contact if they saw I wasn't doing as much walking as normal and say "is everything okay, you've not been as active as usual?" – something like that. If you've done too much, "slow down", you know? (laughs) or the opposite if someone needs a bit of a kick into action!" (Participant 4, 61-year-old, female).*

In addition to using technology to support their physical recovery following surgery, participants also discussed the idea of utilising goal-setting and progress-tracking to support their psychological and mental health too. Participants openly discussed the psychological impact that the disease of lung cancer carried and acknowledged how logging and tracking this, could be of help to *"validate my feelings that it was a tricky day or week as opposed to me just imagining it"* (Participant 14, 55-year-old, female). In the same way of sharing physical activity logs with healthcare professionals, participants described being able to share psychological *"mood logs with the nurse so she can see where my head's at a bit more"* (Participant 14, 55-year-old, female). Other participants described close similarities between their overall physical recovery with that of their mental health recovery following the diagnosis of lung cancer. Participants discussed how the tracking of *"things like my step count and how far I'd walked in a day"* could go a long way in providing psychological boosts in their recovery (Participant 15, 74-year-old, female). In turn, supporting patients to reach their goals could provide them with encouragement to *"be more likely to try and recover 'cause I want to get back to normal life again"* (Participant 15, 74-year-old, female). One participant even discussed how logging and achieving goals would *"act as a distraction so I'm not just sitting about, worried until my next appointment"* (Participant 9, 64-year-old, male). When it came to describing their perioperative journey, numerous participants used terms including *"move* *on"* and *"get on with it"* (Participant 4, 61-year-old, male) in a way to mark completion of their surgery and achievement of their personal recovery goals, in a bid to begin the new chapter of their lives. One participant described how the technology could support them to work towards *"saying good riddance to the (disease)"* as they progressed through their follow-up appointments (Participant 2, 68-year-old, male). Accompanying the surgical treatment for the underlying disease, the impact on a person's mental well-being was often discussed. A number of participants discussed the potential role of apps and forums as a mental health support tool for them; one participant described their intention to set goals to assist in *"making sure my mood recovers... my nerves, I'm still anxious, I'm hoping that side of it recovers over time... it will give me mind something to focus on and feel good about again if I've got something to work towards"* (Participant 15, 74-year-old, female). The remit of supportive technology appeared to go much further than achieving physical milestones and goals; instead, the ability to log and track psychological progress could be equally as beneficial.

8.5 "Comfort in knowing I'm not alone"

Participants discussed the usefulness of sharing experiences with other patients going through lung cancer surgery. Features that enabled digital peer-peer communication were acknowledged to be of value. Peer discussions were regarded as emotionally supportive exchanges that could offer patients *"comfort in knowing I'm not alone"* during their surgical journey (Participant 10, 83-year-old, male). Participants felt comfortable *"talking to someone from a non-medical background"* (Participant 4, 61-year-old, male) about their emotions, worries or anxieties around the surgical procedure, or seeking advice when adapting to life following surgery. One participant remarked that *"you don't worry so much if you know someone else is going through it at the same time"* (Participant 12, 59-year-old, male). Shared experiences could also encourage and motivate them to keep up with healthier lifestyle and dietary changes, where being able to send and receive messages like *"I've been there, I've got the t-shirt, you could do this"* (Participant 9, 64-year-old, male) would *"go a long way to picking you up again"* (Participant 6, 57-year-old, male).

"You could talk to someone else going through it… then you'd be talking to a human-being who knows exactly how you're feeling." (Participant 12, 59-year-old, male)

When considering how digital peer-peer communication could be achieved, participants described how access to *"a general forum board"* where *"people could seek to contact other people if they wanted"* (Participant 9, 64-year-old, female) would be useful. Several participants perceived *"a mock-up of Facebook"* (Participant 9, 64-year-old, male) or a platform that operated *"like a Facebook page"* would enable them to *"comment or post for other people… you could read through comments, reply to other people, start conversations, it's flexible"* (Participant 8, 80-year-old, female). Enabling flexibility in the method of engagement with peers would benefit a wider variety of participants. Some described their preference for active engagement where they could *"write comments, share pictures, message with people"* (Participant 6, 57-year-old, male). Whereas others described preferences for a less-active form of engagement like *"I would rather have a read of what other people are putting first"* until their confidence and familiarity with the platform grew (Participant 13, 60-year-old, female). Participants emphasised that, whichever way the digital communication is delivered, it should be a *"safe space (to ask questions) with people like me"* (Participant 9, 64-year-old, male). However, one participant recognised the challenges that may arise when communicating with peers with lung cancer, and suggested that the technology enables peer communication relative to a person's disease prognosis; they acknowledged that potential difficulties may arise when lung cancer patients *"draw comparisons with others and their outcomes"* (Participant 3, 74-year-old, male). Instead, this participant suggested that peer discussions be specifically matched by the technology, according to each patient's clinical outcome, cancer staging and prognosis.

"(I) had a good outcome from my surgery; they got it all (the cancer). Whereas, other people might've been Stage 3 or Stage 4 where they might not have got as good an outcome and that could be hard to deal with… maybe it would be best talking to patients who were the same as you for their outcome." (Participant 3, 74-year-old, male)

The emotional burden that accompanies lung cancer surgery was widely discussed and participants reflected on the advantages of sharing lived-experiences with peers to *"support others going through the same journey as me"* (Participant 12, 59-year-old, male). Having access to peer-peer communication throughout the surgical pathway was perceived to benefit *"the family involved in the whole process"* (Participant 7, 67-year-old, female). Patients reflected that with the lung cancer diagnosis and associated treatments, it is *"very rarely just one person that's affected, it's the whole family"* (Participant 6, 57-year-old, male). Thus, informal peer-peer discussions were perceived as a potential support strategy for family members involved in their care too. Participants shared that closer involvement of their family or carer with the technology could also help to manage the expectations of both parties post-operatively, meaning they were *"off on the same foot from the start, rather than your family thinking of too high expectations for you when it might not be achievable right away"* (Participant 4, 61-year-old, male). This was felt to be useful when supporting the family and carer's knowledge of the initial recovery period following surgery.

One participant discussed how involving their family in peer discussions could have helped educate them to support their recovery and rehabilitation. One participant in particular reported that *"my wife and my kids were saying "there's no way you'll be doing any exercise again" ... Post-operation, they really didn't believe I'd be able to work towards anything but, actually, there was stuff I could be doing but none of us knew that"* (Participant 12, 59-year-old, male). Another participant shared similar views around the value that could come from *"using others' experiences of things, like what food would be good to make up for me when I might be feeling sickly... 'cause my daughter is going to do all the food preparation so she might find that helpful"* in relation to educating themselves and their family around pre- and post-operative dietary intake (Participant 8, 80-year-old, female). Another participant postulated designing technologies with the capability of enabling multi-user-access, so that materials could be jointly accessed and read by both them and their relatives; that way, *"it would mean we're all up to speed in knowing the same information, the same stuff about what's happening in the operation"* (Participant 2, 68-year-old, male).

Participants felt that their family or carers could be better supported, both educationally and also emotionally. Participants reflected that *"(their daughter) is the one who has got it* *hardest, because she's got to watch me go through it"* (Participant 8, 80-year-old, female) and *"I suppose she (their wife) might feel a bit helpless really because neither of us know anything medical"* (Participant 2, 68-year-old, male). It appeared that technology enabling peer-peer discussions, as well as relative-relative discussions, could carry numerous benefits. For example, signposting to resources was regarded as helpful for their relatives when managing common side effects post-operatively, and gain insight into *"what it means for them (relatives) when we're all adjusting to life after the operation"* (Participant 2, 68-year-old, male).

> *"it's information sharing between people who've had the surgery done, or even people who haven't, and also with the people who are involved in looking after them. Because it's not just me on my own going through it – it's my family as well" (Participant 7, 67-year-old, female).*

Alongside connecting with peers, participants also wished for the technologies to help connect them to the healthcare team, including surgeons and specialist nurses. Closely relating to the underpinning lung cancer diagnosis, participants felt that the surgical journey was a *"very vulnerable time and, obviously, feeling that you've got some extended form of connection"* would better support them pre- and post-operatively to not *"get the impression we're on our own"* (Participant 9, 64-year-old, male). Interviewees recognised that *"there's a need for the continued support (perioperatively) and there's technology out there now and it's getting better and better all the time… why couldn't we use it?"* (Participant 12, 59-year-old, male). Examples of implementing improved connectivity in the form of *"messaging, video-calling and speaking to someone"* (Participant 1, 59-year-old, female) were frequently discussed. While participants perceived peer-peer discussions to be relatively informal, in contrast, they viewed digital connectivity with healthcare professionals as more formal exchanges. For instance, this could be used for medical enquiries, such as *"can you check my wound?"* (Participant 2, 68-year-old, male), *"I've discovered this lump, can I show you?"* (Participant 5, 61-year-old, female), *"did you get it (cancer) all out?"* (Participant 12, 59-year-old, male) and receiving *"progress reports and follow-up care… that's got a bit more of a personal touch"* (Participant 4, 61-year-old, female). Numerous participants reflected on the recent coronavirus pandemic and their growing confidence in using video-calling and digital communication tools. These participants expressed desires to integrate digitally-connected follow-up care with their surgical and oncology teams going forward.

> *"it doesn't just take a pandemic to mean that video calls would be useful; they'd be useful any time because you feel like you're actually seeing them (healthcare professionals) and being treated as a person as opposed to just getting feedback in writing (in letters)" (Participant 4, 61-year-old, male).*

Continuing the use and remit of digital-connectivity in the surgical pathway, participants also discussed the role of technologies to direct questions to their nominated team of healthcare professionals. Patients described the usefulness of this in two respects; firstly, it could enable real-time information-seeking, and secondly it could enable better preparation for follow-up appointments. In the first instance, real-time messaging, akin to using a *"chat box"* function, was perceived as *"quick and useful"* by participants (Participant 5, 61-year-old, female). They described how their questions could *"be free-typed in then sent to the surgeon or the specialist nurse to answer"* (Participant 5, 61-year-old, female). In relation to better preparation for appointments, one interviewee discussed the usefulness of logging questions through a shared platform with their consultant, ahead of time. The rationale for this being that *"before the appointment, the question log could be shared with my consultant so he knew what was on my mind and so he had an indication about topics I wanted to discuss"* (Participant 12, 59-year-old, male). Other participants echoed these views, suggesting *"sending them questions beforehand"* (Participant 14, 55-year-old, female) because it is often difficult to remember questions when put on the spot in the appointment.

8.6 "Getting the timing right for me"

When supporting an individual's journey before and after lung cancer surgery, participants frequently debated the *timing* of implementing and using digital technologies. Individuals recognised the benefits of using digital interventions during the surgical pathway at timepoints pre-and post-operatively, as well as perioperatively across both periods; however, they also reflected that there may *"not be one best time point of starting to use it"* for everyone (Participant 2, 68-year-old, male). Instead, it appeared to come down to the individuals' preferences or *"getting the timing right for me"* (Participant 12, 59-year-old, male).

One pre-operative participant reported that they would prefer to wait to use any form of technology until after their surgery. Reasons for this related to taking time to process the diagnosis and the prognosis of the underpinning lung cancer disease, as well as using the pre-operative period to prepare for upcoming plans for treatment. This participant described feeling they would be in a better place post-operatively to focus on their recovery, aided by the technology. This perspective indicated the importance of understanding each individual's preferences and approach to navigating through the treatment stages of lung cancer, which may affect a person's desire to engage with an additional form of extended support.

> *"I just want to be getting this operation over with first… I just don't think I've got the brain space to be doing much extra at the moment – I just want to get it done and then I can focus on healing" (Participant 8, 80-year-old, female).*

Others saw the technology as a tool that could offer support in their pre-operative journey. Examples included supporting their educational needs to understand the disease itself, and the relevant type of surgical procedure they required. One participant, who was due to undergo surgery five days following the interview, described themselves as being *"the kind of person who wants to hear everything early on so that I've got the truthful picture of where I'm going and what to expect. I'd rather have a little bit of knowledge of what's likely to come than hear nothing at all"* (Participant 14, 55-year-old, female). Another participant gave suggestions of *"patient-friendly information apps for the surgeries for people with cancer"* that could be recommended pre-operatively for patients to read up and learn about *"what they (the surgeons) will do, where they will cut, what it'll look like and various other pieces of information about it (the surgery)"* (Participant 12, 59-year-old, male).

