Knowledge, attitude and practice of health and safety guidelines among laboratory staff in Saudi Arabia

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Abstract

Background

Medical laboratories are required to follow health and safety regulations to minimise occupational risks to laboratory staff. Without knowledge of and adherence to appropriate controls and procedures, laboratory acquired infection (LAIs) can result in morbidity and mortality to staff. The prevention and reduction of LAIs is a key priority for the Kingdom of Saudi Arabia (KSA) healthcare system as part of its infection prevention and control (IPC)/biosafety programme. This mixed-methods study aimed to explore the implementation of the IPC/biosafety programme from the laboratory staff viewpoint and to assess knowledge, attitude and practice of recommended polices and procedures.

Methods

A mixed-methods study design, combining quantitative (survey) and qualitative (semi-structured interviews) methods was employed. The study was conducted in three hospitals (two public, and one private in KSA. Participants included laboratory staff, allied health professionals and infection control specialists. Quantitative data were analysed using descriptive and inferential analysis. Qualitative data were analysed using the Normalisation Process Theory (NPT) framework.

Results

King Abdulaziz Medical City participants had the highest mean knowledge scores (9.81). Hayat National Hospital participants had the highest median attitude scores (53.5). Participants who received training had the highest median practice scores (52.0). There was a positive correlation between the knowledge and practice scores ($r= 0.32$, $p= 0.003$). Several themes regarding the implementation of safety guidelines were identified using NPTs four constructs, such as; awareness and risk perception of LAIs; valuing the benefits of guidelines; compliance with implementing guidelines; assessment and monitoring of guidelines implementation and facilitators of guidelines implementation.

Conclusion

Although the majority of participants had high scores on knowledge, attitude and practice, there were some differences between hospitals, confirming the need for standardisation among hospitals and continuous education and training. Staff were also aware of the risk of LAIs, and value of implementing guidelines to minimise occupational risk. However, factors such as lack of organisational support and lack of resources affected the implementation process. The need for a comprehensive action plan from the Ministry of Health and the General Directorate for Infection Prevention and Control in Healthcare Facilities to facilitate the implementation of the IPC program was regarded as critical to the uptake of safety guidelines.

Dedication

An effective handling of life challenges requires effort, along with the support of those surrounding us.

I respectfully give my efforts to:
Soul of My Father: Omar Aldhamy
Soul of My Mother: Ruqyah Alaqeel
My Husband: Abdullah Alhowail
My Children: Mohammed, Murad and Taim.

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List of Publications

1. Aldhamy H, Maniatopoulos G, McCune VL, Mansi I, Althaqafy M, Pearce MS. Knowledge, attitude and practice of infection prevention and control precautions among laboratory staff: a mixed-methods systematic review. Antimicrob Resist Infect Control. 2023;12(1):1–14. Available from: https://aricjournal.biomedcentral.com/articles/10.1186/s13756-023-01257-5

2. Aldhamy H, Maniatopoulos G, McCune VL, Mansi I, Althaqafy M, Pearce MS. Knowledge, attitude and practice of infection prevention and control precautions among laboratory staff: a mixed-methods systematic review. In Society for Social Medicine Annual Scientific Meeting. 6-8 September, 2023.

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List of abbreviations

CBAHI	Saudi Central Board for accreditation of Healthcare Institutions
CDC	The Centers for Disease Control and Prevention
CI	Confidence intervals
CL	Containment Level
DAG	Directed Acyclic Graphs
ECDC	European Centre for Disease Prevention and Control
GDIPC	General Directorate for Infection Prevention and Control in Healthcare Facilities
HBV	Hepatitis B Virus
HCWs	Healthcare workers
HNH	Hayat National Hospital
IPC	Infection prevention and control
JBI-CAT	Joanna Briggs Institutes Critical Appraisal Tools
JCIA	Joint Commission International
KAMC	King Abdulaziz Medical City
KFSH	King Fahad Specialist Hospital
KSA	Kingdom of Saudi Arabia
LAIs	Laboratory-associated infections
MNG-HA	Ministry of National Guard Health Affairs
MoH	Ministry of Health
NPT	Normalisation Process Theory
OIs	Occupational infections
PEP	Post exposure prophylaxis
PPE	Personal protective equipment
TB	Tuberculosis
UK	United Kingdom
WHO	World Health Organisation

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Chapter 1 Introduction

The first chapter of this thesis introduces the research and presents a comprehensive background of the study. It includes an overview of occupational and laboratory associated infections, a summary of international infection prevention and control guidelines and laboratory health and safety and a description of healthcare system, and infection prevention and control guidelines and laboratory health and safety in the Kingdom of Saudi Arabia (KSA). At the end of this chapter, the rationale of the study and the thesis structure are presented.

1.1 Healthcare systems

A healthcare system is a network of organisations, institutions, specialists, resources, and guidelines that are used to provide healthcare to individuals and communities. It is a linked system that promotes, protects, and improves the population's health and well-being (1). In the past three decades, healthcare systems around the world have become increasingly complex (2). Healthcare systems are comprised of several elements, including government agencies, service delivery, health system financing, healthcare providers, medical research and education, the pharmaceutical and medical device industry, and health information systems (1). There are numerous ways to organise and deliver healthcare to a population, and each country's method is unique and based on its specific circumstances, including its history and traditions, the total amount of money it has to spend, and the importance that it places on different outcomes (3). Some countries have universal healthcare, providing all residents with free access to healthcare services, while others may have either a combination of public and private healthcare services, or a totally private system.

1.2 Occupational infections

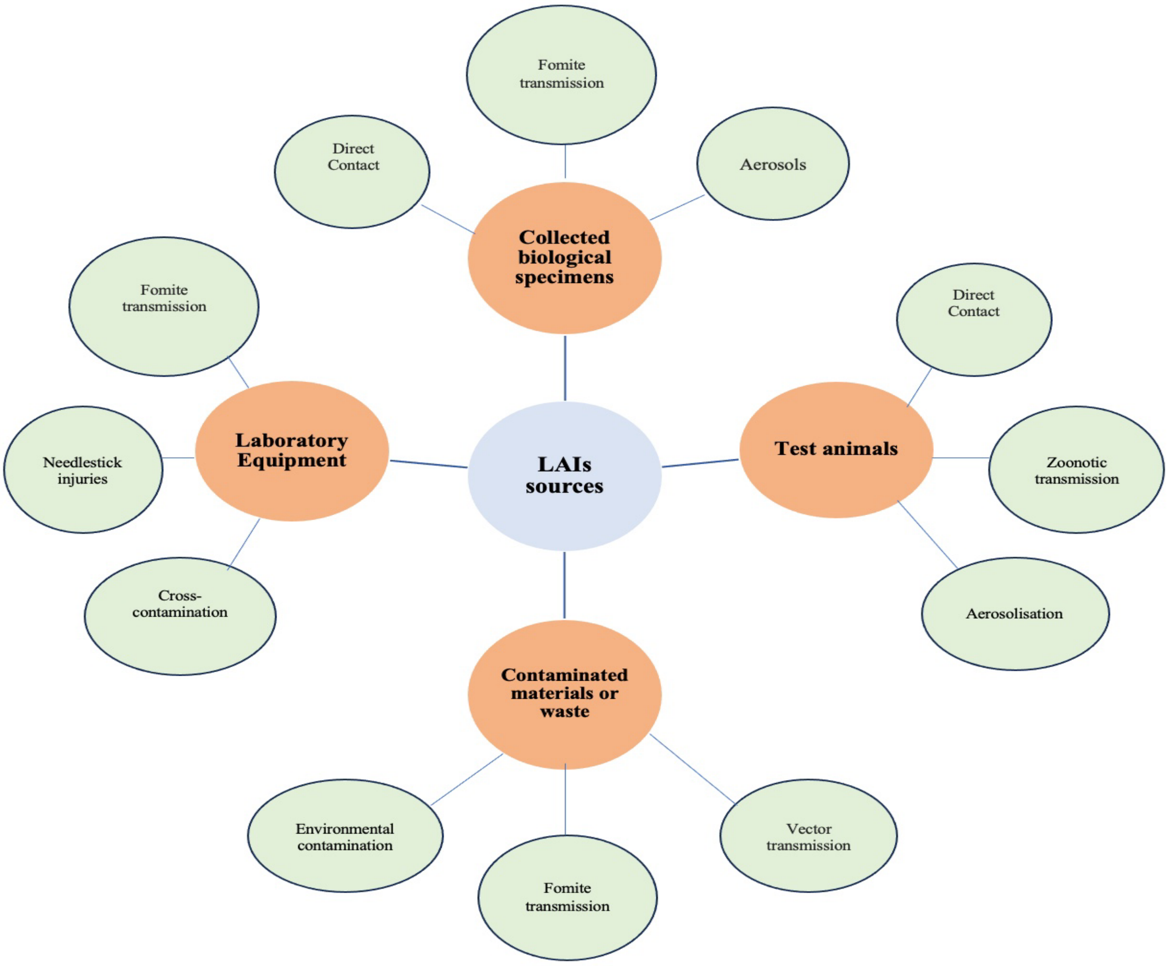
Within healthcare sector, occupational infections (OIs) could be defined as, infections resulted from pathogens transmitted to healthcare worker following exposure in a healthcare setting. Occupational exposure can occur through contact with co-workers, patients (or their clinical samples), visitors, surrounding surfaces, medical devices (such as needlestick injuries), or other healthcare sources (4). According to the World Health Organisation (WHO), *"The most common occupational infections of concern in the health sector are tuberculosis, hepatitis B and C, HIV/AIDS and respiratory infections (coronaviruses, influenza)"* (5). Moreover, it is estimated that 39%, 37% and 4.4% of all hepatitis C infections, hepatitis B infections, and HIV infections, respectively, result from needlestick injuries in laboratories and in the clinical environment (6). As with any infection, OIs can spread to other workers, their families, or their social connections. OIs can be controlled by monitoring the source, the transmission route, and by protecting susceptible people. By implementing appropriate control measures, occupational infections can be prevented in most cases. OIs, particularly those for which vaccinations are available (such as hepatitis B), are more likely to be prevented than other infections (such as hepatitis C). Moreover, preventive programs and health education in the workplace provide an effective method to minimise the risk of OIs (7).

1.2.1 Laboratory associated infections

One type of OIs is laboratory-associated infections (LAIs). LAIs refers to infections acquired by laboratory employees or personnel while working with infectious agents, biological samples, or hazardous materials. When handling specimens that may contain infectious agents, performing diagnostic procedures, or working with infectious organisms, laboratory personnel are at risk from LAIs (8). Laboratory employees are at greater risk of exposure to materials which are likely to contain infectious biological agents, e.g., by culturing them (9).

Infectious agents consist of all pathogenic bacteria, viruses, fungi, prions and parasites that can be transmitted to laboratory personnel through exposure to body fluids, tissues, and secretions, as well as through laboratory procedures and practices (10). The majority of LAIs are caused by bacteria, while parasites are a rare cause (10). Moreover, it has been illustrated that shigellosis, brucellosis, and salmonellosis are the most frequently identified LAIs (11). Figure 1.1 shows the sources of LAIs along with possible infection-causing routes. Several factors and routes play a crucial role in exposure to LAIs, accidental inoculation, and transmission, such as: inhalation (aerosols); percutaneous inoculation (syringe or needle, wounds or abrasions from contaminated products or animal bites); contact of mucous membranes with contaminated material (surfaces or hands); and ingestion (aspiration by pipette, eating or smoking) (12).

Figure 1.1 Sources of LAIs (Green circles represent possible infection-causing routes).