As well as supporting educational needs, pre-operative initiation was also perceived as a strategy to support a person's mindset, mood and psychological health prior to surgery. One participant, who was 10-months post-operative at the time of interview, described how pre-operative timing of interventions would have been beneficial for them. They described the psychological and emotional burden of the disease as a whole, *"on top of the normal amount of anxiety anyone would have, having an operation"* (Participant 6, 57-year-old, male), and indicated the importance of having access to this extended form of support, pre-operatively. This was echoed by another participant who reported *"I was frightened, I was anxious, I had no idea what to do or what was coming up. It wasn't a good place to be in"* (Participant 5, 61-year-old, female). Both participants would have valued pre-operative support strategies, with another participant describing numerous layers of benefits, including *"simply (acting) as a distraction for someone to keep them occupied and not worrying... but it could also actually be a proper saving Grace 'cos it might give you the chance to be better off if you've learnt more of it off of reading some websites or being linked to some apps"* (Participant 1, 59-year-old, female). When supporting psychological health during this timepoint, gaps in knowledge appeared to be influential in underpinning a person's anxiety and pre-operative worries; this signalled the benefits that could arise from an educational pre-operative intervention.

> *"Well, it's cancer! It's all you can think about… looking back, I couldn't control myself when I thought about it… so anything I could be using in that time (pre-operatively) if nothing else, it would've been a distraction for my mind and I know I'll not be the only one in thinking that"*
> *(Participant 1, 59-year-old, female).*

The time at which a technology could be implemented and utilised appeared to not only impact a person's educational and psychological preparation before surgery, but also their physical preparation. Physically, participants recognised the advantages of *"keeping fit in the run up to it (surgery)"* and saw benefit in using pre-operative digital technologies focusing on physical activity to assist them in achieving this (Participant 9, 64-year-old, male). Prior to undergoing surgery, one participant described using technology as a way of *"helping me be better prepared with my fitness"* (Participant 9, 64-year-old, male). They went on to provide examples of how data could be collected: *"stuff like even counting steps or showing I've been for a little walk out so I'm keeping moving"* and was perceived as a strategy supporting pre-operative implementation; specifically, the participant described rationale for this timing to encourage them *"not to be just sitting around waiting for it (surgery) and not doing anything... you'd be preparing yourself a bit better"* (Participant 9, 64-year-old, male). Another participant echoed the view that the pre-operative period was an essential time to *"prepare my body"* for the surgery (Participant 1, 59-year-old, female). Specifically, this participant discussed physical preparations in relation to their weight, their dietary intake and their levels of physical exercise; they acknowledged the possible roles that digital technologies could have in supporting lung cancer surgery patients pre-operatively.

> *"I can only speak from my personal experience but I was very run down, I had lost a lot of weight, I wasn't eating proper, I was very tired and exercising less and less, slowing down and getting really strong feelings of (fatigue) all of the time. 'Cos of this, I think it's easy to feel in a low position before you even go into the hospital... cancer patients, you do go in feeling quite low, I didn't feel strong at all... I think it should be incorporated (pre-operatively) because that can obviously help you in overcoming all that" (Participant 1, 59-year-old, female).*

Focus was also placed on utilising technologies to support a person's recovery following their surgery. Post-operatively, participants acknowledged that the use of digital technologies could encourage them to *"take that path of doing a bit exercise, mixing it in to help me recover and grow stronger"* (Participant 6, 57-year-old, male); however, they were unclear on *when* would be best to deliver these messages. The exact timing of this was discussed by many interviewed. Two participants, who had undergone surgery 5- and 10-months prior to the interview, described the initial weeks following surgery as being a period where physical activity *"was the furthest thing from my mind"* (Participant 6, 57-year-old, male) but *"once you start getting back on your feet and feeling a bit stronger, you start thinking "what can I do now I'm feeling more ready?""* (Participant 12, 59-year-old, male). Another participant, who was 6-months post-operative at the time of interview, also echoed these views. From their experience, they described wishing to wait until *"a couple of weeks (post-operatively), when you're beginning to feel a bit stronger"* before implementing technologies with goals focusing on physical recovery (Participant 1, 59-year-old, female). Perceptions were shared that the initial post-operative period could be focused on recovering from the procedure, with the technology use being *"in the background, there if you needed it for information, but not expecting you to do too much in the early days, but then you can pick it up a few weeks down the line"* (Participant 9, 64-year-old, male). One participant viewed it as important to take time *"to rest, physically, after the surgery until I was well enough and ready to start thinking about getting back to being active and myself again"* (Participant 8, 80-year-old, female). Another described that *"after a week, your mind is probably more ready to be hearing the things of "you should be on the move, you should be walking" and such and such"* (Participant 7, 67-year-old, female).

> *"I think the initial start time of the recovery should be just about getting over it (the surgery), just getting back to feeling less in pain or more human … then I think I might want to hear the information about the exercises after that, when I feel I'm ready. Because, I really don't know if that's a priority for me immediately afterwards" (Participant 10, 83-year-old, male).*

Many participants shared the opinion that the technology could support them to *know "when it's the right time to start"* (Participant 10, 83-year-old, male). Participants discussed using the technology post-operatively to receive *"information to help you getting back to feeling more normal again after the op – I think the information it could give would be what food and drinks to boost you back up, that would be good... get a bit stronger that way... then I think I might want to hear the information about the exercises after that"* (Participant 10, 83-year-old, male). However, emphasis was placed on implementing this support at an appropriate time for each person, which might mean that intervention timing should be an individualised decision. Linking back to the gradual guided support discussed earlier in section 9.3, participants echoed that the timing of post-operative support should consider the individual person at the centre. One participant described that the optimal post-operative implementation time would be at a point which is *"when it's more right for me, which might not be right for someone much younger, because I might end up needing it to start off slower* *whereas they might think it's starting off too slowly for them. It needs to be slower and build up over time for me"* (Participant 8, 80-year-old, female).

Participants also discussed the continued use of technologies throughout the post-operative period and described visions of use on a longer-term basis. Some felt that their engagement with technology may go *"a little bit past"* the point of their recovery (Participant 12, 59-year-old, male) until they *"achieved their goals… and at that point they might disconnect from it"* (Participant 9, 64-year-old, male). Whilst others perceived possible longer-term benefits with continued intervention-use past this point. The way that some interviewees described possible long-term use appeared to indicate a supportive and holistic role for the digital technology; one participant described a desire to *"keep up with the activity even after I felt I was back to my normal baseline"* (Participant 1, 59-year-old, female) and continue with lifestyle changes post-operatively to protect their future health and wellbeing. Another participant considered *"it might be a couple of months later, you can be using it for general activity tracking or even using it for early spotting of changes like "weight is coming back on here, let's be careful""* (Participant 12, 59-year-old, male). Other participants perceived ongoing use of technologies to be based on addressing their own individualised health needs, where *"if people wanted to keep using (the intervention) for long-term support, then I think they should be able to"* (Participant 14, 55-year-old, female).

> *"Even though you might have recovered from the surgery, you've still got so much life to get on with… you don't want to lose that or miss out on any of it, it's the whole idea of using it to help yourself after this" (Participant 5, 61-year-old, female).*

Ensuring that the timing is right for the individual at the centre of the surgical journey is imperative. The timing of digital technology implementation and use in this patient cohort appeared to be strongly guided by the individual person themselves. This highlighted the importance of *"getting the timing right"* for each person and having discussions centred on individualised person-focused treatment (Participant 12, 59-year-old, male).

8.7 Discussion

This patient-centred study highlighted how digital technologies can be used to support people undergoing lung cancer surgery to make changes to their lifestyles and behaviours. The results provided further insights into the role and remit of technologies during the perioperative period to support these changes, both physically and psychologically. By collecting the views and opinions of people at various timepoints across the surgical pathway, a more complete understanding was gained of patient perceptions and lived-experiences across the entire surgical journey. This study described *how* digital support strategies could be delivered, *what* content was perceived to be useful for these interventions to include, and *when* technologies could be implemented within the pathway for lung cancer surgery. The four key themes related to: 1) "getting the technology to tell me, guide me and encourage me"; 2) "tracking me and supporting me to reach my goals"; 3) feeling "comfort in knowing I'm not alone"; and 4) "getting the timing right for me". These findings can be used to enable the design and implementation of tailored digital health technologies for surgical lung cancer patients, and thus potentially contribute to improved post-operative outcomes for this cohort.

When supporting healthier lifestyles and physical activity, participants described usefulness in technologies with the capability to track their progress – namely, step counts and the associated distance achieved from an activity (such as a walk, a run or a cycle). Tracking and logging physical activity has previously been reported as motivational by participants undergoing other forms of surgery,(64, 555-557) as well as those living with chronic diseases, where patient-centred outcomes could be improved through physical activity.(558, 559) In one lung cancer patient population, who did not receive surgery but instead underwent radiation therapy and chemotherapy, the use of digital fitness trackers to monitor pre-treatment step count was acknowledged to aid as a prognostic tool in guiding clinician treatment decisions.(560) In this way, clinicians were able to make decisions tailored to the individual person at the centre of the pathway, guided by their baseline activity levels. In the same way, the participants in this study recognised the potential for technologies to support decision making during the post-operative period. Higher levels of self-reported motivation and self-efficacy to exercise using physical activity trackers have previously been reported in metastatic lung cancer patient populations;(561) when supporting participants in this study, this evidence may complement the rationale for post-operative rehabilitation, aided by technology, to improve surgical outcomes on an individualised-basis.

When discussing capability and functionality features of the technologies to better support their health outcomes, participants identified the need to integrate psychological support strategies alongside those for physical health. There appeared to be a close association between levels of physical activity, the desire to engage with exercise, and a person's psychological wellbeing before and after surgery. Comparable with findings in the wider literature (including surgery for colorectal, breast and gynaecological cancers), experiencing distress and anxiety during the perioperative period has been associated with poorer post-operative outcomes.(562-564) The findings of this lung cancer cohort echoed those from Abelson *et al.*, where colorectal cancer patients also highlighted a desire for the surgeon and surgical team members to play a supportive role with pre- and post-operative coping mechanisms to manage a person's psychological distress.(564) In particular, this study echoed the fact that the provision of educational information could support patients to better understand and prepare for the procedure. This study gained further insight into *how* this extended support could be achieved through the implementation of technologies that incorporated tracking of a person's mood over time, signposting to relevant educational resources to specifically learn about the surgical procedure, and enabling a form of connectedness (to both healthcare professionals and peers) for information-seeking if required. Future studies should seek to examine effectiveness of these functionalities in greater depth and to better understand the perspectives of users from both sides of the digital support strategy; specifically, consideration should be given to understand the workload implications and uptake and engagement from healthcare professionals and healthcare organisations if this digital strategy were adopted into surgical pathways.

Patients in this cohort desired equal amounts of support focusing on their physical health and their psychological health. Previous literature has acknowledged the value and importance of supporting the mental health and wellbeing of cancer patients;(565-568) however specific details in how best to achieve this through a digital-mechanism is lacking. This study has identified the value in ensuring that psychological support strategies exist during both the pre- and post-operative periods; thereby supporting patient preparedness to reduce anxiety during the pre-operative period, and supporting someone to adjust to life following the disease and the surgery. A key take-home message from this qualitative study highlights that a digital intervention should be implemented for lung surgical patients perioperatively, in order to best address their psychological wellbeing needs throughout the surgical pathway. For instance, in a breast cancer surgical cohort, a wearable meditation device was provided to study participants who reported feelings of reduced fatigue, improved quality of life, and reduced stress both pre- and post-operatively.(569) In a similar way, recent findings from Khor *et al.* demonstrated the benefits of 'mindfulness meditation' in a multi-cancer patient population.(570) The authors recognised the emotional burden that accompanies the diagnosis and treatment of cancer, and demonstrated that practicing meditation significantly altered the beta and gamma readings on an electroencephalogram (EEG) report from study participants. Similarities and parallels could be drawn between these broader cancer populations and the participants with lung cancer in this study. Establishing a digital intervention with in-built meditation or relaxation functionalities may be an appropriate mechanism to adopt in this lung cancer surgery population; future studies should seek to gain further insight into this.

Goal-setting has previously been described as an effective behaviour change technique in wider healthcare literature, with previous studies proposing the setting of goals and as underlying component of any successful behavioural intervention.(571, 572) Within the context of surgical research, wider studies have supported the value and effectiveness of interventions that promoted self-management and goal-setting during the perioperative period,(573, 574) and more specifically, when supporting the physical and psychological health and wellbeing of cancer surgery patients more broadly.(575-577) In particular, the participants in this study closely related goal-setting to the desire to meet their own achievements; many of which related to physical activity, such as walking or cycling, in a bid to aid their post-operative rehabilitation and mark progress in their recovery. Alongside this, however, it was recognised that there was an underpinning need for individualisation and personalisation when considering perioperative goal-setting in this cohort; this echoes findings from the wider surgical literature including populations undergoing paediatric,(578) spinal (573) and orthopaedic surgery.(579) Digital technologies with in-built goal-setting functionalities may support surgical lung cancer patients to improve their post-operative outcomes, associated with physical health and psychological wellbeing. Future co-design research may wish to further explore the optimisation of the design and capability of technologies in order to support goal-setting features.

The feeling of “knowing I’m not alone” was an important theme developed in this study. The value of peer support has been discussed in previous literature in the broad context of chronic disease management,(580-582) as well as more specifically in the context of surgical cancer management.(583-586) While the findings from this study echo the importance of providing patients with peer support, the results from this surgical cohort go further; they demonstrate a desire and acceptability to engage with peer support solely on an in-person basis and support the design and implementation of digitally-delivered peer support strategies during the perioperative period. Notably, participants from this study acknowledged both the comfort and the challenges that peer support can bring to pre- and post-operative lung cancer patients; as a result, any design and use of digital mechanisms should consider pairing peers with others of similar prognoses to avoid potential negative consequences from the exchanges.(587)

Alongside discussing the value of digitally-delivered peer support to help with information gathering and anxiety, participants in this study also called for similar mechanisms to be available for their family members and caregivers. Notably, participants in this study referred to family members such as partners or children benefiting from support groups to discuss experiences of caring for a relative through lung cancer surgery. Studies in the wider literature have previously recognised the distress that caregivers (such as friends and family members) may experience when witnessing a care recipient experience a lung cancer diagnosis and journey along the lung cancer surgery perioperative period.(577, 588-590) One study by Lafaro *et al.* adopted a telehealth approach to support patients and their family members through the surgical pathway with pre- and post-operative video calls with physical therapists or occupational therapists.(577) Both physical and psychological outcomes were measured throughout the study, with the authors concluding the feasibility and acceptability of using remote strategies to support family members and caregivers in this way.

It has been recognised that perioperative communication between practitioners and family members can also contribute to alleviating anxiety and better supporting those people who are involved in caring for patients pre- and post-operatively. Within this study, data-sharing functionalities were discussed by participants as a means of including family members more closely in their pre- and post-operative journey. Including family members in communication within the surgical pathway has previously been researched across a number of different surgical specialisms; for instance, communicating clinical updates to the parents of children and adolescents undergoing cardiac surgery,(127, 591) and providing educational support for families and caregivers prior to orthopaedic surgery.(592-594) In one study, by Davis *et al.*, the needs and experiences of patient and their family members during the perioperative period were explored; with the results demonstrating pre-operative planning and communication with family members as being influential in feeling supported.(128) Cunningham *et al.*, highlighted the importance of having a designated liaison route for families, through which communication can be made during the whole perioperative period.(595) In this case, a cancer nurse specialist was available to provide details around pre-operative preparation, clinical information updates and even psychosocial support for relatives.(595) Data sharing in this way could enable relatives with real-time access to information and, as a result, could contribute to better two-way routes of communication between professionals-patients-and their caregivers. Authors have postulated that, in turn, this may reduce the number of phone and in-person encounters required in a person's perioperative care.(596, 597)

Recommendations were made concerning the technology's capability to enable data-sharing and multi-user-access which could facilitate this connectivity. A study by Kneuertz *et al.* reported fewer phone calls to members of the surgical team with use of the app which, instead, could facilitate information-seeking for patients and relatives when managing post-operative recovery.(598) Additionally, in a study focused on paediatric cancer populations by Hodge *et al.*, there were reductions in anxiety levels reported by relatives using an app that provided intraoperative progress reports about their child during surgery.(127) In their study evaluating family communication throughout breast cancer surgery and care, Wolff *et al.* reported greater levels of illness understanding and lower levels of anxiety from relatives who engaged with a digital intervention; an account which detailed patient messages, test results and clinical notes from patient consultations.(599) Accompanying the higher levels of education and improved psychological health were the higher participant-reported satisfaction scores, which demonstrated the feasibility of digitised care, delivered with family-centred principles. There still remains a lack of research that seeks to explore digital strategies to meet this need, particularly in a lung cancer surgical cohort.(600-604) Notably, many recent studies that have investigated the role of digital strategies to support family communication have been conducted on a short-term ‘intra-operative’ period, while the patient is in the operating theatre or on the recovery ward of the hospital.(602, 603) There is a gap for further research to be done that focuses on the longer-term post-operative period, once the patient is discharged home and recovering; as discussed by participants in this study, this longitudinal, continued approach was perceived as valuable to support improved recovery outcomes.

When considering optimal timing to implement digital strategies within the perioperative period, participants described value in both pre- and post-operative implementation. A person’s underpinning cancer prognosis was seen to influence their engagement with technologies in the pre-operative period. Similar to the results from previous studies in the field of orthopaedic surgery as well as lung surgery, pre-operative digital strategies that supported patient education were perceived as acceptable and demonstrated benefits.(605, 606) Whilst the value of pre-operative technology use was recognised in this study, more participants reported preferences to using digital support strategies post-operatively, particularly when their mindset was focused on their recovery. Associations were made between post-operative technologies guiding structured recovery in a way that supported a person’s post-operative confidence building, as well as improving their physical and psychological health outcomes; this echoes findings in wider digital health studies for patients undergoing spinal surgery(606) and transplant surgery(607) amongst others.(578, 608, 609) More specifically to this patient cohort, a recent study by Kneuertz *et al.* demonstrated use of a post-operative smartphone app to decrease anxiety following surgery for lung cancer, which appeared significant in the results from this patient cohort.(610) Importantly, perspectives on the timing of use and the duration of use of digital interventions appeared to relate to an individual person’s preferences, rather than one approach suiting everyone. Given the multitude of post-operative symptoms that can follow lung surgery (including pain, fatigue, emotional distress and anxiety, and the subsequent impact these can have on a person’s quality of life(611)), it is vital to weigh up the implementation of technologies alongside a person’s own preferences. While the finer details of recovery plans may differ between individuals and their respective lung cancer prognoses, the overarching self-management behaviours for post-operative recovery remains the same. Thus, technologies should be made available for the perioperative period for lung cancer surgical patients, and should therefore aim to promote supported recovery across the perioperative period to promote better health outcomes.

The researcher acknowledges there were some limitations with this work. The intended method of in-person data collection was impacted by the COVID-19 pandemic. Whilst virtual call-based software enabled the replication of face-to-face interviews (*i.e.,* responding to verbal and non-verbal cues and building rapport),(519, 520) there are some disadvantages to this interview technique that may have impacted our study. Established familiarity and participant comfort of use may have resulted in the higher number of interviews conducted over the telephone. Despite this, video-calls enabled a unique snapshot into life as a patient recovering at home during the crisis and provided a fuller-picture with more context than a telephone call may have done.(521) Participants currently experiencing remote consultations with members of the surgical team offered timely insights to this study and the wider possibilities of adopting digital strategies in the world of modern healthcare. This research predominantly focused on a small sample of patients in the North of England and, as a result, the experiences shared by participants may not be representative of all care pathways across other locations in the UK. Our study also focused solely on the perspectives of lung cancer surgical patients, and thus the results may not be generalizable to other cancer or general surgical specialties.

The overarching similarities and differences between findings from this patient cohort and those of bariatric (Chapter 6) and orthopaedic surgical patients (Chapter 7) will be discussed in Chapter 9.

8.8 Conclusion of results and take-home messages for the lung cancer surgical cohort

While this study is unique in its approach and has begun to provide insight into patient-centred needs of this population, the need for further research remains. Specifically, this qualitative investigation has identified the role, design, capability and functionality of digital technologies within the perioperative period to (i) act as a guide and motivator for patients, (ii) support them in reaching personalised recovery goals following lung cancer surgery, and (iii) provide them with a form of connectivity with peers and practitioners. Above all, the final theme developed within this data importantly identified that (iv) the timing of using digital technologies within the surgical pathway must be right for the individual at the centre, and this appeared to be guided by the individual person themselves.

Prior to this PhD programme of work, little was known about the optimal way to support lifestyle changes in patients undergoing bariatric, orthopaedic and lung cancer surgery with digital technologies. As a result of these three patient-informed qualitative studies (Chapters 6-8 respectively), the researcher has identified key features to support these surgical patient group through digital health technologies. The following chapter focuses on the overarching discussion and conclusions for this programme of work; it considers both the similarities and differences between the surgical cohorts and identifies the key take-home messages and recommendations developed in this thesis. In addition, Chapter 9 will discuss the strengths and limitations of the qualitative research studies conducted as part of this programme of work, as well as identify the pertinent areas that future research should look to explore.

Chapter 9: Discussion and Conclusions

9.1 Introduction

Given that each results chapter in this thesis (Chapters 6, 7 and 8) included its own discussion of the findings specific to each surgical cohort, this chapter seeks to collate the high-level findings and implications for practice. Reflecting on the overarching research question: “what would make digital technologies (more) effective for elective surgical patients?”, the researcher sought to answer: (i) *what would patients want from digital technologies?*; (ii) *how do they want to use digital technologies during the surgical journey?*; and (iii) *when is the optimum time point to implement them within the surgical pathway?,* so as to support patients to adopt healthier lifestyle behaviours pre- and post-operatively. A summary of the overarching findings from these cohort-specific studies is detailed below (Section 9.2) and possible avenues for future research are explored later (Section 9.5). Drawing on the Medical Research Council framework for the development and implementation of complex interventions,(612) the researcher will also describe how the results from this work could be used to inform future interventions for the surgical cohorts studied. In addition, the strengths and limitations of the three patient-informed qualitative studies are acknowledged, alongside reflections on conducting these studies during the COVID-19 pandemic.

9.2 Comparing the findings from the three surgical cohorts

The researcher has synthesised the main thematic similarities across the three cohorts into five common areas – from the results of this programme of work, these five key areas appeared fundamental in determining both the optimisation of the design, functionality and capability of digital technologies, and in their implementation within the surgical pathway. These areas concern: (1) receiving personalised feedback; (2) goal-setting functionality; (3) data-sharing capability; (4) connectivity to others; and (5) intervention timing (demonstrated in Figure 18). This section will discuss through these five common areas in turn and compare and contrast similarities and differences across the three surgical cohorts.

When comparing the findings from this work, the researcher felt it important to include mention of how patients, as participants, conceptualised digital health technologies. Within each individual surgical cohort, there was variation in use and familiarity with technologies, including those centred on digital health; there were some participants that had no prior history of using or engaging with technologies (at all), some who had limited use or experience of use of digital health technologies, and some people who were already regular users of such tools. Having this broad range of views and experiences was important, as the researcher wished to explore views across the full spectrum of possible end-users of a digital intervention. Furthermore, it was important to have this variation to better understand what may or may not influence technology use, within a modern healthcare setting.

When it came to patient conceptualisation of digital health technologies, this data was captured very early on in the semi-structured interview topic guide. There was a varying depth of understanding demonstrated across all three surgical cohorts, with the majority of patients being able to describe a digital health technology well – even providing named examples and insight into using such tools. This was deemed to be reflective of the widespread adoption of technology within day-to-day lives, especially digital tools, which featured health behaviour elements at the centre. For example, across all surgical cohorts, participants described close familiarisation with digital tools such as ‘step trackers’ and ‘sleep monitors’. To many, digital health technologies were viewed as an extension to the technologies they already used – particularly those that were in-built within smartphones or smartwatches – which demonstrated the feasibility and applicability to easily integrate into people’s lives. Whilst some patients reported very limited prior use of technologies, every participant could comprehend the usefulness of digital health technologies, in an ever-changing technologically-centred world. What appeared most significant in determining a person’s use of the technology, however, was their personal inclination – simply, whether they wanted to use it or not. Some participants comprehended the value of digital technologies but admitted that their own personal preference would be to continue ‘current care’ (without technology), whilst others had already adopted regular technology use. It was important for the researcher to consider these varying levels of how patients conceptualised digital health technologies, when she began to compare the findings from the three surgical cohorts.

Participants emphasised the capability of digital technologies to provide personalised care across all three surgical cohorts. Patients desired personalised feedback from the technologies – across the three different cohorts, there were slight differences in how they wished this to support them. In the bariatric surgery cohort, the usefulness of self-monitoring to track their progress during their weight-loss journey was discussed – for these patients, it was deemed essential that the technology focused on the weight-loss aspect of their recovery, given that it was so important in triggering the need for the surgery itself. Thought and consideration should be given to how this self-monitoring of weight can be supported on both a short- and long-term basis, given the evidence within literature of weight regain occurring up to 24-months' post-operatively; perhaps continued use of the same tool may lead to loss of effect, so technology designers may wish to consider ways in which this self-monitoring can be adapted and refreshed over time. Following on, participants in the orthopaedic cohort described a specific desire to personalise their pre- and post-operative physiotherapy exercises. Very clearly, some participants called for this level of technology personalisation to grant them capability to make exercises more challenging over time, alongside their enhanced recovery. In a directly contrasting way, perhaps technology designers and developers could contemplate the ability to make exercises less challenging too, so that there is a dual-functionality that enables customisation. Within the lung cancer surgical cohort, participants emphasised the importance of tailoring pre- and post-surgical advice dependent on their underlying diagnosis and clinical prognosis. This cohort also echoed views around technology customisation that were shared by the orthopaedic surgical cohort in that exercise-level could be adapted to best suit their needs at varying timepoints pre- and post-operatively.