The first reported case of an LAI was typhoid fever in 1885 (reported by Kisskalt (13)), which was quickly followed by reports of brucellosis, tetanus, cholera, diphtheria, and sporotrichosis, all recorded between 1887 and 1904 (14). A study carried out on a global basis in 2016 by Wurtz et al. aimed to estimate the number of LAIs identified in laboratories working with highly infectious agents and identifying the potential underlying causes of these illnesses (15). The study survey discovered that the most commonly infected individuals were laboratory staff (87%), with airborne being the most common method of transmission (87%) in these cases. In addition, the failure to follow safety guidelines and not applying personal protective equipment (PPE) were two of the main causes of LAIs, indicating that 78% of the LAIs recorded in the survey were a consequence of human error. Infections, injuries, and accidents in the laboratory can have various health impacts on the individual, including: mild to severe illnesses such as respiratory, gastrointestinal, skin infections, or more serious illnesses such as hepatitis and tuberculosis (TB); high medical costs due to hospitalisation and medication; and work-related consequences such as reduced productivity and missed workdays. Furthermore, LAIs can have an impact not only on employees, but also co-workers, the institution, the surrounding community (including the workers' family and friends), and the environment (16).

1.3 International infection prevention and control guidelines and laboratory health and safety

Recent significant epidemics such as the Ebola virus, the Middle East respiratory syndrome coronavirus (MERS-CoV), and the 2019 coronavirus (COVID-19) pandemic have illuminated the extent to which healthcare settings can lead to the spread of infections to patients, healthcare workers, and visitors, if infection prevention and control (IPC) is not adequately addressed (10). IPC is a continuous necessity for protecting patients and healthcare workers (HCWs) in healthcare settings against the spread of infectious illnesses (17). According to the World Health Organisation (WHO), *"Infection prevention and control (IPC) is a practical, evidence-based approach preventing patients and health workers from being harmed by avoidable infections"*(18). International variations in healthcare systems, resources, and the prevalence of particular diseases might cause differences in IPC guidelines. IPC guidelines are typically developed by international organisations like the WHO, Centre for Disease Control and Prevention (CDC), and the European Centre for Disease Prevention and Control (ECDC), as well as by national or regional health authorities. These guidelines consist of standardised recommendations and best practices that serve as a comprehensive resource for healthcare professionals, institutions, and policymakers, providing them with guidance on how to effectively prevent and control the transmission of diseases.

1.3.1 Laboratory Health and Safety

The clinical laboratory is a complex environment where numerous diagnostic procedures and processes are carried out, involving many people (e.g., laboratory technicians, laboratory technologists, biomedical scientists, laboratory managers or supervisors, research scientists, clinical scientists and laboratory directors or principal investigators (19)) and set of rules, guidelines and related practices. It should be highlighted that the clinical laboratory context differs from acute care settings, and infection control practices that are effective in inpatient care areas may not provide the same level of effectiveness in laboratories. The risks and hazards in the laboratory can be more varied than in the clinical environment, mostly due to the requirement to manipulate clinical samples to perform diagnostic tests. The people, places, and things—the laboratory environment—all contribute to infection risks and the difficulties in preventing possible exposures (20). Therefore, clinical laboratories are required to follow health and safety regulations to minimise occupational risks.

For managing health and safety, and infection control in the laboratory, employers need to consider a number of key areas including: hazard groups; containment levels and risk assessment.

1. Hazard Groups

Biological agents have been classified by the WHO into four distinct Hazard Groups according to their primary characteristics, mode of disease transmission, and risk to laboratory workers and the community (21). Microorganisms from Hazard Group 1 are biological agents that are unlikely to cause illness in humans, such as *Lactobacillus acidophilus*. Biological agents in Hazard Group 2 can cause disease in humans and represent significant risks to employees, but have a minimal chance of spreading among these workers or to the population such as *Bacteroides spp*. Prophylaxis and effective treatments for these illnesses are available. Biological agents in Hazard Group 3 cause major disease or danger in humans and employees, with the potential for community spread, but effective treatment or prevention are available, such as *Brucella*. Finally, biological agents that cause serious illness in humans and represent significant risks to employees, as well as the possibility of spreading to the community, are included in Hazard Group 4, such as Ebola virus. There is typically no efficient treatment or prophylaxis available for them (21,22). Considering the pathogenic effects on humans and the potential environmental hazards, effective containment measures and procedures should be followed and adhered to in order to reduce all of these risks (23). Additionally, when handling infectious material, appropriate containment facilities and equipment must be used (24).

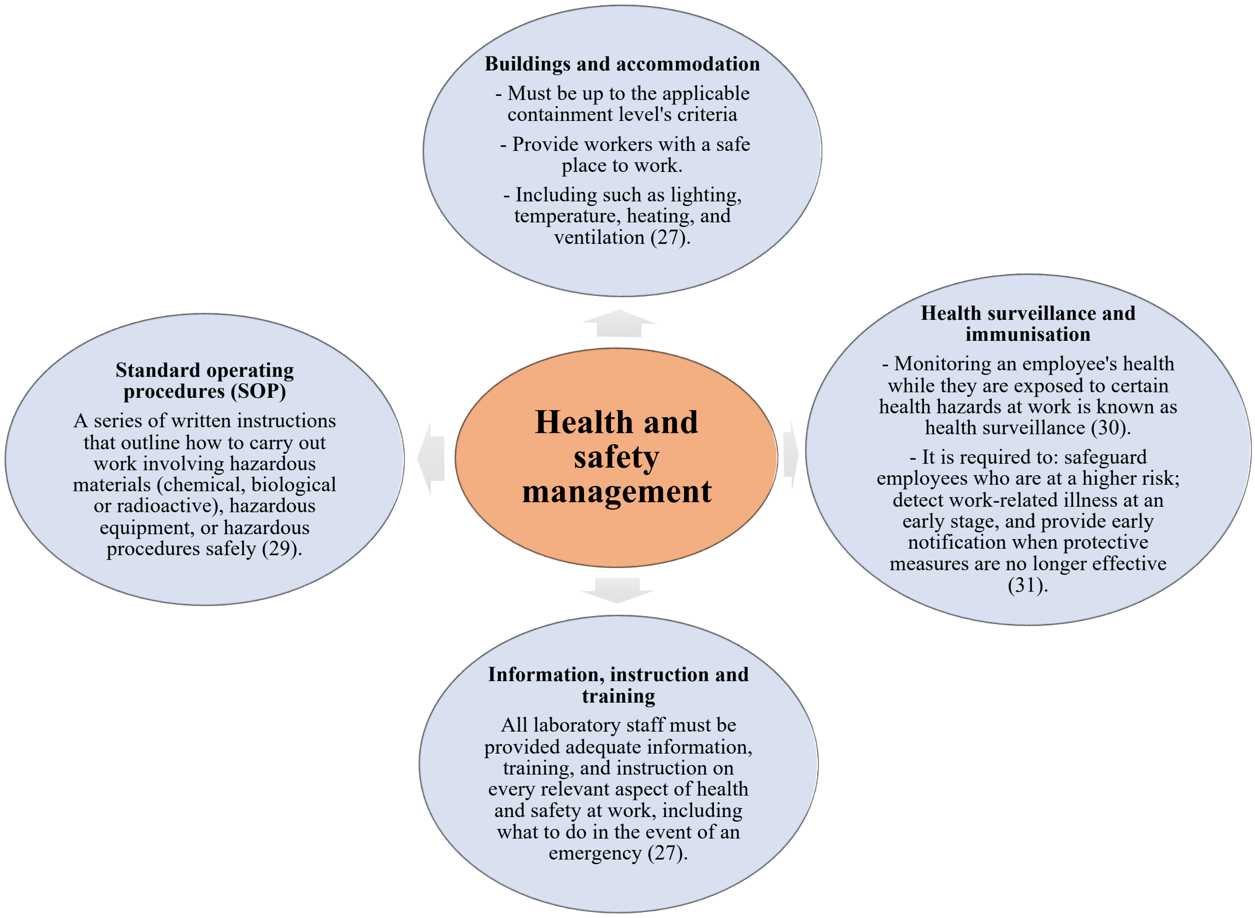
2. Containment Levels

There are four Containment Levels (CL1 to CL4), as described by the CDC. Each level has a unique set of controls for limiting microbes and biological agents. The main risks that determine Containment Levels are infectivity, illness severity, transmissibility, and the type of work being performed. The origin of the microorganism or agent in question, as well as the route of exposure, are essential considerations. Each Containment Level has its own set of containment controls that are required for laboratory procedures, safety equipment, and facility design. CL1 to CL4 are the Containment Levels, with each level building on the regulations of the previous one. Regardless of Containment Level, every microbiology laboratory adheres to standard microbiological practices (25,26).

3. Risk Assessment

The process of risk assessment comprices thoroughly examining the work to determine what biological agents could be present, identifying the main risks, and determining the safety measures required to eliminate or control those risks (27). The process of risk assessment answered the questions *''What can go wrong?', 'How bad are the consequences?', 'How often might it happen?', 'Who might be harmed?' and 'Is there a need for action?'* (28). Two stages are involved in the risk assessment process. Firstly, identify the hazards and then identify who might be harmed and how. Secondly, evaluate the risk itself (the consequence of the hazard being realised) and determine the risk level. The risk level is determined by the risk (consequence) and the probability of that risk occurring. In every case, the goal is to minimise the risk of harm to laboratory workers (28). Figure 1.2 presents the remaining key areas for managing health and safety in the laboratory.

Figure 1.2 key areas for management of health and safety in the laboratory (Sources:* (27) (29)*,* (30)*, and* (31)*).



Examples of key elements covered by the health and safety in the laboratory include: standard precautions; hand hygiene; personal protective equipment (PPE) and environmental cleaning and disinfection.

1. Standard Precautions

Standard precautions encompass a set of infection control measures that are universally applicable to all samples' types, regardless of their suspected or confirmed infectious state, in any healthcare setting (32). These include hand hygiene, gloves, laboratory coats, masks, eye protection. Standard precautions should be considered when coming into contact with blood, bodily fluids, secretions, and excretions (except perspiration), irrespective of their content, as well as nonintact skin and mucous membranes (33).

2. Hand Hygiene

Hand hygiene is a method of washing hands that effectively decreases the presence of possible pathogens on the hands. For successful maintenance of hand hygiene, it should be performed at the appropriate time, utilising the correct product, employing the appropriate method, and ensuring ease of performance (34). Hand hygiene in the laboratory should be undertaken after being exposed to blood or bodily fluids (34). It should also be undertaken when leaving the laboratory (35).

3. Personal Protective Equipment

The use of PPE is imperative in instances where risk assessment has determined that it is necessary, as it helps minimise the potential transmission of infections and other hazards associated with performing laboratory tasks. PPE is the final component within the hierarchy of controls, applied only when all alternative control measures are deemed inadequate in reducing the risk of infection (36). Examples of PPE covered by the health and safety in the laboratory includes gloves, face shields, medical masks, respirators for certain processes (e.g., N95 or FFP2 standard or similar), goggles, and gowns (36). Failure to timely remove PPE can result in the transmission of infections among individuals. Additionally, the use of unnecessary PPE negatively affects worker comfort, increases costs, and contributes to adverse environmental consequences. Therefore, the use of PPE must be based on an in-depth assessment of potential risks (34).

4. Environmental Cleaning and Disinfection

According to the CDC, it is generally known that environmental contamination contributes to the spread of infections in healthcare settings (37). Environmental cleaning is thus a crucial IPC guideline. It is part of standard precautions that should be used at all healthcare facilities (37). Within the laboratory, disinfection, decontamination and sterilisation of services and materials are essential to maintain a clean environment.

It is essential to acknowledge that these guidelines are regularly updated in accordance with the most recent scientific findings and information, newly developing infectious illnesses, and evolving healthcare practices. Therefore, it is recommended that healthcare practitioners, administrators, and policymakers consult the relevant international organisations' sources in order to obtain the most up-to-date versions of the recommendations and successfully apply them within their specific settings.

1.4 Implementation of health and safety guidelines

Implementation refers to the process of transforming evidence and ideas into practical policies and practices that benefit people in everyday situations. It involves putting a plan into action—both the 'how' and the 'what' (38). In a healthcare system, efficient implementation of health policies and legislation is crucial to their success. Policies or pieces of legislation can fail even when they are of high quality if they are not implemented effectively, resulting in unintended health consequences and ineffective public resource usage (39).