Incorporating personalisation tools and settings within the technology could be a technique utilised by designers and developers to provide a sense of personalised care for the end-user. As discussed in Chapter 6, participants perceived value in having access to a home page with their name and details on, where personalised messages or notifications could be sent/received and pages toggled to create a unique experience for each user. This was primarily discussed by participants who had undergone or were in receipt of bariatric surgery, but was also mentioned by participants in the other cohorts. Thought was given about the context and value that this could bring to patients, especially those who have consented to surgery and, thus, have ceded control over their care and placed trust in the surgical teams involved; however, customising components of these digital health tools may also offer them a feeling of autonomy and ownership over a part of their surgical journey. Consideration should be given to catering for this when technologies are being designed and reviewed.

The main similarity described across the three surgical cohorts centred on the setting of personalised goals to support personalised recovery paths. All three surgical cohorts discussed goal-setting and the premise of being motivated to work towards an end-goal after surgery; while the 'goal' itself differed depending on the type of surgery a person was receiving (for example, those undergoing bariatric surgery focused on weight-loss, whereas goals described for participants undergoing orthopaedic surgery centred on physical activity), the motivation of post-operative rehabilitation was deemed beneficial. When considering the goal-setting features of a technology, concepts of gamification and incentivisation featured more prominently in the data from bariatric and orthopaedic surgery cohorts compared to those from the lung cancer surgery group. Participants from the bariatric and orthopaedic surgery cohorts could 'visualise' functionalities as useful – whether it be related to tracking a person's weight loss or tracking a person's physical activity and exercise over time. Features such as logging activities, accumulating steps, working towards an end goal and having an element of 'reward' when it was achieved were all recognised as important for motivation. In particular, participants discussed feeling motivated when they knew they had achieved a certain milestone and how incentives encouraged them to often keep going. Within the lung cancer surgery cohort, participants discussed making lifestyle changes, like increased physical activity, but positioned these alongside navigating a gradual post-operative recovery towards life without lung cancer (rather than aiming to push themselves to achieve certain milestones). Participants did recognise the value of a prescriptive and directive digital tool to gently persuade them to start moving, and what levels of exercise were safe in the post-operative period. However, participants undergoing lung cancer surgery perceived support for psychological health was just as important as support for physical health.

Having autonomy and feelings of ownership over aspects of the surgical journey appeared important to participants across all three surgical cohorts. Bariatric, orthopaedic and lung cancer surgical patients described the value of self-monitoring through their surgical journey, and also viewed the possibility of sharing progress data as empowering. For the bariatric surgery cohort, this was discussed as posting visual images of their weight loss (either images of themselves or a graph of weight loss over time) which could be viewed by peers who have undergone, or were undergoing, similar procedures. This attitude was similar to the orthopaedic surgery cohort, who perceived the sharing of self-monitoring data and physical activity tracking as motivational for themselves, and potentially for their peers too. In the lung cancer surgery cohort, participants appeared more reserved about posting this kind of data publicly but were still willing to share this data with members of the healthcare professional team – this was deemed to be important not only in managing their experiences privately, but also in case the prognosis of their peers was not similar to their own.

Participants discussed the value of receiving individualised feedback on their post-operative progress through their digital technologies. This feedback was perceived as beneficial for two reasons; it provided patients with reassurance that they were not recovering 'alone' and without anyone checking on them, but also to keep members of the surgical multidisciplinary team updated during their recovery. The psychological reassurance appeared to be of great importance to all cohorts. One participant in the bariatric surgery cohort believed data-sharing to be of benefit to the surgical professionals, as they could almost take some 'credit' for the success of their surgery skills in supporting weight-loss. Some participants believed that the technology could act as an extension of face-to-face follow-up care provided by the multidisciplinary teams. They viewed data-sharing functionalities as a mechanism to provide ongoing longer-term post-operative care and recognised that the duration of this may depend on the individual person and how long they wished to continue using the technology for. Across all surgical cohorts, participants also recognised that data-sharing could enable clinical interventions to be made if the surgical teams believed the data was not showing a 'normal' recovery pattern. Perceptions like this appeared to validate the significance of personalised elements of digital care, implying that technology has the potential to extend as a form of support for physical and psychological support for all three surgical cohorts throughout the pre- and post-operative period.

Another finding that underpinned all three surgical cohorts was the inclusion of digitally-enabled peer support. Participants valued the ability to share their experiences with others on similar journeys. Pre-operatively, peer support was perceived as a useful tool to become educated about a surgical process and be supported in making decisions to undergo surgery. Particularly in the orthopaedic cohort, participants discussed seeking advice from other people who had gone through similar surgeries to learn about their experiences and ability to return to their previous baseline level of activity. Peer support was also linked to supporting the emotional journey a person can experience when going through surgery, with encouragement and motivation appearing as a facilitator in making and maintaining healthier lifestyle changes. Participants undergoing bariatric surgery discussed the emotional connectedness that can come from discussing their worries and concerns with people who have experienced the same operation; specifically, around side effects (such as hair loss and bloating) that were unique to bariatric surgery. Some participants were also mindful of drawing comparisons with other people which may negatively affect a person's emotional status and thus engagement with pre- and post-operative lifestyle changes.

Unique to the lung cancer surgery cohort were the perceptions of digital peer support tool that could be used by the family or carers of the patient. Given the nature of the diagnosis accompanying the need for surgery, signposting to online resources was regarded as helpful for their relatives when helping to manage common side effects following surgery for lung cancer. In addition, family-only or carer-only digital forums were perceived as safe spaces for relatives to openly discuss their feelings around their loved-one's upcoming surgery. Not only did participants feel that peer support for their family or carers would be beneficial for educational purposes, they also alluded to the emotional assistance that could come from it. This was a unique finding for this surgical cohort – it was not something that was discussed by the other two surgical groups, which was interpreted to reiterate the power and value of wider networks within cancer care.

Lastly, one of the research questions for this programme of work focused on identifying the optimal time during the perioperative pathway for digital technologies to be used. Across all three surgical journeys there was a common theme that pre-operative implementation and post-operative continuation of digital interventions was feasible and acceptable. Patients undergoing bariatric surgery viewed the pre-operative timepoint as critical for information-seeking to encourage understanding about their upcoming weight-loss surgery, as well as to seek a sense of preparedness for the whole surgical experience. Continuing technology use post-operatively was perceived as supportive amongst this cohort, particularly in the initial period of making and adhering to dietary changes, receiving ongoing advice about their weight loss and in learning to take their new, life-long medication supplements following surgery.

In a similar way, participants from the orthopaedic surgery cohort described the benefits of pre-operative technology to support with information-seeking and education about the procedure, as well as to mentally prepare for the surgery and the rehabilitation processes that were to follow. Post-operatively, participants undergoing orthopaedic surgery described the value of digitally-delivered advice to support physical rehabilitation, physiotherapy exercises and recommendations to aid a structured recovery.

For those participants undergoing lung cancer surgery, timing of technology use appeared to be more closely linked with an individual's preference and 'readiness' to seek and digest information in the pre-operative phase; more so than in other cohorts, this was influenced by the disease underpinning the need for surgery, as well as a person's emotional status. Post-operatively, participants from the lung cancer surgery cohort were in agreement that digital technologies should be used both in the immediate recovery phase as well as on the longer-term to support healthier recovery.

There still remains an uncertainty as to whether the pre-operative initiation and post-operative continuation timing is a fixed predilection for all participants – it is more likely that the optimal time for technology use is governed by the individual and their own preferences. However, the results from these three studies demonstrated that there is potential for technologies to be integrated at timepoints spanning the entire surgical pathway, which offers opportunity to improve healthier lifestyle behaviours and influence post-operative outcomes.

The researcher makes further recommendations around intervention timing in Section 9.5.

1) Receiving personalised feedback

- Bariatric surgery: specific to their **weight-loss** journey.
- Orthopaedic surgery: specific to their pre- and post-operative **physiotherapy** exercises.
- Lung cancer surgery: advice dependent on **individual diagnosis** and prognosis.

2) Goal-setting functionality

- Bariatric surgery: working towards a target for **weight loss**.
- Orthopaedic surgery: to reach a specified level of **physical activity**.
- Lung cancer surgery: working more **broadly towards life without cancer** - **physical and psychological** support required.

3) Data-sharing capability

- Bariatric surgery: sharing of **visual data to document weight loss**; happy to share with peers (motivational).
- Orthopaedic surgery: sharing of **tracked physical activity** data; happy to share with peers (motivational).
- Lung cancer surgery: **less specific physical activity data** or tracking; to share with healthcare professionals, mindful of not sharing with peers unless same diagnosis or prognosis.

4) Connectivity to others

- Bariatric surgery: educational **connectedness** with peers
- Orthopaedic surgery: hearing about **the experiences of others**, returning to physical function.
- Lung cancer surgery: some emphasis on connecting with others with same diagnosis and prognosis; with **a focus of involving family/relatives or carers** in connectivity - unique to this cohort.

5) Intervention timing

- Bariatric surgery:
  - Pre-operative ✓
  - Post-operative ✓
- Orthopaedic surgery:
  - Pre-operative ✓
  - Post-operative ✓
- Lung cancer surgery:
  - Pre-operative ?
  - Post-operative ✓

Figure 18: Optimising the design, functionality and capability of digital technologies for surgical patients - the five overarching take-home messages.

9.3 Strengths and weaknesses of the three patient-informed qualitative studies

9.3.1 Overarching strengths and weaknesses involving participants in the three study cohorts

All three patient cohorts were sampled and studied from the North East of England. The variation in socio-economic deprivation within the North East of England has been previously well documented.(613-615) It is useful to reflect on this deprivation and levels of digital exclusion in the North East of England in comparison to the national average; for example, the proportion of people in the North East who are not online is 8% compared to 5% across the remaining populations of England; and there are lower levels of digital engagement reported in the region (32%), compared to the national average (28%).(613, 616, 617) It is therefore likely that participants of different socioeconomic classes may have had varied experiences with technologies, and the results of all three studies should therefore be interpreted with this in mind. Importantly, efforts were taken throughout this PhD programme of work to purposively sample participants from different socio-economic demographic groups (considering employment status and occupation for example, which has been reported for all participants involved in this programme of work, see Table 16, Chapter 5). In addition, questions in the semi-structured interview topic guide also sought to understand a person's prior use of technology; this ensured consideration was given to the potential for variation in access to digital technologies, which is closely associated with socio-economic deprivation. This approach was viewed favourably for inclusivity and equality by the Newcastle University Patient and Public Involvement and Engagement (PPIE) group and the NHS Ethical approval panel.

Ethnicity has also been associated with socio-economic deprivation and, in turn, the potential for engagement and use of digital technologies amongst these cohorts is important to consider;(615, 618-620) the ethnicity of all participants involved in the three studies was documented in Table 16, Chapter 5. The researcher recognises participant ethnic diversity as a limitation of this work, given that there were substantially fewer participants from ethnic minority groups within all three study populations (compared to those with ethnicity reported as White); in particular, there were no patients from ethnic minority communities enrolled within the lung cancer surgery cohort (despite four people being approached but declined to be involved). UK Census data has demonstrated that the ethnic diversity of communities is now growing in cities within the North East of England, including Newcastle upon Tyne and Middlesborough.(613, 621, 622) It is vital that the views and perspectives of these community groups are not underrepresented within health and social care research. Thus, future research should focus efforts on greater recruitment of participants from ethnic minority groups to ensure their voices are present and heard.

Notably, two thirds of the data collected for this PhD programme of work was collected during the COVID-19 pandemic. This was a time of minimised face-to-face contact for participants going through surgery, with many elective procedures being delayed, rescheduled or cancelled altogether. It is important to note the effect that this could have had on the participants. In fact, participants in the orthopaedic and lung cancer surgery cohort discussed and described using video-calls as part of their post-operative physiotherapy rehabilitation, which was something of a new adaptation by the care provider.

It is also necessary to consider the growing presence of ‘remote strategies’ in everyday life as a result of the pandemic. The pandemic resulted in some members of society using digital technologies in their day-to-day life more than ever before. Working from home became the norm for many people and with it came the regular use of Zoom® and Microsoft Teams®, two software that were infrequently used *en masse* by many of the general public prior to the pandemic.(623, 624) Governmental lockdowns also meant that multiple forms of socialising shifted to remote and digitised formats which, again, meant that a large proportion of society were utilising smartphone apps and video calling software to socialise.(623) It is important to consider the effect that this digital shift may have had upon the views of the participants in this study. Reflexive efforts were made to highlight this when collecting data with the orthopaedic and lung cancer surgery cohorts, and this has been reported in both chapters respectively (for example, including the views of patients utilising video calls as part of post-operative rehabilitation alongside those who had no prior use of technology).

Finally, participants involved in this study were only involved once in a single semi-structured interview, to which there were no follow-up interviews. The researcher acknowledges the potential benefits that could arise from conducting a longitudinal study in surgical cohorts. Further insights could be gained if there were multiple points of interaction and interviews throughout a person’s pre- and post-operative journey; this is explored further in Section 9.5.

The remainder of this section will discuss the strengths and weaknesses recognised in each of the surgical cohorts in turn.

9.3.2 Strengths and weaknesses specific to the bariatric surgery cohort

This study was one of the first to incorporate the views of pre- and post-operative participants, thus contributing to the growing international base of digital interventions for bariatric surgical pathways. However, the researcher acknowledges that there were some limitations in the work conducted within this cohort. Firstly, the research predominantly focused on a sample of patients from one specialist hospital in the North East of England. The researcher is mindful that the population demographics from this region may differ to those of other regions within the United Kingdom, and thus, future research may wish to include a greater number of hospital sites to gain representative spread. However, it is worth noting that bariatric surgical procedures do not take place in every hospital within the UK; the specialist nature of the procedures mean that they take place in specialist sites, one of which was where this study took place and included patients travelling over 2.5 hours to attend given the geographical area covered by the Trust.

It was also recognised that the population sample in this study included more female participants (n= 15, 75%) than male (n= 5, 25%). However, this demographic difference is not uncommon in bariatric surgery. Much evidence exists to demonstrate that, globally, bariatric surgeries take place more frequently in females than males; in the years between 2014 and 2018, the overall reported proportion of female patients undergoing weight-loss surgeries was 73.7%.(625) Furthermore, this demographic split between female and male participants has been one that is consistently reported in global baseline studies, from 2003,(626) 2008,(627) 2011(628) and 2013.(629) The cohort in this study was therefore deemed realistic and reflective of the population in clinical practice.

The researcher was acutely aware of the influence that the COVID-19 pandemic may have upon her participants; it was important to consider this for the patients within the bariatric surgery cohort. Though the interviews were conducted in-person prior to the pandemic, immediately prior to the governmental lockdown restrictions, it is still important to consider the environment in which these participants were taking part in this research. The setting for these interviews was a clinical consultation room, based within the hospital that they attended for their care. The researcher noted that the clinical setting may have been one which the participants felt less comfortable in, compared to their own home setting (which is where the participants from the lung cancer and orthopaedic cohorts were based during their interviews); this may be a reason for the less extensive quotes, and shorter interview durations, seen in this cohort compared to the others. Furthermore, the researcher self-reflected on her formal dress and professional attire (such as wearing an NHS lanyard) for these interviews and considered whether this could have had a contribution to the 'clinical feel' of these interviews.

9.3.3 Strengths and weaknesses specific to the orthopaedic surgery cohort

There were also some limitations affecting the research conducted with the orthopaedic surgery cohort. Alike the work done with the participants undergoing bariatric surgery, this study was one of the first conducted in the speciality of orthopaedic surgery that focused on digital interventions from the perspective of patients; this is in contrast to the multitude of studies concerning the views, perspectives and experiences of orthopaedic clinicians adopting or utilising digital technologies during surgery. As a result, the findings from this piece are timely and topical given the growing demand for digital strategies to be integrated throughout the pre-operative and rehabilitative periods accompanying orthopaedic surgery.

It was also recognised that the population sample in this study included more male participants (n= 11, 61%) than female (n= 7, 39%); however, the split in this orthopaedic cohort was also perceived as reflective of clinical practice. Studies have demonstrated that it is more common for males to undergo elective orthopaedic surgery (for knee and hip replacements),(630) with statistics reporting males to be three times more likely to receive knee arthroplasty compared to females.(631, 632) Implicit assumptions around the rate and intensity of physical activity have previously been reported to be a contributor to this disparity,(632, 633) however, further research could be conducted in this area to better understand this demographic difference.

There are also some possible disadvantages to the interview techniques employed within this study (telephone calls and virtual call-based software). More interviews were conducted over the telephone compared with using video call software; the latter enabled a unique snapshot into life as a patient recovering at home during the crisis, and provided a fuller-picture with more context than a telephone call may have done.(521) As a result of the COVID-19 pandemic, many elective orthopaedic surgeries were also cancelled throughout the UK. Consequently, this resulted in greater challenges around recruitment of pre-operative participants (n=6) in comparison to post-operative (n=12). However, this did not solely affect orthopaedic surgeries in isolation; cancellations for non-life-threatening elective surgical procedures were widespread. Future research may wish to place more emphasis on the recruitment of pre-operative participants given that elective orthopaedic surgeries have now resumed. Uniquely, the duration of a person's pre-operative phase now may be much longer than those pre-pandemic, which in itself may pose as an interesting topic for capitalising on the possible pre-operative teachable moment as discussed in Chapter 1.

9.3.4 Strengths and weaknesses specific to the lung cancer surgery cohort

This work presents a unique investigation in the field of surgery for lung cancer, a speciality that previously had limited research centring on the views of patients regarding digital technology use during the surgical pathway. Unique to this PhD, this qualitative study included the perspectives of participants currently experiencing remote consultations with members of the lung cancer surgical team – something that was not present in the wider literature. The researcher acknowledges that there were limitations in the conduct of this study that should be discussed.

While the sample was a fairly even split between male (n=7, 44%) and female participants (n=9, 56%), there were a higher number of post-operative participants interviewed (n= 10, 62.5%). The lower number of pre-operative participants was recognised by the researcher and supervisory team as being reflective of the surgical population secondary to the COVID-19 pandemic.(634) Due to societal fear and anxiety about the pandemic, and the subsequent reluctance to seek healthcare,(635, 636) many patients presented later to the team when their lung cancer was at an advanced stage and thus, inoperable. The ongoing burden of the pandemic on health-seeking behaviours has been recognised,(637) and may continue for some time yet.(638) Although the researcher asked post-operative participants to reflect back on their experiences prior to surgery, it is possible that they may have been unable to accurately recall their feelings or needs at that time; this is something that could be overcome in future longitudinal studies by following patients in real-time throughout the pre- and post-operative periods.

It is important to highlight that the average age of this population was the highest of all three surgical cohorts (65-years, SD 8.29). While this is reflective of typical age demographics of people receiving surgery for lung cancer,(639) it is also important to consider this in light of engagement with technologies. A strength of this study was that participants were included from a broad age range (the youngest being 55-years and the eldest being 83-years), given the previous associations reported between digital participation and digital exclusion amongst older people.(640-642) It is important to consider these potential barriers when it comes to providing digital support for a typically, older patient population who will require surgery for lung cancer.

9.4 Where to go next with the results from these studies?

The use of theory is advocated by the Medical Research Council framework for the development and evaluation of complex interventions.(612) It has been acknowledged that applying this approach could result in interventions that are more likely to be successful for the population cohorts intended to use it.(612, 643, 644) Involving theory in the design of future interventions that have a focus around changing or promoting healthier behaviours is important. Previous literature reviews have described interventions underpinned with theory as more effective than those that are non-theory-based; this was also a point of discussion within Chapter 2 of this programme of work and the published systematic review by the research team.(645, 646) However, the use of theory when designing digital interventions targeting behaviour change has been recognised as limited.(312)

A theoretical framework could be used in this work to map the findings gained from these three studies to elucidate which component(s) of a technology-based intervention is (most) effective. Taking one of the theoretical models discussed in Chapter 1.3.5 of this thesis,(85, 86) there are particular points of overlap between the patient-informed findings, and the Capability, Opportunity, Motivation and Behaviour (COM-B) components. The results from the three studies have highlighted potential areas for technology developers to focus on targeting, which may result in more successful changes to patient lifestyles pre- and post-operatively. Table 20 below explains the COM-B components along with defining statements (the author has provided some broad examples relevant to the patient cohorts as identified in this work). Tables 21-23 have been designed to visually report and map the areas discussed in the patient-informed findings from this work. A table has been produced for each of the three surgical cohorts involved in this work: the ‘tick’ symbol indicates where patient perspectives were provided and where patient capability, opportunity and motivation could be supported by digital technologies throughout the stages of the surgical pathway.

The researcher acknowledges that it is not fully known to what extent frameworks like the COM-B model have been used when designing digital technologies or digital interventions, particularly in the context of supporting surgical patients. Studies conducted in other fields of healthcare (such as dental and oral health,(84) gestational diabetes management(647) and smoking cessation(648)) have previously applied the COM-B model in attempts to inform the design of interventions targeting lifestyle changes. Learning from this work could be applied to the context of surgery-specific digital interventions as part of future research strategies. There is also limited knowledge around which population groups are particularly responsive to behaviour change interventions and which components specifically are of most benefit. Discussion around this, and other areas for future research, are further considered in Section 9.5 below.

Table 19: An explanation of the COM-B components (produced by A Robinson; adapted from definitions by Michie et al.)(85, 312)

COM-B components		**Statements of component definitions**	**Examples relevant to the surgical patient cohort**
Capability (An individual's physical and psychological capacity to engage in the behaviour)	**Physical**	Includes skill, dexterity and strength required for the behaviour; capacity to engage in necessary physical processes.	Individualised timeframe provided for re-starting physical activity after lung cancer surgery.
	Psychological	Knowledge of the behaviour and the ability to comprehend information; the capacity to engage in necessary thought processes.	Prescriptive instructions around dietary intake and common side effects following bariatric surgery.
Opportunity (All factors lying outside the individual that make performance of the behaviour possible / or to prompt it)	**Physical**	Created by the environment, for example: access to resources; physical opportunity provided by the environment.	Remote physiotherapy exercises following orthopaedic surgery.
	Social	Norms and expectations of behaviour that dictates the way we think about things.	Peer-peer and family/carer forums to discuss with others going through lung cancer surgery.
Motivation (All brain processes that energise and direct behaviour)	**Automatic**	Habits, emotions and impulses arising from associative learning and/or innate dispositions.	Interactive goal-setting for physical activity after orthopaedic surgery.
	Reflective	Motivational elements such as planning and decision-making; evaluations and plans.	Reflections on post-operative weight loss following bariatric surgery.

Table 20: Mapping the patient-informed findings from the bariatric surgery study to the components in the COM-B model.

COM-B component		Patient-informed findings: features contributing to the optimisation of digital technologies to best support patients before and after bariatric surgery			
		Providing surgery specific content and support	Facilitating self-monitoring and goal-setting	Delivering the information in an accessible, trusted and usable manner	Meeting information-sharing and engagement needs at timepoints before and after surgery
Capability	Physical	✓		✓	✓
	Psychological	✓		✓	✓
Opportunity	Physical	✓	✓	✓	✓
	Social	✓	✓	✓	✓
Motivation	Automatic	✓	✓	✓	
	Reflective	✓	✓	✓	✓
Key: the 'tick' symbol (✓) indicates where patient perspectives were provided and where patient capability, opportunity and motivation could be supported by digital technologies throughout the stages of the surgical pathway.					

Table 21: Mapping the patient-informed findings from the orthopaedic surgery study against the components in the COM-B model.

COM-B component		Incorporating interactive, user-centred features	Directing a descriptive and structured recovery	Enabling customisable, patient-controlled settings	Delivering general and specific surgical advice in a timely manner
		Patient-informed findings: features contributing to the optimisation of digital technologies to best support patients before and after orthopaedic surgery			
Capability	Physical	✓	✓		✓
	Psychological	✓	✓		✓
Opportunity	Physical	✓	✓	✓	✓
	Social		✓		✓
Motivation	Automatic	✓	✓	✓	✓
	Reflective	✓	✓	✓	✓

Key: the 'tick' symbol (✓) indicates where patient perspectives were provided and where patient capability, opportunity and motivation could be supported by digital technologies throughout the stages of the surgical pathway.

Table 22: Mapping the patient-informed findings from the lung cancer surgery study against the components in the COM-B model.

COM-B component		Patient-informed findings: features contributing to the optimisation of digital technologies to best support patients before and after <u>lung cancer surgery</u>			
		"Getting the technology to tell me, guide me and encourage me"	"Tracking me and supporting me to reach my goals"	"Comfort in knowing I'm not alone"	"Getting the timing right for me"
Capability	Physical	✓		✓	✓
	Psychological	✓		✓	✓
Opportunity	Physical	✓	✓	✓	✓
	Social	✓	✓	✓	
Motivation	Automatic	✓	✓		✓
	Reflective	✓	✓	✓	✓
Key: the 'tick' symbol (✓) indicates where patient perspectives were provided and where patient capability, opportunity and motivation could be supported by digital technologies throughout the stages of the surgical pathway.					