Given the risks of laboratory acquired infection, successful implementation of health and safety policies is crucial. Healthcare organisations should ensure that policies are incorporated into all of their systems and services, as well as evaluate how practices are being implemented to align staff behaviours with prevention goals and activities (20). Several steps should be taken to successfully implement the health and safety policies in the laboratory setting, including: the development and approval of policies; ensuring a trained and competent health and safety team lead the program of work; education and training of staff; initiation of protocols and procedures; obtaining essential supplies and equipment; and the development of communication strategies among staff (40). In addition to the previous steps, it is essential to monitor compliance with guidelines and recommendations. External (from outside the healthcare facility) in addition to internal (from inside the healthcare facility) monitoring or assessment plays an important role in improving staff performance and in achieving successful implementation.

Reflecting the fact that the implementation of health and safety guidelines is a complex process, several barriers may hinder its progress (41). According to Akagbo et al. (2017), a variety of barriers prevent HCWs (including laboratory staff) from adhering to guidelines, including:

unavailability of PPE; practice of guidelines is time consuming; and the available equipment is ineffective (42). Similarly, a systematic review conducted by Alhumaid et al. (2021), to assess the potential factors that may influence compliance with safety guidelines among all healthcare workers, reported that knowledge, education and training, and experience were the most important factors that influence compliance and adherence to guidelines (43). Moreover, within the laboratory setting, unacceptable behaviours may appear which may also affect the implementation process. For example, a lack of effective heating and cooling in the laboratory can cause secondary responses that overcome established infection prevention methods, such as laboratory coats being removed, sleeves rolling up on overgarments, or avoiding wearing gloves in uncomfortably warm work settings. Moreover, if PPE is incorrectly sized, employees may fail to use it or modify it inappropriately to make it more comfortable or convenient to wear (20). Generally, implementation research suggests that maintainable implementation requires professionals to understand and realise what they need to do, be capable of doing it, and find it meaningful within their institutional and professional contexts (44).

The guidelines are designed to be appropriate for application and implementation throughout all departments in healthcare settings. In some countries, such as the United Kingdom and Australia, IPC guidelines relate more to clinical work and the prevention of infection transmission on wards only, and the IPC team consists of specialist nursing and medical staff (45). In clinical laboratories and other facilities where people may be exposed to biological agents, health and safety guidance is applied (27,46). Therefore, the terminology 'IPC guidelines' is rarely used within clinical laboratory settings, where 'Health and Safety' is the preferred terminology. However, in other countries, such as the Kingdom of Saudi Arabia (KSA), the United Arab Emirates (UAE), Qatar, and Nigeria, the IPC guidelines are applied to clinical laboratories in addition to the wards, hospitals and other healthcare settings, and the laboratory staff can be part of the IPC team as well (47–49). The issue of different use of safety guidelines terminologies across countries could correspond to certain priorities or objectives within the frameworks for occupational safety and healthcare in each country. In addition, it may be a reflection of variances in national regulatory frameworks and standards managing laboratory safety procedures. Clear communication, education, and training programs are necessary for addressing terminology gaps and provide a common understanding of safety concepts and practices internationally. As the term 'health and safety' is not used in the KSA, it will not be used in the rest of the thesis and will instead be replaced by the term 'IPC guidelines'.

1.5 The healthcare system of the Kingdom of Saudi Arabia

The KSA's government places a high priority on healthcare, and the quality and quantity of healthcare have both improved greatly in recent decades (50). According to Gallagher (2002), *"Although many nations have seen sizable growth in their healthcare systems, probably no other nation (other than Saudi Arabia) of large geographic expanse and population has, in comparable time, achieved so much on a broad national scale, with a relatively high level of care made available to virtually all segments of the population"* (50, p.182). The health system in the KSA was ranked 25th in the world by the WHO, ahead of many developed countries such as Canada (30^{th}), Australia (32^{nd}), and the United States of America (USA) (37^{th}) (52).

The KSA's healthcare system is distributed into three categories: primary, secondary, and tertiary. The primary healthcare system provides free and basic healthcare for all citizens. The Ministry of Health (MoH) is responsible for providing government health services and currently provides 26.0% of the country's total healthcare services. As shown in Figure 1.3, The KSA is divided into 17 health regions, each supervised by a regional director of the MoH (53,54). In addition to the MoH, a number of other government agencies provide healthcare services for the general public, as well as their employees and dependents. These agencies involve the security forces (such as the Ministry of National Guard Health Affairs (MNG-HA), the army, and the security forces), Johns Hopkins Aramco Healthcare, the Royal Commission for Jubail and Yanbu Health Services, and school health units run by the Ministry of Education and the Red Crescent Society (52). In total, these agencies manage 39 government-owned hospitals with 10,822 beds (55).

Figure 1.3 Map of Health Regions in the KSA (2014) (Source (54)*)*

Hospitals in the Saudi healthcare system are owned and operated by both the public and private sectors (52). Healthcare is provided by the public sector at all levels, primary, secondary and tertiary, as well as in emergencies and high-risk situations. Additionally, there are many private healthcare services in the country, including 125 hospitals with 11,833 beds and 2218 clinics and dispensaries, most of which are located in major cities and towns (52). Furthermore, there are several private and public facilities that offer specialised treatment, including the King Faisal Specialist Hospital, higher education hospitals, and research centres (50). The government hospital network is often designed to complement rather than compete, with some hospitals focusing primarily on cancer and on paediatrics and maternity services. Government contractors, such as Aramco employees and their families, are also offered free treatment (56). As public sector healthcare is provided free to all Saudi citizens at the point of delivery, it is incomparable to the general hospital healthcare offered by private hospitals (52). Differences in healthcare offered between both sectors in terms of accessibility, quality and other factors may exist. It should be highlighted that, earlier this year, Saudi Arabia opened the world's largest virtual hospital, Seha Virtual Hospital. With its expanding network of medical facilities, services, and staff, the hospital can accommodate more than 400 patients as it enables the delivery of healthcare services remotely, without the need for physical visits, and it was designed for simultaneous handling of a large number of patients. Digital health users in Saudi Arabia are estimated to exceed 21 million in 2023, according to Statista Digital Market Insights (57).

Within the KSA, there are government-owned clinical laboratories which are generally a part of a hospital or medical center, providing a wide range of laboratory services and procedures used for patients' diagnosis and treatment. There are also many private laboratories in the country which are a part of a privately-owned healthcare institution, such as Al Borg Medical Laboratories, AL-AZZAZ Company Limited, and Delta Medical Laboratories (58). For processing samples, each laboratory consists of the following sections: clinical chemistry, clinical microbiology, hematology, blood banking and serology, histopathology and cytopathology, and molecular biology, all operated by a diverse team of highly trained specialists including laboratory manager, laboratory specialists, laboratory technicians, pathologists, and support staff. It should be highlighted that, at KSA' hospitals, laboratory staff in some institutions have the ability also to work as phlebotomists in emergency situations and the laboratory is responsible for most of phlebotomy procedures (48), in contrast to other countries such as UK in which laboratory staff has no role in this area. To ensure accuracy and reliability of results, hospital laboratories in the KSA use modern technologies and advanced equipment (59). They also employing stringent quality control measures, and some laboratories may seek accreditation from appropriate accreditation bodies to verify compliance with international standards (such as Joint Commission International (JCIA)), and Saudi Central Board for accreditation of Healthcare Institutions (CBAHI)). CBAHI is *"the official agency authorized to grant accreditation certificates to all governmental and private healthcare facilities operating today in Saudi Arabia"* (60). It has been established to assess whether healthcare facilities are in compliance with healthcare quality and safety standards (60). Some hospital laboratories in the KSA engage in research and provide training and educational programs for laboratory students and staff, maintaining scientific and professional development.

1.5.1 Current challenges and considerations in the KSA's healthcare system

Although the Saudi healthcare system has improved significantly, the countries MoH still faces many challenges such as funding of healthcare services, and lack of trained professionals to deal with infection control, and Hajj pilgrimage, which present a major challenge to KSA infection control and require new strategies and policies in partnership with other sectors (50). Recently, the KSA has experienced a variety of nosocomial and community infectious disease outbreaks. This includes MERS (Middle East Respiratory Syndrome), which is caused by beta coronavirus strain named 'MERS-CoV' and is associated with a high mortality rate (61); the pandemic influenza A virus (H1N1) (62); the highly pathogenic avian influenza (H5N1) (63); Rift Valley Fever (64) and Severe Acute Respiratory Syndrome Coronavirus 2 (65).

LAIs have been shown to be an issue in the KSA. A study in the KSA by Memish and Mah (2001) between 1991 to 2000 found that seven hospital employees had brucellosis, six of whom worked in laboratories. Their diagnosis was confirmed by either a high serologic titer (≥1:320) or a positive blood culture. The infections were acquired from laboratory processing of *Brucella* cultures although all six employees followed safety precautions including gloves, biosafety hood, gown, and surgical mask while handling suspected Brucella-positive specimens (66). Examples of the reasons behind acquiring the infection were misidentification of a Brucella-positive culture plate by another employee, thus, the biosafety cabinet was not used for handling the specimen, and airborne transmission during thawing frozen Brucella specimens in a biosafety cabinet, as reported by the authors. It is also known that TB is an occupational hazard among laboratory staff in the KSA. According to Hassan and Diab (2014), laboratory staff are more likely than other HCWs to have latent TB infections (67). Thus, there is a need to adhere rigorously to IPC guidelines while processing respiratory samples (e.g., handling TB samples in a microbiological safety cabinet in containment level 3) in order to minimise the risk of exposure to biological agents in clinical samples.

1.5.2 Infection prevention and control guidelines in the KSA

In the KSA, all healthcare facilities and institutions have infection control quality assurance departments that implement an IPC programme and guidelines under the supervision of the General Directorate for Infection Prevention and Control in Healthcare Facilities (GDIPC) (48). The IPC program is developing discipline. Assiri et al. (2014) conducted a study that aimed to describe and evaluate the status of IPC program at MoH healthcare facilities in the KSA. This study examined the status of several core components of IPC programs that are considered essential for building capacity to prevent infections. These core components include efficiently run services, effective hospital-based infrastructure, and professional communication in nationwide arenas. The study's authors reported that *"the infrastructure for infection control programmes in Saudi Arabian hospitals remains underdeveloped"* and that *"there were defects in the identified components of effective infection control programmes"*(54, p.490).

Several studies have indicated that the KSA faces numerous challenges, limitations, and barriers to implementing an effective IPC programme, a situation which increases the number of health issues (55,64). The KSA's hospitals lack the trained specialists to deal with infection control across all healthcare facility departments, and awareness initiatives are needed to address this problem. The KSA has a relatively underdeveloped infrastructure for infection control programs (55). There is also a relatively high level of uncertainty amongst HCWs regarding infection prevention-related issues such as hospital-specific issues (e.g., lack of training programs and shortage of staff), standards for reporting and surveillance standards, willingness and competence to implement IPC policies (64). Therefore, healthcare facilities in the country should evaluate the need for infection control and implement an active infection control program to reduce infection risks and ensure patients and HCWs' safety.

1.5.2.1 The Infection Prevention and Control Department in the KSA's Ministry of Health

The Saudi MoH established its own infection prevention and control programme drawing upon international recommendations from organisations such as the WHO, the CDC, and international and regional collaborations with other countries in the Gulf Cooperation Council (GCC) (68). At the national level, a number of disease control and prevention centres have been established by the KSA's MoH. The Command-and-Control Centre (CCC), for example, was created with the objective of enhancing infection prevention as well as tracking infections both in the KSA and worldwide (52). In addition, the MoH facilitates the development of infection control services at all hospitals it supervised, as well as providing field and in-house training to HCWs on infection control. To keep up with the latest scientific evidence and emerging infectious disease threats, IPC guidelines are regularly updated by the MoH. Some of the main objectives of MoH to align with the country's vision of 2030 are establishing a new, cost-effective, and highly efficient model for IPC programs, increasing the capacity and improving the quality of healthcare education by collaborating with the Ministry of Education and enhancing the quantity and quality of healthcare professionals in all departments via increasing their training (48,69).