9.5 Recommendations from this project: future strategies and areas of focus

This PhD has identified three main areas for future research. These include: (i) targeting and supporting patient lifestyle change before and after surgery; (ii) improvements to the design of patient-centric digital technologies with an individualised care agenda; and (iii) the integration of digital technologies within the surgical pathways of modern healthcare settings. Each of these areas will now be discussed individually, below.

9.5.1 Targeting and supporting patient lifestyle change before and after surgery

Real-time, qualitative studies could be performed within each surgical speciality to gain further depth and insight into how best to support lifestyle changes perioperatively. By adopting a longitudinal approach to a study, researchers could conduct interviews and follow-up consultations with patients at regular points during their pre- and post-operative journey. This would enable the collection of real-time data and reduce and minimise recall bias, given that some patients remain on surgical pathways for a substantive time (for example, those undergoing bariatric surgery remain on post-operative follow-up for up to 2-years and those undergoing lung cancer surgery can remain under follow-up care for up to 5-years). Further, a person's needs may change significantly over this period of follow-up; gaining deeper qualitative insight into patient experiences with technologies offering pre- and post-operative support could enable better understanding of how technology functionalities and capabilities may need to change over time, in order to provide ongoing lifestyle support. Adopting this strategy of longitudinal qualitative studies, with each surgical speciality in turn, would also allow for greater understanding of how lifestyle changes could be targeted, supported and perhaps even maintained over time.

A greater understanding is also needed of the psychology behind behaviour change in surgical cohorts. Currently, limited evidence exists around behavioural theory underpinning digital technologies in these surgical patient cohorts. Future research should build on the findings of this study to fill this research gap and provide much needed evidence to target and support lifestyle changes both pre- and post-operatively. The results from this chapter aligning qualitative findings with the COM-B model (in Section 9.4) provides a starting point for technology developers when designing features to incorporate into technologies. The researcher seeks to investigate this further with plans to supervise systematic review(s) conducted by her undergraduate Master of Pharmacy research students at Newcastle University.

Furthering on the design and development of technologies with a person-centred focus, future research should seek to involve mixed-method approaches; in doing so, there would be potential to progressively refine the intervention's design, capability and functionality to best meet the needs of the patients. With qualitative studies, you can only draw so many conclusions from the data, especially with regard to patient safety and more precise measurement of surgical outcomes – there is certainly scope to further collect and explore quantitative evidence to complement the qualitative insights from this PhD. For example, using the technology to collect and report the data in real-time would mean there is less reliance on self-reporting (and thus, reducing the potential for self-reporting bias) when it comes to recording pre- and post-operative behaviours. The technology itself could collect, aggregate and report the data to help support understanding of changing behaviours, whilst being complemented with qualitative studies to further explore perspectives and lived-experiences of people at the centre of the journey. The focus should always be supporting individualised lifestyle change to improve surgical outcomes, yet the researcher acknowledges the challenges that can come with aiming to implement a tailored or individualised approach within a healthcare system that is so driven by policy and procedure (for example, balancing standardisation versus customisation).

9.5.2 Improvements to the design of patient-centric digital technologies with an individualised care agenda

To deliver on the design of a patient-centric technology that supports individualised care, future research should take the findings from this programme of work and gather further details about what constitutes "effective engagement" for each surgical patient cohort; that is, to seek to expand knowledge around what quantifies rates of engagement to achieve the intended post-operative outcomes. This approach should firstly be conducted within the three surgical specialities, before moving on a wider scale across other areas of elective surgical procedures. Longitudinal trials that follow patients through the pre- and post-operative journey could be conducted, enabling quantitative data measurements to be collected as an intervention arm and compared to that of current 'standard care'.

Moving beyond the findings in this work, future studies should seek to adopt co-design approaches to work collaboratively in association with the patients who will be using the digital technologies. Co-design workshops should be conducted with patients, as well as with practitioners who are involved in the surgical multidisciplinary team and members of the technology design teams; this approach would help to build on the findings from this PhD, as well as further identify specific detail on the preferences and practicalities of digital support tools. Collaboratively gaining perspectives from both end-users of the technology, as well as representation from the designers, could enable the creation of a truly patient-centred intervention. The practicalities of using the technology from all accounts could then further be explored using implementation science approaches.

Further to this, research should also consider the barriers that may affect patient engagement with digital strategies and seek to identify ways to overcome them. Researchers should consider elements of digital exclusion and digital health literacy in order to ensure that interventions that are developed which are inclusive, accessible and usable for all participants requiring surgery. Given the diversity of patient populations (broadly, in terms of a person's ethnicity, levels of social deprivation, level of education, underlying health conditions and their age), it is essential that digital inequalities to access are understood and that steps taken to address them. It is worth considering that digital exclusion may not only encompass a person's access to technology, but also the inequality in skill level when (i) using the technology and (ii) understanding the information at hand.(649, 650) Thus, future research should seek to work with underserved and vulnerable communities to understand the place of technology to complement their surgical care; the researcher has already taken steps to lay the foundations of this workstream, including undertaking a systematic review to better understand engagement with digital technologies by people from ethnic minority communities (publication under review at the time of thesis submission).(651)

9.5.3 The integration of digital technologies within the surgical pathways of modern healthcare settings

Given its person-centred and patient-informed approach, this programme of work has focused on the identification of patient priorities relating to using digital technologies as part of their surgical care. It is vital to explore patient perspectives, given that they are the end-users of the technologies and the ones whose surgical outcomes can be influenced by their use. However, it is also important to consider the integration of technologies from a healthcare professional perspective as this will be influential in embedding technology within current care practices. Future research is also needed to identify the priorities, views and opinions of the healthcare professionals involved in the surgical pathway. Exploring in this way may better inform the factors that need to be addressed in order to understand (i) what could influence engagement from healthcare professionals, (ii) the ways technology could reform and complement the care pathways currently in existence and (iii) what steps are required to lead to the integration of digital technologies within the surgical pathways of a modern National Health Service.

Perspectives from policy makers within healthcare organisations and healthcare systems should also be explored, given the input they may have over recommendation of technologies within clinical guidelines. Acknowledging patient safety and surgical outcome perspectives, quantitative data could be collected to demonstrate the impact of integrating technologies into care pathways. Alike any change to a clinical guideline, there should be an evidence-base to demonstrate improved patient outcomes, as well as studies reporting the cost-effectiveness and health economics of the intervention. In 2018, the National Institute for Health and Care Excellence (NICE) first published the 'Evidence Standards Framework for Digital Health Technologies'.(652) This document was recently updated in August 2022, and described key considerations and standards for digital health technologies that should be available or developed in the UK Health and Social Care system. These include: accurate and reliable measurements; accurate and reliable transmission of data; credibility with UK health professionals; relevance to care pathways in the UK; acceptability with users; and equality considerations. This framework has aimed to "demonstrate evidence for performance ... that are intended to be realistic and achievable for digital health technology companies, while being of a sufficiently high standard to give the health and social care system confidence in the digital health technology. This balance is intended to encourage the confident use of innovative, effective digital health technologies in the health and social care system".(652) In addition, the framework acts as a reference point for a number of stakeholder groups to identify the optimisation and implementation of digital health tools – one example given related to technology innovators using the framework to better understand the level of evidence required for tools to be commissioned (thus supporting evidence generation plans to be faster and more cost-effective). However, the researcher identified that gaps within the framework exist, which the results of this PhD programme of work could help to address. Qualitative, experience-based findings could be used alongside quantitative safety data to feed into such frameworks, with a specific focus on ensuring optimisation and implementation that is most acceptable to patients as the end-users of the technology. This patient-focused approach should sit alongside other quantitative approaches to make it easier to understand what 'optimal' evidence for digital health technologies looks like. Furthermore, given the interest of the researcher, this future work should also be conducted with the aim of (better) delivering on equity and equality considerations as mentioned in the NICE Evidence standards framework document (this is discussed further below).

The successful integration of digital technologies within a care pathway can also rely upon the recommendation and signposting toward digital strategies by a clinician. Ensuring that the technology is fit for purpose and is positively received by practitioners is vital to ensure 'digital signposting' takes place. In order for this to be known, researchers may wish to consider qualitative exploration of the perspectives of healthcare professionals, in order to gain insight into the acceptability and feasibility of this form of integration. As possible end-users themselves, practitioner satisfaction rates should be explored to understand the impact of technology integration within their current workload. Previously, the 'NHS Apps Library' was a website that contained NHS approved or recommended applications (apps) for use in health and social care. These had been deemed to meet required Digital Technology Assessment Criteria (DTAC), including technical and safety standards, and had been approved by experts in a particular speciality. The DTAC, as part of NHS England, aims to bring together legislation and good practice within clinical safety, data protection, technical security, interoperability, usability and accessibility of digital health tools. However, the NHS Apps Library was decommissioned in December 2021. Now, NHS England and NHS Improvement teams have begun to integrate recommendations for digital health tools and apps throughout the NHS website, in a bid to make them more accessible to patients and easy to signpost to by practitioners. Further research should seek to understand how accessible this information actually is, and explore the extent to which 'digital signposting' is happening within current care systems.

Future research should also consider the digital health literacy skills of the practitioners in the surgical multidisciplinary teams, particularly if they are likely to engage with the technology themselves, for instance being required to interpret the data shared from patients. Exploration of educational support strategies should take place to review and assess the skills and training a healthcare professional may require. Linking closely with digital health literacy, the researcher also recommends future work to explore and address privacy and security concerns that may accompany the integration of digital technologies. Privacy and security breaches in 2017 led to the WannaCry ransomware cyber-attack,(653, 654) which has since raised questions around the ability of healthcare organisations to securely store, handle and share patient data. In collaboration with technology designers, healthcare organisations should also seek to introduce mechanisms that assures the security and confidentiality of patient data that may be inputted, tracked or monitored when using digital technologies. Understandably, privacy and security concerns should also be considered from the viewpoint of patients or users of the technologies; this should be further explored by gaining patient perspectives to better understand the subsequent barriers and facilitators that may affect implementation and use.(655-657)

Whilst driving the integration of digital technologies in healthcare, it is also important to ensure that advances encourage digital inclusivity, rather than causing digital exclusion. The potential barriers that could arise when integrating technologies should be acknowledged and measures taken to promote digital inclusivity of patient cohorts that are at risk of digital inequalities;(658) for instance, people living in remote hard-to-reach locations without internet, people with disabilities or limiting conditions that may affect technology use, and people with language and communication barriers such as those people from ethnic minority groups, for whom English may not be their first language.(659, 660) Only one participant across the three surgical cohorts discussed their concern about digital technology use and digital exclusion – this was in relation to an elderly relative of theirs and whether, based on their age and familiarity with technology, a digital health technology integrated into their pre- and post-operative care would be suitable for them (or not). While the researcher is mindful that the digital gap between older and younger populations has begun to narrow over time, there should still be consideration given to digital exclusion amongst ageing cohorts too.(661, 662) Efforts were taken within the purposive sampling strategy to ensure variation within age ranges of participants, especially to consider their perspectives on technology adoption and use; it was interesting to note that age did not appear to be a barrier to technology use, with the oldest participant in the study (Participant 10 in the surgical cancer cohort) self-reporting one of the highest rates of current engagement with digital tools. Future research should seek to ensure that digital technology integration is achieved whilst, importantly, mitigating risks of digital exclusion.

9.6 Concluding remarks

As discussed in the Introduction to this programme of work, governmental health and care policies have recognised the role that digital technologies and wider Health Information Technology interventions can play in supporting the delivery of safe, high-quality, efficient and person-centred healthcare. For the people at the centre of the surgical journey, digital technologies have appeared to be supportive in facilitating and motivating healthier lifestyle changes, both pre- and post-operatively. Data generated from the two systematic reviews, one literature review and three qualitative studies from this thesis support the integration of technologies within the surgical pathway and highlight the approaches that should be adopted to optimise their effectiveness. Specifically for each surgical cohort, underpinning features of technology design, functionality and capability were identified in order to optimally support behaviour change. While each surgical cohort reported their own individualised support needs when considering their capability, opportunity and motivation to change their behaviours, there were distinct commonalities between groups where digital technologies could be used effectively to support this. Importantly, the role that technologies can play in the surgical pathway has been proven to support with patient physical health improvements, as well as those focused on psychological health and well-being outcomes.

The elective surgical pathway offers a unique opportunity to capitalise on surgical teachable moments, where digital technologies can empower and provide patients with the capability, opportunity and motivation to make healthier lifestyle changes. Take-home messages and results from this programme of work should be used to inform the optimisation and integration of digital technologies within a modern National Health System. The findings should be used by policy makers to address, shape and deliver national healthcare commitments towards personalised digital interventions to complement traditional surgical care. Future work should also seek to adopt co-design approaches to work collaboratively in association with the patients who will be using the digital health tools, as well as look to implementation science as a strategy to facilitate the uptake of research into clinical practice. Importantly, whilst driving the optimisation and implementation of digital technologies in health and surgical care, steps must be taken to ensure that such advances encourage digital inclusivity for all.

Appendices

Appendix 1: The value of teachable moments in surgical patient care and the supportive role of digital technologies

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Perioperative Medicine

COMMENTARY Open Access

The value of teachable moments in surgical patient care and the supportive role of digital technologies

Anna Robinson[1*], Robert Slight[2,3], Andrew Husband[1] and Sarah Slight[1,3]

Abstract

Evidence strongly supports improved outcomes following surgery when patients are more physically active, have better dietary intake, or are generally fitter prior to surgery. Having an operation is a major life event for patients, and many are not educated around what they can do as individuals to aid a speedier and more successful recovery following their operation. What if there was a time point before surgery where clinicians could inspire patients to adjust their lifestyles for the better, in order to see fewer complications after surgery? This is where the concept of teachable moments comes into play.

This commentary explores the concept of teachable moments and their value in surgical patient care and discusses the potentially under-utilized opportunities on hand to the surgical multidisciplinary team to remotely support patients using digital health technologies.

Keywords: Teachable moments, Surgery, Surgical improvement, Digital technology, Behavior change, Perioperative medicine

Appendix 2: Digital technology to support lifestyle and health behaviour changes in surgical patients: systematic review

OXFORD

BJS Open, 2020, 5(1), zraa009
DOI: 10.1093/bjsopen/zraa009
Systematic Review

Digital technology to support lifestyle and health behaviour changes in surgical patients: systematic review

A. Robinson [1], A. K. Husband [1], R. D. Slight [2] and S. P. Slight [1,2,*]

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[2]Newcastle upon Tyne Hospitals NHS Foundation Trust, Newcastle upon Tyne, UK

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Abstract

Background: Digital technologies (such as smartphone applications, activity trackers, and e-learning platforms) have supported patients with long-term conditions to change their lifestyle health behaviours. The aim of this study was to examine the effectiveness of digital technologies in supporting patients undergoing elective surgery to change their health behaviours.

Methods: A systematic review was conducted of articles reporting a digital intervention supporting behaviour change in adult patients who underwent elective bariatric, oncological or orthopaedic surgery. MEDLINE, Embase, CINAHL, PsycINFO, Web of Science, and Scopus were searched from inception to March 2019 for quantitative intervention studies with a specific focus on physical activity, dietary intake, and weight loss in patients before and after surgery (PROSPERO: CRD42019127972). The Joanna Briggs Institute critical appraisal checklist was used to assess study quality.

Results: Of 3021 citations screened, 17 studies were included comprising 4923 surgical patients; these included experimental (pre–post design, feasibility studies, and RCTs) and observational studies. Three factors were identified as effective for supporting health behaviour change in elective surgical populations: digital technology delivery, implementation, and theoretical underpinning. Six of eight studies that referred to behaviour change theories observed significant improvements in health behaviour relating to reduced weight regain, and improved lifestyle choices for physical activity and diet. Meta-analysis was not possible because of heterogeneous outcome measures.

Conclusion: Digital technologies may effectively support behavioural change in patients undergoing elective surgery.

Appendix 3: PROSPERO registration

NIHR | National Institute for Health Research

PROSPERO
International prospective register of systematic reviews

The effectiveness of digital technologies to support surgical patients in changing their health behaviors: a systematic review

Citation

Anna Robinson, Sarah Slight, Robert Slight, Andrew Husband. The effectiveness of digital technologies to support surgical patients in changing their health behaviors: a systematic review. PROSPERO 2019 CRD42019127972 Available from: https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42019127972

Review question [1 change]

We aim to review the existing literature to assess the effectiveness of digital interventions that are implemented within a surgical pathway, and whether these interventions promoted or supported health behaviour change in surgical patients. This health behaviour change could, for example, have improved physical activity levels before and after surgery to optimise a patients' ability to recover.

Our review concerns any common surgery where there is a defined pre- and post-operative period in which the patient is encouraged to make lifestyle changes. This included, for example, bariatric surgery, where there is an emphasis on lifestyle behaviour change before and after surgery, or orthopaedic surgery, where there is a focus on post-operative physical activity to aid rehabilitation. Any form of acute surgery (such as acute unplanned procedures) was deemed outside of the scope of this review as behaviour changes cannot be planned pre-operatively.

Appendix 4: Digital and Mobile Technologies to Promote Physical Health Behaviour Change and Provide Psychological Support for Patients Undergoing Elective Surgery: Meta-Ethnography and Systematic Review

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Review

Digital and Mobile Technologies to Promote Physical Health Behavior Change and Provide Psychological Support for Patients Undergoing Elective Surgery: Meta-Ethnography and Systematic Review

Anna Robinson[1], MPharm, PG Dip; Umay Oksuz[1], MPharm; Robert Slight[2,3], MBChB, PhD, FRCSEd (C-Th); Sarah Slight[1,3], MPharm, PhD, PG Dip; Andrew Husband[1], MPharm, MSc, PhD, PG Dip

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Abstract

Background: Digital technology has influenced many aspects of modern living, including health care. In the context of elective surgeries, there is a strong association between preoperative physical and psychological preparedness, and improved postoperative outcomes. Health behavior changes made in the pre- and postoperative periods can be fundamental in determining the outcomes and success of elective surgeries. Understanding the potential unmet needs of patients undergoing elective surgery is central to motivating health behavior change. Integrating digital and mobile health technologies within the elective surgical pathway could be a strategy to remotely deliver this support to patients.

Objective: This meta-ethnographic systematic review explores digital interventions supporting patients undergoing elective surgery with health behavior changes, specifically physical activity, weight loss, dietary intake, and psychological support.

Methods: A literature search was conducted in October 2019 across 6 electronic databases (International Prospective Register of Systematic Reviews [PROSPERO]: CRD42020157813). Qualitative studies were included if they evaluated the use of digital technologies supporting behavior change in adult patients undergoing elective surgery during the pre- or postoperative period. Study quality was assessed using the Critical Appraisal Skills Programme tool. A meta-ethnographic approach was used to synthesize existing qualitative data, using the *7 phases of meta-ethnography* by Noblit and Hare. Using this approach, along with reciprocal translation, enabled the development of 4 themes from the data.

Appendix 5: PROSPERO registration

NIHR | National Institute for Health Research

PROSPERO
International prospective register of systematic reviews

The use of digital health technology to provide holistic care to the elective patients in pre- and post-operative pathway - a meta-ethnography

Citation

Umay Oksuz, Anna Robinson, Andrew Husband. The use of digital health technology to provide holistic care to the elective patients in pre- and post-operative pathway - a meta-ethnography. PROSPERO 2020 CRD42020157813 Available from: https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42020157813

Review question

The aim of this study was to evaluate the effectiveness of digital health technology, whether it provides holistic care for elective patients in their pre and post-operative pathway. This review only aimed to focus on the most common type of elective surgeries, which are bariatric, orthopaedic and cancer. We did not specify the specific type of these three elective surgeries. These selected surgeries require physical and mental support before and after the surgery, therefore they perfectly fit into our research project.

Searches

One researcher (UO) will develop search strategies with assistance from her supervisors. The following databases will be systematically searched, using MeSH terms and keywords: MEDLINE, Embase, PsycINFO, CINAHL and Scopus. There will be a search restriction of the English Language and no date restriction. The searches will be performed using a combination of MeSH terms and keywords, utilising the following Boolean operators to either narrow or broaden the search: 'OR' and 'AND'. This search will be carried out in October 2019.

Types of study to be included

Qualitative analysis/research and mixed-methods of quantitative and qualitative studies

Appendix 6: Digital support for patients undergoing bariatric surgery: narrative review of the roles and challenges of online forums

Review

Digital Support for Patients Undergoing Bariatric Surgery: Narrative Review of the Roles and Challenges of Online Forums

Anna Robinson[1], MPharm, PGDip (Adv); Andrew K Husband[1], PhD; Robert D Slight[2], PhD; Sarah P Slight[1], PhD

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Abstract

Background: The internet has become an important medium within health care, giving patients the opportunity to search for information, guidance, and support to manage their health and well-being needs. Online forums and internet-based platforms appear to have changed the way many patients undergoing bariatric surgery view and engage with their health, before and after weight loss surgery. Given that significant health improvements result from sustained weight loss, ensuring patient adherence to recommended preoperative and postoperative guidance is critical for bariatric surgery success. In a patient cohort with high information needs preoperatively, and notoriously high attrition rates postoperatively, online forums may present an underutilized method of support.

Objective: The aim of this study was to conduct a narrative review focusing on the developing roles that online forums can play for patients with bariatric conditions preoperatively and postoperatively.

Methods: A literature search was conducted in October-November 2019 across 5 electronic databases: Scopus, EMBASE, PsycINFO, CINAHL, and MEDLINE. Qualitative or mixed methods studies were included if they evaluated patients undergoing bariatric surgery (or bariatric surgery health care professionals) engaging with, using, or analyzing online discussion forums or social media platforms. Using thematic analysis, themes were developed from coding patterns within the data to identify the roles and challenges of online forums for patients undergoing bariatric surgery.

Results: A total of 8 studies were included in this review, with 5 themes emerging around (1) managing expectations of a *new life*; (2) decision making and signposting; (3) supporting information seeking; (4) facilitating connectedness: peer-to-peer social and emotional support; and (5) enabling accessibility and connectivity with health care professionals.

Appendix 7: Study Participant Information Sheet

How can the use of digital technologies be optimised in elective surgical pathways to support patients in improving their health behaviours? A patient-informed qualitative study.

Participant Information Sheet – Patient Interview

Names of Investigators: Miss Anna Robinson, Dr Sarah Slight, Mr Robert Slight, Professor Andrew Husband
Ethical Approval Ref: 19/NE/0318
IRAS Project ID: 265725

Invitation paragraph
You have been invited to take part in a research study. Before you decide whether or not to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully.

Background
Early research has proven digital technologies (*e.g.* smartphone apps, websites, activity trackers *etc.*) to be beneficial in supporting and educating patients around the time of having surgery. Some trials have found that patients can benefit from extra support before and after operations (particularly related to lifestyle and health habits), but no study has sought to find out the perspectives of patients about this.

The overall purpose of this research is to explore how digital technologies can be used to support surgical patients to improve their lifestyles and health habits. We anticipate that taking part in this study could result in wider advantages for patients undergoing many different types of surgery, and determine whether there is a need for patient-focused digital support. The findings from this research could also help to shape the design of guidelines and/or interventions in the future.

Why have I been chosen to take part?
This project is offered to any patient that is under the care of *[(delete as appropriate) cancer / bariatric / orthopaedic clinic]* who will be/has undergone surgery as part of their treatment at *[(delete as appropriate) Newcastle Upon Tyne Hospitals NHS Foundation Trust / South Tyneside and Sunderland NHS Foundation Trust]*.

What will taking part involve?
Participation will involve taking part in an interview (which could either be face-to-face, over the phone or *via* call-based software like Skype) to discuss digital technologies to support patients undergoing surgery. The interview is expected to last approximately 30-40 minutes. The interview will be recorded and typed up word for word (transcribed). Once transcribed, the recording will be erased.

Do I have to take part?
It is up to you to decide whether or not to take part. If you decide to take part, you will be given this information sheet to keep and will be asked to sign and return the consent form.

You are free to withdraw from this study at any time and without giving a reason. Your decision will not affect the quality of care you will receive from *[(delete as appropriate) Newcastle Upon Tyne Hospitals NHS Foundation Trust / South Tyneside and Sunderland NHS Foundation Trust]*.

Will my taking part in this study be kept confidential?
Yes – all discussions and information provided will be kept confidential. Any information reported from the interview will not enable you to be recognised. You will not automatically be expected to take part in any future research. Consent forms will be securely stored within *[(delete as appropriate) Newcastle Upon Tyne Hospitals NHS Foundation Trust / South Tyneside and Sunderland NHS Foundation Trust]* in a filing cabinet within a locked office, or on a password-protected University computer, and held securely in accordance with regulations. Any personal data will be destroyed as soon as is practical and reasonable.

What will happen to the results of this research study?
We plan to submit the findings of this study to medical journals for publication. You will not be identified in any report or publication that comes from this study.
If you wish to be given a summary of the results, please provide your name and contact details – once the study is completed, this can be compiled and sent to you.

Who has reviewed this study?
This study has been reviewed and approved by the NHS Health Research Authority and Health and Care Research Wales (HCRW) – reference: 19/NE/0318.

Who funds/sponsors the research?
This research is funded and sponsored by Newcastle University (as part of the Dr WE Harker Surgical Sciences scholarship programme) and is being carried out as part of a PhD project.