Management of IPC guidelines in the KSA laboratories is the responsibility of MoH in addition to the GDIPC by establishing guidelines applicable to laboratory settings. Moreover, the IPC department within each local hospital in KSA is dedicated to monitor and manage IPC activities and establish a culture of safety within the organisation (including the laboratory).

1.5.2.2 The Infection Prevention and Control Department in the Ministry of National Guard - Health Affairs

Based on Joint Commission International (JCI) standards for USA, CDC recommendations, and KSA's MoH guidelines, MNG-HA developed and maintains a comprehensive Infection Prevention and Control Programme (70). The IPC Programme provides guidelines and instructions to train and instruct soldiers and HCWs on how to prevent and control healthcare and work-related infections, as well as create a healthy, safe, supportive, and cost-effective workplace (71). The IPC guidelines are modified to emphasise the potential infectious nature of all bodily substances. In the Western Region, Jeddah, the Infection Prevention and Control Department manages and supervises all services provided by MNG-HA facilities. It consists of three main units (hospital infection control, public health, environment and occupational health and safety). In each of these areas, specific services are provided to the King Abdulaziz Medical City (KAMC), linked clinics, and communities within the Saudi Arabian National Guard-Western Region (71).

1.6 Rationale of the study

The IPC guidelines are crucial for preventing and controlling infections in healthcare facilities, and infections such as occupational infections can increase morbidity, mortality, and healthcare costs. Thus, in order to improve overall healthcare quality and protect patient and HCWs, it is essential to understand the extent to which IPC guidelines are implemented and followed.

Moreover, appropriate education of HCWs is important for the successful implementation of IPC guidelines in the healthcare setting. A good place to start is by assessing workers' knowledge of the guidelines. Although in any healthcare setting, it is important to assess compliance with infection control guidelines among laboratory staff, and according to Kelman *"knowledge is essential to change practice and a positive attitude is a key instigator to bring change"* (67, p.2). However, no such studies that comprehensively assess the knowledge, attitudes, practices, and implementation of IPC guidelines have been conducted in the KSA.

In addition, to the best of the researcher's knowledge, no study has assessed the professional and organisational differences in implementation, knowledge, attitudes, and practices of IPC guidelines among laboratory staff in KSA. Therefore, such scientific data is important to determine the defect and the reasons behind the variations (if available) and allow for the identification of best practices, potential disparities, and opportunities for improvement to inform policy and practice.

1.7 Thesis structure

A total of 8 chapters comprise the thesis, including this introductory chapter (Chapter 1).

Chapter 2 presents a mixed-methods systematic review of knowledge, attitudes, and practices of infection prevention and control guidelines among hospital laboratory staff. The evidence is narratively synthesised into a group of themes, including knowledge of IPC guidelines, attitudes to IPC guidelines, practices of IPC guidelines, associations among knowledge, attitudes, and practices, and barriers and facilitators to implementation. The review provides a clear picture regarding compliance with the IPC guidelines among laboratory staff.

Chapter 3 defines the aim and objectives of the study.

Chapter 4 describes the research design, the approach used to achieve the aim and objectives of the study, and the procedures followed.

Chapter 5 presents the results obtained from the analysis of quantitative data of laboratory staff, allied health professionals, and infection control specialists based on a cross-sectional survey to determine knowledge, attitudes, practices, and perception of the implementation of IPC guidelines.

Chapter 6 presents results obtained from the analysis of qualitative data based on in-depth interviews in order to investigate the risk perceptions of LAIs and explore the different views on the implementation process within the hospitals.

Chapter 7 provides an overall discussion, including an analysis of the contributions, strengths and limitations of the thesis, a summary of the main findings (integration of quantitative and qualitative findings), an description of how the results relate to the relevant literature, and an explanation of why they are valid and how they are compatible with previous knowledge of the topic.

Chapter 8 presents overall conclusions with a summary and implications of the main findings and offers recommendations for policymakers and future research.

Chapter 2 Systematic review

This chapter presentes a mixed-methods systematic review of knowledge, attitudes, and practices of infection prevention and control guidelines among laboratory staff, starting with aim, objectives and methodology. A group of themes were identified after synthesising the evidence narratively. Finally, a summary of the current knowledge in addition to the evidence gap and review conclusion is provided. A part of this systematic review was published in the peer reviewed journal, BMC Antimicrobial Resistance & Infection Control (73).

2.1 Aim and objectives

To date, there is a lack of evidence about knowledge, attitudes and practice with respect to IPC guidelines among laboratory staff globally. Moreover, no reviews have been conducted on the assessment of knowledge, attitudes and practices of IPC guidelines. The aim of this systematic review was to identify, critically appraise and synthesise the current state of research evidence related to the implementation and knowledge, attitudes and practice of IPC guidelines among laboratory staff globally.

The principal objectives of the review were to systematically search for published qualitative, quantitative and mixed-methods studies on the implementation and knowledge, attitudes and practice of IPC guidelines, to synthesise and assess the quality of studies included and to evaluate the existing evidence surrounding IPC guidelines. Moreover, this review identified the gaps in the data on implementation, adherence and knowledge, attitudes and practices of IPC guidelines among laboratory staff around the world with the aim of identifying priorities for future research.

2.2 Methodology

2.2.1 Search strategy

A protocol for this systematic review was prepared, followed and was registered in PROSPERO (CRD42023188876) (74). This systematic review was conducted following the reporting items for systematic reviews and meta-analyses specified by the PRISMA 2020 checklist (75).

A number of electronic databases were searched to locate the relevant studies using a combination of search terms. Databases searched include MEDLINE, EMBASE, Scopus and CINAHL (EBSCO). PubMed and grey literature including Google scholar and other organisational websites such as those of the WHO and CDC, were also searched using the same search terms. In addition, reference lists and citations of relevant documents identified from databases were searched to locate relevant studies. No time limit was applied to the search because the aim of this review was to identify all existing articles. The last search of articles for the paper was done in November 2021. Subsequently, an update of the review for this thesis was made and the last search of articles was done in November 2023.

The search was performed using medical headings that cover the topic of interest, which were then combined using the Boolean operator terms. The search strategy used in MEDLINE was modified for use on other databases searched. The search terms used were: knowledge OR health knowledge OR health perception OR risk perception; AND attitudes OR behavior; AND practice OR practice guidelines; AND adherence OR implementation; AND infection control OR infection prevention OR policy OR guidelines OR universal precautions OR standard precautions OR laboratory safety OR safety guidelines OR biosafety OR occupational safety; AND healthcare personnel OR medical laboratory personnel OR laboratory specialists OR laboratory staff OR laboratories OR hospital. The complete search strategy for each database is presented in Table 2.1 and Table 2.2.

An EndNote library (version X8) was created for this review and used to download the titles and abstracts after searching each database. This allowed clarification and elimination of any duplicated studies within and between databases.

Table 2.1: Search Strategy: Medline and Embase-Ovid

Search term used
1. Knowledge/ or Knowledge.mp. or Health Knowledge, Attitudes, Practice/
2. Health perception.mp.
3. Risk perception.mp.
4. 1 OR 2 OR 3
5. Attitude.mp. or "Attitude of Health Personnel"/ or Attitude/ or Attitude to Healt
6. Behaviour.mp.
7. 5 OR 6
8. Clinical practice/Practice Guideline/ or Practice.mp.
9. 4 AND 7 AND 8
10. Implementation.mp.
11. Adherence.mp
12. 10 OR 11
13. Infection control.mp. or Infection Control/
14. Infection prevention.mp.
15. Universal precautions.mp. or universal precaution/
16. Infection control/ or standard precautions.mp.
17. policy/ or Policy.mp.
18. Laboratory safety/ safety/ or biosafety/ or occupational safety.mp.
19. Safety precautions.mp.
20. 13 OR 14 OR 15 OR 16 OR 17 OR 18 OR 19
21. 12 AND 20
22. 9 AND 21
23. Healthcare personnel.mp.
24. Laboratory personnel.mp.
25. Medical laboratory personnel.mp.
26. Laboratory specialists.mp.
27. 23 OR 24 OR 25 OR 26
28. 22 AND 27
29. Hospital laboratory/Hospital.mp. or Hospitals/

30. Secondary care.mp. or Secondary Care/
31. 29 OR 30
32. 28 AND 31
33. Qualitative research.mp. or Qualitative Research/
34. Mixed methods.mp.
35. 33 OR 34
37. 32 AND 35

Table 2.2: Search Strategy: CINAHL

Search term used
1. Knowledge, attitude and practice
2. Attitudes or perceptions or opinions or thoughts or feelings or beliefs
3. Practice
4. Risk perception or perceived risk
5. Adherence or compliance
6. Implementation
7. 1 OR 2 OR 3 OR 4 OR 5 OR 6
8. Infection control or infection prevention or infection control and prevention
9. Laboratory safety
10. 8 OR 9
11. 7 AND 10
12. Laboratory personnel
13. healthcare professionals
14. 12 OR 13
15. 1 AND 14
16. Hospital or acute setting or inpatient or ward
17. 15 AND 16
18. Qualitative research or qualitative study or qualitative methods or interview
19. Quantitative research or quantitative study or quantitative
20. Mixed methods or 'qualitative' and 'quantitative'
21. 18 OR 19 OR 20
22. 17 AND 21

2.2.2 Screening

The Rayyan Qatar Computing Research Institute (web for systematic reviews) was used to perform the initial title and abstract screening. Then, full texts of the included articles were screened for eligibility by two reviewers independently (HA and Ilaf Mansi). Finally, decisions of inclusion/exclusion were made by the reviewers and reasons for exclusion were recorded; any disagreement between reviewers was solved by discussion of each included and excluded paper.

2.2.3 Inclusion criteria

Studies eligible for inclusion were qualitative, quantitative, mixed-methods research whose authors discussed risk perception and knowledge, attitudes and practices of IPC guidelines among laboratory staff in any healthcare setting, including tertiary care settings, primary care settings, long-term care, acute hospital settings or community settings. Studies on awareness or compliance with specific infection control guidelines such as hand hygiene and waste disposal, and those that covered occupational injuries such as sharp implement injuries, were also included. Furthermore, studies on laboratory-related infections and safety precautions associated with them and those focusing on different vaccinations required for HCWs were included. Also, studies that covered infection control guidelines and safety measure policies and how they change over time in different countries were included. There were no restrictions on country of study. However, the included studies had to be published in English.

2.2.4 Exclusion criteria

Cohort, case-control and randomised controlled trials were excluded from this review. This was because the identified studies did not address the aim of this review and thus did not display any relevant data. For the same reason, studies on the effectiveness of interventions on the knowledge, attitudes and practices of laboratory staff were excluded. Studies were excluded if they were focused on HCWs, but did not include laboratory staff in the sample as participants, as well as studies solely on nurses and dental workers. Papers in which data for laboratory staff could not be separated from the data gathered on other HCWs were excluded. Studies on students and university laboratories were excluded. Finally, general discussion papers such as letters, editorials and comments, conference abstracts and poster presentations were also excluded.

2.2.5 Data extraction

Data on papers that met the inclusion criteria were extracted by one reviewer (HA), and a standardised data extraction form was developed that included the following headings: author/year, main focus of the study, method, country, sample, outcome measures and the study results.

2.2.6 The quality assessment exercise

Because more than one type of research was included in this review, Joanna Briggs Institutes Critical Appraisal Tools (JBI-CAT) was appropriate to assess the quality of the included papers. JBI-CAT are designed to be used for multiple study designs with the purpose of assessing the quality of a study methodology and to determine the extent to which there is possibility of bias in its design, handling and analysis was addressed in the study (76). Two different checklists of JBI-CAT were employed based on the types of included studies (see Appendices A & B).