What if something goes wrong?
In case you have a complaint, you can approach the Chief Investigator of the study: Dr Sarah Slight (contact details below). Independent advice is also available from *[(delete as appropriate) Newcastle Upon Tyne Hospitals NHS Foundation Trust Research & Development Department via phone: +44 (0191) 282 5959 or email: trust.r&d@nuth.nhs.uk / South Tyneside and Sunderland Foundation Trust Research & Development Department via phone: +44 (0191) 404 1000 or email: carly.brown@stft.nhs.uk]*

Will the use of my data meet GDPR rules?
GDPR stands for the General Data Protection Regulation. All research using patient data must follow UK laws and rules. See the following sections covering use of your information.

How will we use information about you?
We will need to use information from you for this research project. This information will include only your opinions. People will use this information to do the research or to check your records to make sure that the research is being done properly. We will keep all information about you safe and secure. Once we have finished the study, we will keep some of the data so we can check the results. We will write our reports in a way that no-one can work out that you took part in the study.

What are your choices about how your information is used?
You can stop being a part of the study at any time, without giving a reason, but we will keep information/audio-recordings about you that we already have. We need to manage your records in specific ways for the research to be reliable. This means that we won't be able to let you see or change the data we hold about you.

Where can you find out more about how your information is used?
You can find out more about how we use your information:

- at www.hra.nhs.uk/information-about-patients/
- by asking one of the research team via email (contact information below).

Who can I contact for more information about this study?
PhD student: Miss Anna Robinson, Institute of Health and Society, King George VI Building, Newcastle University, Newcastle Upon Tyne, NE1 7RU. Email: A.Robinson16@ncl.ac.uk.
Supervisor/Chief Investigator: Dr Sarah Slight, School of Pharmacy, King George VI Building, Newcastle University, Newcastle Upon Tyne, NE1 7RU. Email: Sarah.Slight@ncl.ac.uk.

Thank you very much for considering taking part in this research study.

Appendix 8: Participant Consent Form

How can the use of digital technologies be optimised in elective surgical pathways to support patients in improving their health behaviours? A patient-informed qualitative study.

Participant Consent Form – **Semi-structured Patient interview**

Ethical Approval Ref: 19/NE/0318
IRAS Project ID: 265725

Name of Researcher: ____________________________________

Name of Participant: ____________________________________

Please initial box

1. I confirm that I have read and understand the participant information sheet version number 1.6, dated September 2020, for the above study and have had the opportunity to ask questions. ☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving a reason. ☐
3. I understand that should I withdraw, the information collected so far cannot be erased, and that this information may still be used in the project analysis. ☐
4. I understand that notes may be taken during the recorded interview, and I will be asked a few questions. The interview (which could either be over the phone or *via* call-based software) will be transcribed, and any anonymous direct quotes may be used in the study reports and publications. ☐
5. I understand that all information supplied will be kept confidential. Any information reported or published will not enable me to be recognised. ☐
6. I understand that relevant sections of the data collected during the study may be looked at by individuals from: the study team, the sponsor (Newcastle University), and from regulatory authorities, where it is relevant to taking part in this research. ☐
7. I agree to take part in the above study. ☐

________________________	______________	____________________
Name of Participant	*Date*	*Signature*
________________________	______________	____________________
Researcher taking consent	*Date*	*Signature*

For more information about the study, or to ask further questions, feel free to contact the lead researcher: Anna Robinson, A.Robinson16@ncl.ac.uk

2 copies: 1 for participant and 1 for the project notes

How can digital technologies be optimised in elective surgical pathways to support patients in improving their health behaviours?
IRAS Project ID 265725 / Consent Form / Version 1.6 / September 2020

Appendix 9: IRAS Ethical Approval

Ymchwil Iechyd
a Gofal Cymru
Health and Care
Research Wales

NHS
Health Research
Authority

Dr Sarah Slight
School of Pharmacy, King George VI Building
Newcastle University
Newcastle Upon Tyne
NE1 7RU

Email: hra.approval@nhs.net
HCRW.approvals@wales.nhs.uk

11 November 2019

Dear Dr Slight

HRA and Health and Care Research Wales (HCRW) Approval Letter

Study title:	**How can the use of digital technologies be optimised within elective surgical pathways to best support patients in making healthier lifestyle behaviour change? A patient-informed qualitative study.**
IRAS project ID:	**265725**
Protocol number:	**Not applicable**
REC reference:	**19/NE/0318**
Sponsor	**Newcastle University**

I am pleased to confirm that **HRA and Health and Care Research Wales (HCRW) Approval** has been given for the above referenced study, on the basis described in the application form, protocol, supporting documentation and any clarifications received. You should not expect to receive anything further relating to this application.

Please now work with participating NHS organisations to confirm capacity and capability, in line with the instructions provided in the "Information to support study set up" section towards the end of this letter.

How should I work with participating NHS/HSC organisations in Northern Ireland and Scotland?
HRA and HCRW Approval does not apply to NHS/HSC organisations within Northern Ireland and Scotland.

If you indicated in your IRAS form that you do have participating organisations in either of these devolved administrations, the final document set and the study wide governance report (including this letter) have been sent to the coordinating centre of each participating nation. The relevant national coordinating function/s will contact you as appropriate.

Please see IRAS Help for information on working with NHS/HSC organisations in Northern Ireland and Scotland.

How should I work with participating non-NHS organisations?
HRA and HCRW Approval does not apply to non-NHS organisations. You should work with your non-NHS organisations to obtain local agreement in accordance with their procedures.

What are my notification responsibilities during the study?

The standard conditions document "*After Ethical Review – guidance for sponsors and investigators*", issued with your REC favourable opinion, gives detailed guidance on reporting expectations for studies, including:

- Registration of research
- Notifying amendments
- Notifying the end of the study

The HRA website also provides guidance on these topics, and is updated in the light of changes in reporting expectations or procedures.

Who should I contact for further information?
Please do not hesitate to contact me for assistance with this application. My contact details are below.

Your IRAS project ID is **265725**. Please quote this on all correspondence.

Yours sincerely,

Natalie Wilson
Approvals Specialist

Email: nrescommittee.northeast-newcastleandnorthtyneside2@nhs.net

Copy to: *Ms Kay Howes, University of Newcastle, Sponsor contact*
Ms Anna Robinson, University of Newcastle, Student researcher

Appendix 10: Non-substantive HRA adjustments

Notification of Non-Substantial/Minor Amendments(s) for NHS Studies

This template **must only** be used to notify NHS/HSC R&D office(s) of amendments, which are **NOT** categorised as Substantial Amendments.
If you need to notify a Substantial Amendment to your study then you MUST use the appropriate Substantial Amendment form in IRAS.

Instructions for using this template

- For guidance on amendments refer to http://www.hra.nhs.uk/research-community/during-your-research-project/amendments/
- This template should be completed by the CI and optionally authorised by Sponsor, if required by sponsor guidelines.
- This form should be submitted according to the instructions provided for NHS/HSC R&D at http://www.hra.nhs.uk/research-community/during-your-research-project/amendments/which-review-bodies-need-to-approve-or-be-notified-of-which-types-of-amendments/ . If you do not submit your notification in accordance with these instructions then processing of your submission may be significantly delayed.

1. Study Information

Full title of study:	How can the use of digital technologies be optimised within elective surgical pathways to best support patients in making healthier lifestyle behaviour change? A patient-informed qualitative study.
IRAS Project ID:	265725
Sponsor Amendment Notification number:	1
Sponsor Amendment Notification date:	24/4/2020
Details of Chief Investigator:	
Name [first name and surname]	Dr Sarah Slight
Address:	School of Pharmacy, King George VI Building, Newcastle University
Postcode:	NE1 7RU
Contact telephone number:	0191 208 6000
Email address:	Sarah.slight@newcastle.ac.uk
Details of Lead Sponsor:	

Partner Organisations:
Health Research Authority, England NIHR Clinical Research Network, England
NHS Research Scotland NISCHR Permissions Co-ordinating Unit, Wales
HSC Research & Development, Public Health Agency, Northern Ireland

Name:	Kay Howes on behalf of Newcastle University
Contact email address:	Kay.howes@newcastle.ac.uk
Details of Lead Nation:	
Name of lead nation *delete as appropriate*	England
If England led is the study going through CSP? *delete as appropriate*	No
Name of lead R&D office:	South Tyneside and Sunderland NHS Foundation Trust and Newcastle upon Tyne Hospitals NHS Foundation Trust

2. Summary of amendment(s)

This template **must only** be used to notify NHS/HSC R&D office(s) of amendments, which are **NOT** categorised as Substantial Amendments.
If you need to notify a Substantial Amendment to your study then you MUST use the appropriate Substantial Amendment form in IRAS.

No.	Brief description of amendment *(please enter each separate amendment in a new row)*	Amendment applies to *(delete/ list as appropriate)*		List relevant supporting document(s), including version numbers *(please ensure all referenced supporting documents are submitted with this form)*		R&D category of amendment *(category A, B, C) For office use only*
		Nation	**Sites**	**Document**	**Version**	
1	Amendment to method of data collection Previously data was collected through face-to-face interviews with patients. However, due to COVID-19 implications and restrictions, we would like to give the lead researcher the choice of conducting these interviews by phone or *via* a call-based software, if possible.	England	All sites or list affected sites	1) Updated Consent Form – Patient 2) Updated Participant Information Sheet – Patient 3) Updated Study Protocol (with the above items included)	V1.5 V1.6 V2.5	
2						
3						
4						
5						

[Add further rows as required]

Appendix 11: Designing Digital Health Technology to Support Patients Before and After Bariatric Surgery: Qualitative Study Exploring Patient Desires, Suggestions, and Reflections to Support Lifestyle Behaviour Change

JMIR HUMAN FACTORS Robinson et al

Original Paper

Designing Digital Health Technology to Support Patients Before and After Bariatric Surgery: Qualitative Study Exploring Patient Desires, Suggestions, and Reflections to Support Lifestyle Behavior Change

Anna Robinson[1,2], MPharm, PG Clin Dip (Adv); Andrew Husband[1,2], PhD; Robert Slight[2,3], PhD; Sarah P Slight[1,2], PhD

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Abstract

Background: A patient's capability, motivation, and opportunity to change their lifestyle are determinants of successful outcomes following bariatric surgery. Lifestyle changes before and after surgery, including improved dietary intake and physical activity levels, have been associated with greater postsurgical weight loss and improved long-term health. Integrating patient-centered digital technologies within the bariatric surgical pathway could form part of an innovative strategy to promote and sustain healthier behaviors, and provide holistic patient support, to improve surgical success. Previous research focused on implementing digital technologies and measuring effectiveness in surgical cohorts. However, there is limited work concerning the desires, suggestions, and reflections of patients undergoing bariatric surgery. This qualitative investigation explores patients' perspectives on technology features that would support behavior changes during the pre- and postoperative periods, to potentially maintain long-term healthy lifestyles following surgery.

Objective: This study aims to understand how digital technologies can be used to support patient care during the perioperative journey to improve weight loss outcomes and surgical success, focusing on *what* patients want from digital technologies, *how* they want to use them, and *when* they would be of most benefit during their surgical journey.

Methods: Patients attending bariatric surgery clinics in one hospital in the North of England were invited to participate. Semistructured interviews were conducted with purposively sampled pre- and postoperative patients to discuss lifestyle changes and the use of digital technologies to complement their care. The interviews were audio recorded and transcribed verbatim. Reflexive thematic analysis enabled the development of themes from the data. Ethical approval was obtained from the National Health Service Health Research Authority.

Appendix 12: Designing the Optimal Digital Health Intervention for Patients' Use Before and After Elective Orthopaedic Surgery: Qualitative Study

JOURNAL OF MEDICAL INTERNET RESEARCH Robinson et al

Original Paper

Designing the Optimal Digital Health Intervention for Patients' Use Before and After Elective Orthopedic Surgery: Qualitative Study

Anna Robinson[1,2], MPharm, PGDip; Robert D Slight[2,3], PhD; Andrew K Husband[1,2], PhD; Sarah P Slight[1,2], PhD

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Abstract

Background: Health behavior changes made by patients during the perioperative period can impact the outcomes and success of elective surgeries. However, there remains a limited understanding of how best to support patients during this time, particularly through the use of digital health interventions. Recognizing and understanding the potential unmet needs of elective orthopedic surgery patients is central to motivating healthier behavior change, improving recovery, and optimizing overall surgical success in the short and long term.

Objective: The aim of this study is to explore patient perspectives on technology features that would help support them to change their lifestyle behaviors during the pre- and postoperative periods, and that could potentially maintain long-term healthy lifestyles following recovery.

Methods: Semistructured interviews with pre- and postoperative elective orthopedic patients were conducted between May and June 2020 using telephone and video call–based software. Patient perspectives on the use of digital technologies to complement current surgical care and support with lifestyle behavior changes were discussed. Interviews were audio recorded and transcribed verbatim. Reflexive thematic analysis enabled the development of themes from the data, with QSR NVivo software (version 12) facilitating data management. Ethical approval was obtained from the National Health Service Health Research Authority.

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