2.2.7 Data synthesis and analysis

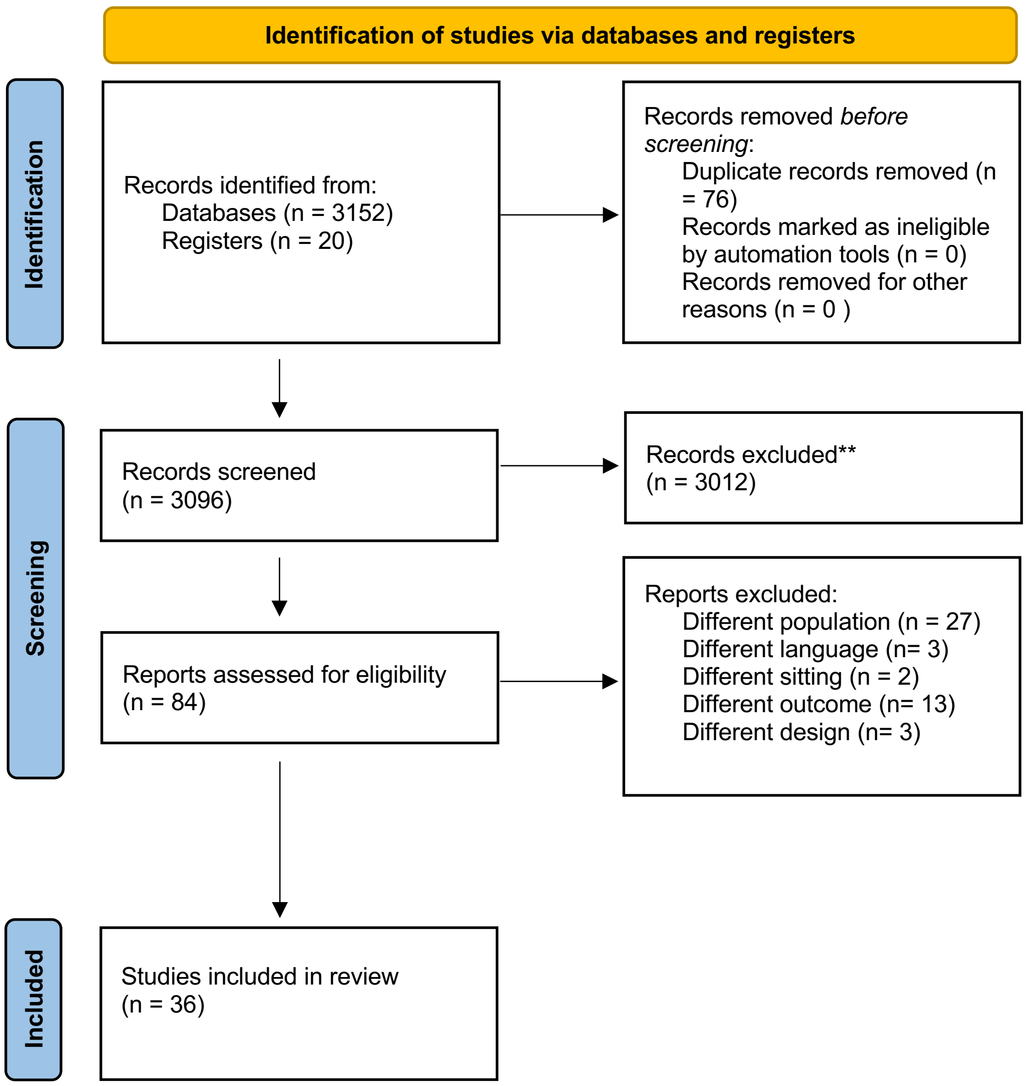
Full text review of the included papers was carried out by HA. Afterwards, the information corresponding to the aim and objective of this review was identified, using the authors' interpretations and textual quotes (from qualitative studies). Finally, categories and related themes whose origin was the main topic of the study emerged and are shown in the results section.

Owing to the nature of the data in this mixed-methods review, along with the limited availability of numerical (quantitative) data for applying a meta-analysis approach, a narrative synthesis approach was followed. A narrative synthesis approach has been defined as an "*approach to the systematic review and synthesis of findings from multiple studies that rely primarily on the use of words and text to summarise and explain the findings of the synthesis*" (72, p.5). This approach can be utilised in qualitative, quantitative and mixed-methods studies alike and assists integration of both qualitative and quantitative data to achieve the aim of the review.

2.3 Results

The review identified 3152 articles through the systematic literature search. After removal of duplicates and title and abstract screening, 3012 articles were excluded, leaving a total of 84. After full-text screening, a total of 36 articles remained and were included in the final review. The PRISMA 2020 flow diagram was used as a template for reporting study inclusion (see Figure 2.1).

Figure 2.1: Flow chart of included and excluded studies



2.3.1 Location

Seven of the 36 studies were conducted in Nigeria (49); (78); (79); (80); (81); (82); (83); four in Ethiopia (84); (85); (86); (87); three in Pakistan (88); (89);(90); five in the KSA (91); (92); (64); (93); (94); two in India (95); (96); two in the USA (97); (98); and one each in the UK (99), Ghana (42), Mongolia (100), Yemen (101), Tanzania (102), Afghanistan (103), Lebanon (104), China (105), Cameron (106), Canada (107), Kenya (108), Russia (109), and Bangladesh (110).

2.3.2 Study design

Thirty-three of the articles reported research of a cross-sectional design (quantitative studies) (49,78,80–83,111); (42,64,85–99); (101–108);(110); three were qualitative studies (100); (84); (109).

Detailed characteristics of the included studies are presented in Table 2.3.

Table 2.3: Detailed characteristics of the included studies

Author/ Year	Main focus	Method	Country	Sample	Outcome measures	Results
(101) Al-Abhar, 2017	Knowledge and practice of biosafety among laboratory staff working in clinical laboratories	Cross-sectional study	Yemen	362 participants	Knowledge level and practice of laboratory standard precautions	Of the private and public laboratory staff, 67% and 32% had received training on biosafety (P < 0.001), respectively. Overall, only 38% of respondents had good knowledge of LSP, 49% had fair knowledge, and 13% had poor knowledge. Only 32% of respondents had good practice of LSP, 59% had fair practice level, and 9% had poor practice
(110) Ahammed et al., 2023	Evaluation of biosafety assessment among laboratory staff in selected hospitals and diagnostic centers at Jashore District	Cross-sectional study	Bangladesh	192 laboratory staff	Assess the knowledge, attitude and practice of laboratory staff on bio-safety in selected healthcare institutions in Jashore district Bangladesh	About 155(80.7%) of participants aware about universal work precaution. Only 112(58.3%) sometimes eat in the laboratory. 145 (75.5%) never washed hands before putting gloves and 70(36.5%) always used PPE. Among the participants, 104 (54.2%) received formal safety training

(42) Akagbo, 2017	Knowledge of standard precautions and barriers to compliance among healthcare workers	Cross-sectional study	Ghana	100 participants (5 laboratory technicians)	Knowledge, compliance and barriers to compliance with standard precautions	Knowledge of SP was low; only 37.0% of HCWs knew that SP includes hand washing before and after any direct contact with the patient. 50% of respondents always protect themselves from blood and body fluids injections. About a quarter of the respondents do not recap needles after use. 48% of HCWs had regular training in SP HCWs were thought that wearing PPEs—such as gloves, aprons, gowns and goggles—might cause patients to panic sometimes (63.0%) and complying with SP sometimes interferes with the ability to provide care (38.0%). Due to the demands of patient care, HCWs do not have enough time to comply with the rigours of SP (44.0%) and sometimes PPEs are not available
(91) Alam, 2002	Knowledge, attitude and practices among HCWs on needle-stick injuries	Cross-sectional study	KSA	70 participants (10 laboratory staff)	Demographic data, job category, HBsAg, anti HCV and HIV status of the healthcare worker. The knowledge and use of preventive measures regarding needle-stick injuries	74% had a history of needle -stick injuries and only 21% reported the injuries to the hospital authority. Only 66% were aware of Universal Precaution Guidelines. 60% had been vaccinated against hepatitis B, while 40% were not vaccinated against hepatitis B
(84) Alemie, 2012	Exploration of healthcare workers' perceptions on occupational risk of HIV transmission	Qualitative study	Ethiopia	7 participants (1 laboratory staff)	The risks related to their work, their experience of HIV related hazards and their general views on the transmission of HIV	All the respondents were aware of the risk of acquiring HIV in healthcare settings. Some had experienced accidents that made them take post-exposure prophylaxis. They also expressed their feelings that their workplace was not the best place to work at

(82) Bello et al., 2016	Health workers' knowledge, attitude and practice towards hepatitis B infection	Cross-sectional study	Nigeria	108 participants (13 laboratory technicians)	The relationship between knowledge, attitude and practice among health workers towards hepatitis B infection	There is a gap in knowledge and lack of compliance to infection control and preventive measures among healthcare professionals
(98) Benzekri et al., 2010	Laboratory worker knowledge, attitudes and practices towards smallpox vaccine	Cross-sectional study	USA	45 laboratory workers	Adherence to ACIP recommendations, assess potential barriers to vaccination and determine the influence of training on laboratory worker attitudes	Eighty seven percent had received a smallpox vaccination in their lifetime; 73% received vaccination in the past 10 years. The main barrier to vaccination may be fear associated with possible vaccine adverse effects and a willingness to risk accidental infection rather than be vaccinated
(94) Binsaleh et al., 2021	Awareness and practice of COVID-19 precautionary measures among healthcare professionals	Cross-sectional study	KSA	155 laboratory technicians	Knowledge and practice of protective measures by HCWs in Saudi Arabia during the beginning of the COVID-19 pandemic and to identify potential trends and predictors	About 72.3 % of the laboratory technicians participated in the study had high score for wearing protective equipment during the COVID-19 Pandemic

(107) Buxton et al., 2012	Prion disease risk perception	Cross-sectional study	Canada	426 medical laboratory workers.	Knowledge, attitudes and reported behaviours of medical laboratory workers in relation to prion disease to understand their risk perception and the need for national laboratory guidelines on prion infection control	18% believed they were at risk when processing these specimens. Less than one-third of those receiving specimens believed they were adequately trained. The mean (±SD) knowledge score was 9.25±4.5/24; individuals who had received training scored significantly higher than those who were untrained (P<0.01). 81% of respondents would be more comfortable processing specimens if national guidelines existed and were used in their laboratory. There is a high perception of risk and few perceived benefits of processing prion-associated specimens. It is concerning that only one half of respondents who worked in laboratories reported that their protocols include standard precautions
(102) Chalya et al., 2016	Knowledge, practice and factors associated with poor compliance with universal precautions among healthcare workers	Cross-sectional study	Tanzania	200 participants (34 laboratory staff)	The knowledge, practice and factors associated with poor compliance universal precautions among healthcare workers. Independent variables of interest were age, sex, job category, professional qualification, working place, working experience and previous training on universal precaution. The dependent (outcome) variable was compliance with universal precaution	More than three quarters (82%) of participants had adequate knowledge of universal precautions. Out of 200 HCWs, 154 (77.0%) practiced universal precautions. training on universal precautions was significantly associated with good practice of universal precautions (P < 0.001). There was a strong correlation between knowledge and compliance (practice) with universal precautions (r=0.76). Lack of PPE, lack of knowledge and emergency situations accounted for the most frequently mentioned reasons for poor compliance
(99) Davidson and Gillies, 1993	Safe working practices and HIV infection: knowledge, attitudes, perception of risk, and policy in hospital	Cross-sectional study	UK	1530 participants (170 laboratory staff)	Knowledge of safe working practices and hospital guidelines; attitudes towards patients with AIDS; perception of risk of occupational transmission of HIV; availability of guidelines	All staff knew of the potential risk of infection from needlestick injury (98%, 904/922). In all, 32% of staff (303/958) indicated that they thought they were at some risk of HIV infection in their occupational setting, only 23% of doctors and laboratory workers and 38% (48/127) of nurses considered themselves to be at risk

(85) Deress et al., 2018	Assessment of knowledge, attitude, and practice about biomedical waste management and associated factors	Cross-sectional study	Ethiopia	296 participants (49 laboratory staff)	Sociodemographic and HCF related factors, knowledge, attitude, and practice	56.8%, 66.2%, and 77.4% had adequate knowledge, favourable attitude, and adequate practice score, respectively. Less than one-third (30.7%) of the study participants were vaccinated for HBV. Regarding previous training, only 109 (36.8%) had taken BMWM training
(87) Desta et al., 2018	Knowledge, practice and associated factors of infection prevention among healthcare workers	Cross-sectional study	Ethiopia	150 participants (13 laboratory technicians)	The dependent variables studied were knowledge and practice of healthcare workers towards infection prevention. Whereas, the independent variables include institutional factors (training about infection prevention, availability of infection prevention supplies)	84.7% of healthcare workers were found to be knowledgeable but only 86 (57.3%) of respondents demonstrated a good practice on infection prevention. Healthcare professionals who have taken Infection prevention training were 35.33%. In-service training, availability of infection prevention supplies and adherence to infection prevention guidelines was also associated with the practice of infection prevention
(80) Fadeyi et al, 2011	Awareness and practice of safety precautions among HCWs in the laboratories	Cross-sectional study	Nigeria	130 participants	Awareness of safety precautions and availability of protective equipment in the laboratory. Practice and attitude related to safe laboratory practice such as use of protective equipment, handling of contaminated items and post-laboratory accidents/injury measures	58.5% of the respondents were aware of Safety Precaution. Participants attest to availability of various safety devices and equipment including hand gloves (86.2%), disinfectants (84.6%), HBV immunisation (46.2%) and post exposure prophylaxis (PEP) for HIV and HBV (79.6%) Attitude to safety is unsatisfactory as 60.0% eat and drink in the laboratory, 50.8% recap needles and 56.9% use sharps box. Even though 83.1% are willing to take PEP, only 1.5% will present self-following laboratory injury

(103) Fayaz et al., 2014	Knowledge and practice of universal precautions among healthcare workers	Cross-sectional study	Afghanistan	300 participants (133 allied medical professionals)	Knowledge and practice of universal precautions	Among the 300 respondents, the mean knowledge score was 5.2 with a standard deviation (SD) of 1.5. On the practice score, the mean was 8.7 (SD =2.2). A total of 90.6% and 70.8% of HCWs believed that UPs were necessary in contact with urine/faces and tears, respectively, although UPs are not necessary in these cases. On the other hand, 57.8% reported that they always recapped the needle after giving an injection, and 31.8% did not always change gloves in between patients. There were no associations between the knowledge and self-reported practice of UPs
(78) Ibeziako and Ibekwe, 2007	Knowledge and practice of universal precaution	Cross-sectional study	Nigeria	246 participants (34 laboratory staff)	Knowledge and practice of infection control policy	124 (50.4%) of the respondents were aware of universal precaution, while 88 (35.8%) knew the correct definition of universal precaution. 34 (13.8%) had received training on universal precaution. Hands gloves were used by 86.6% of the respondents and 43.9% practiced appropriate hand washing. Training significantly associated with knowledge (P=0.006)
(100) Ider et al., 2012	Perceptions of healthcare professionals regarding the main challenges and barriers to effective hospital infection control	Qualitative study	Mongolia	87 participants (35 infection control professionals and 8 other health professionals)	Challenges and barriers to successful implementation of infection control programmes in Mongolia- 1) the formulation; and (2) the implementation of infection control policy	Poor IC education of health professionals; limited laboratory capacity; inappropriate use of antibiotics; low compliance with hand hygiene; poor disinfection and sterilization; and poor implementation of occupational health programmes

(81) Isara and Ofili, 2012	Prevalence of occupational accidents/injuries among healthcare workers	Descriptive cross-sectional study	Nigeria	167 participants (20 laboratory workers)	Socio-demographic data of the HCWs and their exposures to needle pricks and other occupational accidents	10 (50.0%) laboratory workers had had needle pricks, only 43 (25.7%) of respondents reported to the staff clinic after sustaining accidents/injuries
(49) Izegbu et al., 2006	Attitudes, perception and practice of workers in laboratories in the two colleges of medicine and their teaching hospitals as regards universal precaution measures	Cross-sectional study	Nigeria	154 participants Medical laboratory scientist	Eating in the laboratory, storage of food and water in the refrigerator meant for body fluids, drugs chemicals or other specimens, application of cosmetics, smoking or sniffing, cutting of fingernails with teeth or putting the biro in the mouth, wearing of hand gloves, putting on of laboratory coats, immunization against hepatitis B virus (HBV), washing of hands after removal of hand gloves and wearing of gloves	All the participants wear gloves during laboratory work. 20.8% of the participants had heard of measures. 45.6% of the participants eat in the laboratory, 47.0% of them store foods and water in the refrigerators meant for storage of body fluids and chemicals, 31.5% of them put on cosmetics in the laboratory, 91.5% are not immunized against HBV. 82.0% of the participants do not feel that the use of masks is necessary in laboratory 53.23% (n=82) of the participants had had cuts or punctures from needles, surgical blades, sharp device
(105) Jin et al., 2020	Perceived infection transmission routes, infection control practices, psychosocial changes, and management of COVID-19 infected healthcare workers	Cross-sectional study	China	7 medical technicians	Perceived causes of infection, infection prevention, control knowledge and behaviour, psychological changes, symptoms and treatment were measured	41.8% thought their infection was related to protective equipment, utilization of common equipment (masks and gloves). The main perceived mode of transmission was not maintaining protection when working at a close distance and having intimate contact with infected cases

(104) Kahhaleh and Jurjus, 2005	Adherence to universal precautions among laboratory personnel	Cross-sectional study	Lebanon	290 participants	Variables included the knowledge, attitudes and practices of laboratory technicians concerning blood-borne pathogens (e.g., HIV, HBV and HCV) and adherence to universal safety precautions in relation to experience, formal training and workplace setting among technicians dealing with blood and body-fluids, as well as laboratory directors	. Almost all the technicians knew that while working they should take protective measures by wearing laboratory gowns or gloves and that they should dispose of used needles and syringes in special containers. 45 (20.3%) had training on how to perform HIV testing. It was, however, observed that the technicians actually wore gloves in only 27 laboratories and laboratory coats in only 63
(93) Khabour, 2018	Assessment of biosafety measures in clinical laboratories	Cross-sectional study	KSA	208 medical laboratory staff	Attitude, knowledge, and practices of medical laboratory staff	About 89% of the sample had very good to excellent awareness about infection routes. The majority (> 80%) followed guidelines for disposing medical wastes, decontamination of sample spills, and use of protective laboratory coats, gloves, etc. However, among participants, 24.2% used to eat, drink or use gum, 18.3% used cosmetics and 24.6% used the mobile phone in the laboratory. About 18.4% reported that they continued working with a finger cut
(92) Khan et al., 2014	Knowledge and attitude of healthcare workers about middle east respiratory syndrome	Cross-sectional study	KSA	153 participants (24 laboratory staff)	Demographic information of the respondents. The source of respondents' MERS knowledge. The knowledge of healthcare workers regarding MERS. The attitude of respondents towards MERS	The correlation between knowledge and attitude was significant (correlation coefficient: 0.12; P <0.001. Although the majority of respondents showed positive attitude towards the use of protective measures (1.52 ± 0.84), their attitude was negative towards their active participation in infection control program (2.03 ± 0.97)

(88) Nasim et al., 2010	Practices and awareness regarding biosafety measures among laboratory technicians working in clinical laboratories	Cross-sectional study	Pakistan	253 laboratory technicians	Awareness and biosafety measures taken by hospital-based laboratory technicians during their routine work in clinical laboratories such as unsafe work practices (e.g., eating or drinking in laboratories), mouth pipetting of biological samples, use of PPE, and proper disinfection, specimen handling, collection, and processing	46.2% of the laboratory technicians did not use any kind of PPE, and almost 39.5% of the respondents recapped used syringes regularly. Although mouth pipetting is considered obsolete, 38% of the technicians continue to do so for various purposes. Additionally, accident records were not maintained in 83.4%. No formal biosafety training had been provided to 85% of the respondents
(89) Nasim et al., 2012	Biosafety perspective of clinical laboratory workers	Cross-sectional study	Pakistan	1,782 laboratory technicians	The awareness of biosafety measures and the practices performed by laboratory technicians during their routine laboratory work	28.4% of the laboratory technicians from Punjab, 35.7% from Sindh, 32% from Balochist and 38.4% from Khyber Pakhtoon Khawa (KPK) did not use any PPE. Furthermore, 30.7% of the respondents said they discard used syringes directly into municipal dustbins. The majority (66.7%) claimed there are no separate bins for sharps, so they throw these in municipal dustbins. Accident records were not maintained in 83.4%. No formal biosafety training had been provided to 84.2% of the respondents

(83) Ndu and Arinze-Onyia, 2017	Standard precaution knowledge and adherence: Do doctors differ from medical laboratory scientists	Ccross-sectional study	Nigeria	143 doctors and 136 medical laboratory staff	Demographical variables, knowledge and adherence to standard precautions and associated factors	General knowledge of SP was high,76.2% in doctors and 67.6% in MLSs. Use of personal protective equipment as well as safe handling of contaminated equipment or surfaces was higher amongst doctors. Even though more than half of respondents in both groups, 53.1 % among doctors and 58.1% among MLSs had received training on standard precautions, this did not reflect in the practice. MLS reported more use PPE (100% in MLS and 35% of doctors). Recapping of syringes was higher amongst doctors (63.6%) than MLS (55.1%). Constraints that affected SP included non-availability of PPEs and emergency situations for both groups
(106) Ngwa et al., 2018	Assessment of the knowledge, attitude and practice of healthcare workers in Fako Division on post exposure prophylaxis to blood borne viruses	Cross-sectional study	Cameroon	148 participants (68 laboratory staff)	Knowledge, attitude and practice of healthcare workers on post exposure prophylaxis and also determine the factors influencing reporting of occupational exposures among HCW	A high proportion of participants 58% had poor knowledge on post exposure prophylaxis and 60.6% of participants proved to have a positive attitude towards post exposure prophylaxis. 50.9% (110/216) of all participants had at least one occupational exposure with a low uptake 19.1% (21/110) of post exposure prophylaxis recorded among participants who were exposed

(108) Njagi et al., 2012	Knowledge, attitude and practice of healthcare waste management and associated health risks	Cross-sectional study	Kenya	599 participants at KNH and 261 at MTRH.	Identification of gaps in knowledge, attitude and practice in the management of healthcare waste	Most of them acquired knowledge on waste-management through on-job training from seminars and informally through organized talks at work- places. The hospital attendants had also an opportunity to acquire the knowledge through organized training at workplaces. The training improved the workers' compliance to hepatitis B vaccinations and use of personal protective equipment when handling healthcare waste. handling medical waste
(90) Qazi et al., 2016	Comparison of awareness about precautions for needle stick injuries	Cross-sectional study	Pakistan	198 participants (58 laboratory technicians)	Level of awareness amongst healthcare workers Adopting precautionary measures i.e., using gloves for standard procedures, knowledge of standard method of discarding needles i.e., without recapping, practicing method of discarding needles, awareness of Hep B spread through NSIs, awareness of Hep C spread through NSIs, awareness of HIV spread through NSIs, receiving booster dose and reason of not getting vaccinated	51 % knew that the standard method of discarding needles is without recapping. 80.3 % were still recapping needles. 90.9 % HCWs were vaccinated against Hepatitis B. The prevalence of NSIs was 50 % and out of these, 31.3 % had experienced an NSI while recapping. Only 24.2 % people who experienced an NSI were aware enough to take post exposure prophylaxis, a greater number of which were the laboratory technicians 11 (45.8 %)
(64) Rabaan et al., 2017	Infection prevention and control in healthcare facilities in regards to Middle East Respiratory Syndrome	Cross-sectional study	KSA	607 Participants (233 laboratory staff)	Attitudes to, and awareness of, infection prevention and control policies and guidelines among healthcare workers	Carelessness of healthcare workers was the top-cited factor contributing to causes of outbreaks (65.07% of total group), and hospital infrastructure and design was the top-cited factor contributing to spread of infection in the hospital (54.20%), followed closely by lack and shortage of staff (53.71%) and no infection control training program (51.73%). An electronic surveillance system was considered the most effective by staff (81.22%)

(111) Sadoh et al., 2006	Practice of universal precautions among HCWs	Cross-sectional study	Nigeria	433 participants (93 laboratory staff)	Practice of recapping and disposal of used needles, use of barrier equipment and handwashing	About a third of all respondents always recapped used needles. Compliance with nonrecapping of used needles was highest among trained nurses and worst with doctors. 63.8% always used PPE. A high percentage (94.6%) of participant observed handwashing after handling patients
(86) Sahiledengle et al., 2018	Infection prevention practices and associated factors among healthcare workers	Cross-sectional study	Ethiopia	605 participants (58 laboratory staff)	Awareness on IPC components Presence of hand washing facility. Availability of PPE. Ever had needle stick or sharp injury. Awareness on availability PEP available daily/weekly. Knowledge of HCWs on infection prevention measures. Attitude of HCWs toward infection prevention practices	66.1% healthcare workers had good infection prevention practices. Having good knowledge on infection prevention measures (AOR =1.53), having positive attitude towards infection prevention practices (AOR=2.03)
(97) Thomas et al., 2004	Factors promoting consistent adherence to safe needle precautions among hospital workers	Cross-sectional study	USA	1,454 participants (151 medical laboratory staff)	Consistent adherence, structural support, equipment availability , key leader support and HCW perceptions and attitudes	Positive predictors of consistent adherence included infection control personnel hours per full-time–equivalent, employee frequency of standard precautions education. facilities providing personal protective equipment and management support for safety (OR, 1.05). Negative predictor was increased job demands

(96) Wader et al., 2013	Knowledge, attitude, practice of biosafety precautions amongst laboratory technicians in a teaching hospital	Cross-sectional study	India	19 laboratory technicians	Safety Precaution, Disinfection of working area, Handling of blood and body fluid, Hand washing, Disposal of waste, Handling and transport of specimens, Dealing with sharp injury	According to knowledge, in pathology 50% of study subjects were having average and 50% were having good scores while in biochemistry 25% had average and 75% had good scores and in microbiology 100% of study subjects had good grade. For attitude, in pathology dept 83.3% had average and 16.7% had good grades. In biochemistry 12.5% had poor grades, 75% had average grades and 12.5% had good grades. In microbiology 100% had good grades. For practice in pathology dept 16.7% had poor grades, 66.7% had average grades and 16.7% had good grades. In biochemistry 81.5% had average grade and 12.5% had good grades. In microbiology 100% of study subjects had good scores
(109) Woith et al., 2012	Barriers and facilitators affecting tuberculosis infection control practices of Russian HCWs	Qualitative study	Russia	96 participants (12 laboratory staff)	How TB is transmitted and when a person is infectious; what IC methods were used and when these were used; and what barriers and facilitators existed to use of infection control	Barriers and motivators related to knowledge, attitudes and beliefs, and practices were identified. Three main barriers were a) knowledge deficits, including the belief that TB was transmitted by dust, linens, and eating utensils; b) negative attitudes related to the discomfort of respirators; and c) practices with respect to quality and care of respirators. Education and training, fear of infecting loved ones, and fear of punishment were the main facilitators
(49) Zaveri, 2012	Knowledge, attitude, and practice of universal work precautions amongst medical laboratory technicians	Cross-sectional study	India	154 laboratory technicians.	Attitude and practices of participants were included in the study. Participants were also scored on some items on biohazards and biosafety. Furthermore, participant's knowledge on the subject was sought by inquiring what they would do if they sustained injuries in the laboratory. The Hepatitis B vaccination statuses were also determined	32% of participants were aware of Universal Work Precaution. All the participants wear gloves during laboratory work but 81.2% wear a single pair. 17.5 % of the participants claimed to know what to do if exposed to infection. 45.6% of the participants eat in the laboratory, 47.0% of them store foods and water in the refrigerators, 31.5% of them put on cosmetics in the laboratory, 12.6% smoke in the laboratory, 10.0% cut their fingernails with teeth in the laboratory. 91.5% are not immunized against HBV. 99.0% of them do not take shower immediately after laboratory work. 82.0% of the participants do not feel that the use of masks is necessary in laboratory. 53.23% of the participants had had injury

2.3.3 Assessment of quality

Two authors (HA and IM) contributed independently to appraisal of included studies, and any disagreements were solved by discussion. Scores of either 0 or 1 point were given per criterion. One point was given if the answer was YES (the item was mentioned in the study) and zero if the answer was NO or UNCLEAR (the item was not mentioned or was unclear). All studies (low and high quality) were included in the review, and study quality was used to inform the results and the conclusions made throughout. The quality assessment results are shown in (Tables 2.4) and (Table 2.5). Thirty-two papers (49,78,111); (81–87); (89)(91,92); (42,93–110) were considered to be of a high quality. The remaining four were considered to be of a low quality, mainly owing to lower representativeness of inclusion/exclusion criteria of study participants, outcome measures and dealing with confounding factors.

Table 2.4: Quality assessment results (Cross-sectional studies)

Study	Inclusion criteria	Subjects and settings	Exposure measure	Measurement of the condition	Confounding factors	Dealing with confounding factors	Outcomes measure	Statistical analysis	Total quality scores
(49)	Yes	Yes	Yes	Not applicable	No	Unclear	Yes	Yes	6/8
(78)	Yes	Yes	Yes	Not applicable	No	Yes	Yes	Yes	7/8
(111)	Yes	Yes	Yes	Not applicable	No	Unclear	Yes	Yes	6/8
(80)	Yes	Yes	Unclear	Not applicable	No	Unclear	No	Yes	4/8
(81)	Yes	Yes	Yes	Not applicable	No	Unclear	Yes	Yes	6/8
(82)	Yes	Yes	Yes	Not applicable	No	Yes	Yes	Yes	7/8
(83)	Yes	Yes	Yes	Not applicable	No	No	Yes	Yes	6/8
(85)	Yes	Yes	Yes	Not applicable	No	Yes	Yes	Yes	7/8
(86)	Yes	Yes	Yes	Not applicable	Unclear	Yes	Yes	Yes	7/8
(87)	Yes	Yes	Yes	Not applicable	Yes	Yes	Yes	Yes	8/8
(88)	Unclear	Yes	Unclear	Not applicable	No	No	Yes	Unclear	3/8

(89)	No	Yes	Unclear	Not applicable	No	Yes	Yes	Yes	5/8
(90)	No	Yes	Unclear	Not applicable	No	No	Yes	Yes	4/8
(91)	Yes	Yes	Unclear	Not applicable	No	Unclear	Yes	Yes	5/8
(92)	Yes	Yes	Yes	Not applicable	No	No	Yes	Yes	6/8
(64)	No	Yes	Unclear	Not applicable	No	No	Yes	Yes	4/8
(93)	Yes	Yes	Yes	Not applicable	Unclear	Yes	Yes	Yes	7/8
(94)	Yes	Yes	Yes	Not applicable	No	No	Yes	Yes	5/8
(95)	Yes	Yes	Yes	Not applicable	No	Unclear	Yes	Yes	6/8
(96)	Yes	Yes	Yes	Not applicable	No	No	Yes	Yes	6/8
(97)	Yes	Yes	Yes	Not applicable	No	Unclear	Unclear	Yes	5/8
(98)	Yes	Yes	Unclear	Not applicable	No	Unclear	Yes	Yes	5/8
(99)	Yes	Yes	Yes	Not applicable	No	Unclear	Yes	Yes	6/8
(42)	Yes	Yes	Yes	Not applicable	No	No	Yes	Yes	6/8

(101)	Yes	Yes	Yes	Not applicable	Unclear	Yes	Yes	Yes	7/8
(102)	Yes	Yes	Yes	Not applicable	No	Unclear	No	Yes	5/8
(103)	Yes	Yes	Yes	Not applicable	No	Yes	Yes	Yes	7/8
(104)	Yes	Yes	Yes	Not applicable	No	No	Yes	Yes	6/8
(105)	Yes	Yes	Yes	Yes	No	Unclear	Yes	Yes	6/8
(106)	Yes	Yes	Yes	Not applicable	No	No	Yes	Yes	6/8
(107)	Yes	Yes	Yes	Not applicable	No	Unclear	Yes	Yes	6/8
(108)	Unclear	Yes	Yes	Not applicable	No	Unclear	Yes	Yes	5/8
(110)	Yes	Yes	Yes	Not applicable	No	No	Yes	Yes	5/8

Table 2.5: Quality assessment results (Qualitative studies)

Study	Philoso-perspective and method	Method and research question or objectives	Method and data collection methods	Method and data representation and analysis	Method and results interpretati on	Locating the researcher culturally or theoretically	Influence of the researcher on the research, and vice-versa	Representation of participants and their voices	Ethical approval by an appropriate body	Relationship of conclusions to analysis, or interpretation of the data	Overall score
(84)	Yes	Yes	Yes	Yes	Yes	Unclear	No	Yes	Yes	Yes	8/10
(100)	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	9/10
(109)	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	9/10

2.3.4 Knowledge, attitude and practice regarding infection control guidelines

For the purposes of this review, knowledge, attitudes and practice among the study participants refers to the level of compliance related to the implementation of IPC guidelines among laboratory staff and includes one of the following definitions (112,113).

Knowledge: Information possessed about IPC guidelines.
Attitudes: Opinion on and behaviour towards IPC guidelines.
Practices: Observable actions towards IPC guidelines.

Of the 36 included studies, knowledge, attitudes and practices of IPC and biosafety guidelines were identified and grouped into several themes; the specific definition of each theme was identified from the included studies (see Table 2.6).

Table 2.6: Definitions of themes

Theme	Specific definition
(1) **Knowledge of IPC guidelines**	Refers to the awareness and understanding of the conditions the IPC guidelines should be followed.
Immunisation against infectious diseases	Refers to the participants' compliance with the recommended vaccinations for laboratory staff (such as HBV).
Training on IPC guidelines	Training refers to any formal or/and informal training undertaken on IPC guidelines by laboratory staff to inform compliance with the guidelines.
(2) **Attitude to IPC guidelines**	Refers to determining how well IPC guidelines are adopted in everyday practice.
Perception of risk	Perception of risk refers to an individual's intuitive risk assessment, reflecting attitudes or beliefs about potential harm while working in the laboratory.
(3) **Practice of IPC guidelines**	Refers to the actual exercise and use of measures that minimise the risk of physical harm in the workplace.
Exposure and post-exposure prophylaxis (PEP)	PEP refers to the participants' exposure to injuries by a needle or any sharp instrument contaminated with blood or any body fluids including the administration of treatment following that exposure in order to prevent or reduce the likelihood of transmission of infection.
(4) **Associations among knowledge, attitude and practice**	Associations among knowledge, attitude and practice refer to the extent of knowledge and understanding of the IPC guidelines associated with the participants' attitude and their actual practices.
(5) **Barriers and facilitators to implementation**	Barriers and facilitators refer to factors that enable or inhibit the implementation of IPC guidelines.

(1) Knowledge of IPC guidelines

There was a lack of standardised criteria for classifying knowledge as 'poor', 'moderate' or 'good' across studies. However, it has been concluded that the term 'poor knowledge' was generally used when < 50% of participants had adequate knowledge of the information about IPC guidelines. Similarly, the terms 'moderate' and 'good' knowledge were used when the participants with adequate information about the guidelines were between 50–70% and >70%, respectively. These thresholds are applied for the remaining themes.

Knowledge was examined in 18 studies. Eleven studies (64,83,85–87,91,93,96,102,104,110) reported good knowledge of IPC precautions among laboratory staff. Ndu et al. (83) attempted to differentiate between the knowledge among two groups of healthcare professionals: doctors and laboratory staff. Although the authors found there were differences between the two groups regarding their knowledge of IPC components, both showed a good level of knowledge (76.2% in doctors and 67.6% in laboratory staff). About 55.4%–84.7% of laboratory staff had a good level of knowledge, as reported in studies (85–87), and it should be clarified that the number of laboratory staff included in these studies was very low compared to other HCWs (13/150; 29/49; 58/605, respectively). The reported results of knowledge in studies (64,91,93,96,101,110), were (81.97%, 66%, 84%, 75%, 82% and 80.7%, respectively). Because a small number of laboratory staff (10) participated in study (91), it may not be an accurate representative of laboratory staff. Rabaan et al. (64) assessed the knowledge of IPC policies and guidelines, but it is considered a low-quality study because it contains no information regarding the inclusion/exclusion criteria of its study sample. Almost all the technicians were knowledgeable about IPC precautions (100%) in the Lebanese study (104).

In contrast, four studies (49,78,80,90) reported moderate knowledge of IPC precautions among laboratory personnel. In Fadeyi et al.'s study (80), only 58.2% of the participants were aware of safety precaution principles, while in Ibeziako and Ibekwe's study (78), 50.4% of the respondents were aware of IPC precautions. The results of Izegbu et al.'s study (49) showed that only 20.8% of the participants had heard of IPC precautions and only 37.5% of these could define and state their objectives. Only 51% of the participants knew that the standard method of discarding needles is without recapping (90). However, this study had flaws in the study design because no information regarding the inclusion/exclusion criteria of its study sample were reported. Furthermore, the instrument used for data collection was not pretested to check its validity and reliability.

The remaining three studies (42,95,101) reported a poor level of knowledge among laboratory staff. The reported results of knowledge in study (95) was (32%), in Akagbo et al. the reported level was (37.0%) (42), and only 38% of respondents had a good level of knowledge in the Yamani study (101). It is important to highlight that the findings of study (42) were drawn from only five laboratory members of staff out of 100 HCWs.

The participants of one qualitative study included in this review claimed that many infection control decisions were made by those who have a non-medical background or are non-knowledgeable in infection control. In addition, all the study's participants acknowledged poor knowledge of infection control and reported that IPC guidelines were not well taught at the under- and postgraduate levels of education. Poor knowledge of disinfection and sterilisation were also reported because standards and guidelines had not been updated in the laboratory (100) (see Table 2.7).

Immunisation against infectious diseases

Assessment of the immunisation status of laboratory staff was reported in eight studies. In the KSA, 60% of respondents who worked in laboratories had been vaccinated against hepatitis B (91), and 87% had received a smallpox vaccination in their lifetime (98). However, the situation in Nigeria is different, with findings revealing that awareness of the hepatitis B Virus (HBV) vaccine was inadequate, with only 46.2% of the respondents aware of the availability of the HBV vaccination at their workplace even though 72.3% were willing to be vaccinated (80). It was further found that 91.5% of the participants were not immunised against HBV (49).

Results from India were similar, in that 91.5% were not immunised against HBV (95). Meanwhile, in Pakistan, 90.9% of participants were vaccinated against HBV (90).

A Kenyan study's authors found that all participants were aware of the importance of the vaccination, but because it was optional in their institution, they chose to remain unvaccinated (108). Meanwhile, in Afghanistan, 78.0% of a study's participants were vaccinated despite the fact that the HBV vaccination is not covered by the government and HCWs have to pay from their own funds to receive it (103).

Training on IPC guidelines

Thirteen studies' authors reported the results of training on IPC guidelines.

In a Nigerian study, only 13.8% had received training on universal precautions (78), and the authors of this study investigated how low and unequal levels of training among staff contribute to poor knowledge of and compliance with those guidelines. The training level was similar between medical doctors and laboratory staff (53.1% for the former and 58.1% for the latter). However, in Ndu et al.'s study (83), 73.5% of laboratory staff had received training on wearing and removing PPE, which may contribute to the low use of PPE among doctors compared to laboratory staff.

In a study by Desta et al. (87), participants who had undertaken IPC training amounted to 35.33%, and there was an association between training and practice. Only 36.8% of the participants had taken biomedical waste management training, which led to overall unsatisfactory level of knowledge, attitudes and practices scores in the study (85).

Training status was reported in two Saudi studies. In one study, 68% of the participants reported receiving training in laboratory safety either through a course during college education or through training workshops at the workplace (93). However, the results showed that some unacceptable behaviours in laboratories were associated with lack of training in IPC precautions. Of the participants, 23.06% reported having received no training (64), and when the participants were asked to identify factors that contribute to the spread of infection in the hospital, 51.7% reported no infection control training program as a factor.

A Tanzanian study revealed that the percentage of the study sample who had received training on universal precautions was 98.5%. It also reported that previous training was significantly associated with good practice ($P<0.001$) (102). The authors of a Pakistani study found that no formal biosafety training had been provided to 84.2% of the participants (89). In Ghana, it was reported that only 48% of one study's participants had regular training in IPC precautions (42), and in Yemen 67% and 32% of private and public laboratory staff had received training, respectively (101). Among the participants in a Bangladeshi study included in this review, only 54.2% of the participants reported having received formal safety training (110). After investigation, no associations found between training and practice in all four studies (42,89,101,110).

(2) Attitude to IPC guidelines

There was a lack of standardised criteria for classifying attitudes as 'poor,' 'moderate,' or 'good' across studies. However, it was generally concluded that a 'poor attitude' referred to cases where less than 50% of participants demonstrated positive behaviors towards IPC guidelines (such as avoiding eating, drinking, or smoking in the laboratory). A 'moderate attitude' was indicated when 50–70% of participants exhibited positive behaviors, while a 'good attitude' was applied when more than 70% of participants followed the guidelines appropriately.

The attitude of laboratory staff to IPC precautions were examined in ten studies.
Good attitudes were reported in four studies (92,93,96,104). This result was observed in three departments in laboratories: 83.3% in a pathology department, 75% in a biochemistry department and 100% in a microbiology departmen (96). Only eight from 73 (11.0%) technicians showed some behavioural lapses inside the laboratory: eating, drinking, smoking or pipetting with their mouths (104). In Khan et al.’s study (92), although the majority of respondents demonstrated good behaviours towards the use of IPC protective measures (58.8%), they displayed poor behaviours towards their active participation in infection control programs (24.2%). Meanwhile, in Khabour et al.’s study (93), 24.2% of participants ate, drank or chewed gum, 18.3% used cosmetics and 24.6% used their mobile phones in the laboratory.

Four studies reported moderate attitudes (80,85,86,110). In Fadeyi et al.’s study (80), 60.0% of the participants were willing to eat and drink in the laboratory, while in Ahammed et al.’s study, 58.3% of the participants sometimes ate in the laboratory (110). The reported attitudes levels in study (85) and (86) were 66.2% and 66.1%, respectively.

Poor attitude levels are observed in two studies (49,95). In Izegbu et al.’s study (49), 45.6% of the participants ate in the laboratory and 47.0% of them stored food and water in refrigerators meant for the storage of body fluids and chemicals, attitudes that indicate a disregard for IPC and safety precautions. The results of Zaveri et al.’s study (95) matched exactly the findings from Izegbu et al.’s study (49).

Perception of risk

Only three studies in this review were related to risk perception among laboratory staff.

Only 23% of laboratory workers in the UK thought they were at some risk of HIV infection in their occupational setting; this low percentage may relate to a high knowledge of safe working practice and practical working experience, or that they worked in safe laboratory using safe practices (99). A study assessing prion disease risk perceptions among laboratory staff in Canada found that 18% believed they were at risk of prion transmission when processing prion-associated specimens and 81% would be more comfortable processing specimens if safety guidelines existed and were used in their laboratory (107). One qualitative study concerned HCWs' perceptions of occupational risk of HIV transmission (84). Alemie (84) reported that all the participants were aware of the risks of acquiring HIV in healthcare settings and all of them were worried about the inadequacy of protective materials required to prevent HIV transmission, which was mentioned as the main reason for perceived high risk (see Table 2.7).

(3) Practice of IPC guidelines

There was a lack of standardized criteria for classifying the practice of IPC guidelines as 'poor,' 'moderate,' or 'good' across studies. However, it was generally concluded that 'poor practice' referred to cases where less than 50% of participants adhered to IPC guidelines (e.g., improper hand hygiene, failure to use personal protective equipment). A 'moderate practice' was indicated when 50–70% of participants followed the guidelines, while 'good practice' was applied when more than 70% of participants consistently adhered to the recommended practices

The majority of studies (n=25) in this review focused on laboratory staff practice of IPC precautions.

Six studies were Nigerian, and the authors of those included in this review assessed how IPC precautions were practised in laboratories. Poor practice results were reported in two studies (43%) (49), and (45.6%) (82). Moderate findings were reported by Fadeyi et al. (80) in that 69.2% of the participants wore gloves when handling samples, and in Sadoh et al.'s study (111), 63.8% of the participants always used PPE. The findings in Ndu et al.'s study (83) demonstrated that laboratory staff reported good practice and greater use of PPE such as gloves and coveralls than doctors (100% and 35%, respectively). The same level of good practice was reported in Ibeziako and Ibekwe's study (78), with gloves were used by 86.6% of respondents.

One Ethiopian study showed a good level of practice (85) (77.4% of the respondents). However, two other studies (87) and (86) showed moderate results (57.3% and 66.1%, respectively).

In the KSA, it was observed that only 27% of one study's participants reported wearing gloves all the time when completing tasks, while 48 (69%) did so only occasionally (91). It was further documented that 10–25% of laboratory injuries occurred while recapping a used needle (91). Nevertheless, Khabour et al.'s study (93) demonstrated good levels of practice among laboratory staff, and the majority (> 80%) of participants following guidelines for disposal of medical waste, decontamination of sample spills and use of protective laboratory coats and gloves, among other measures. Moreover, Binsaleh et al. reported that about 72.3 % of the laboratory technicians participating in their study had high scores for wearing PPE during the COVID-19 pandemic (94).

Two Indian studies indicated good practice levels (95) and (96). All the participants of one study wore gloves during laboratory work (95), and 66.7%, 81.5% and 100% of participants in the pathology, biochemistry and microbiology departments, respectively, gave positive answers to the practice questions in the study's questionnaire (96).

All three studies conducted in Pakistan demonstrated a poor level of practice. There was a lack of awareness of good laboratory practices reported in Nasim et al.'s study (88) (because 46.2% of the participants did not use any kind of PPE, and almost 39.5% recapped used syringes regularly), and 46% of the participants reused syringes either occasionally or regularly (89). Qazi et al.'s study (90) yielded poor results because 80.3% of 208 participants recapped needles, leading to 31.3% experiencing a needlestick injury while recapping.

The studies conducted in Lebanon (104), Kenya (108), and Tanzania (102) showed good levels of prcactice. In them, 93.2% of participants wore gloves while working in the laboratory (104), 97.8% used PPE (gloves, overalls, gumboots, mouth masks and other protective equipment) when handling medical waste (108), and 77.0% applied universal precautions (102).

Conversely, the studies from Yemen (101), Afghanistan (103) , and Bangladesh (110) revealed a poor application level and the study from Ghana (42) revealed moderate attitude levels. In Afghanistan, 57.8% of respondents reported that they always recapped the needle after giving an injection (103), while in Yemen only 32% of respondents had good practice of IPC precautions (101). Only 50% of respondents always protected themselves from injections, and about a quarter of the respondents did not recap needles after use in Ghana (42). In addition, 75.5% of the participants never washed their hands before putting gloves and only 36.5% always used PPE in Bangladesh (110).

The participants of Ider et al.'s study (100) conducted in Mongolia perceived that hand-hygiene practice among health professionals there was low. They also wondered why, despite most hospitals conducting staff hand-hygiene training once or twice a year, hand-hygiene practice remained poor. The main reasons for this may be the unavailability of hot water and sinks and a poor supply of soap, poor supply of alcohol-based hand sanitisers and skin care products, and a high workload for health professionals (100) (see Table 2.7).

In one study conducted in China, the authors aimed to assess infection control practices among COVID-19-infected HCWs (105). Before the COVID-19 outbreak, 53.4% of respondents always followed the procedure for wearing and removing PPE, 66.0% always wore masks and 51.5% wore gloves in their routine work. However, approximately 41.8% of the participants thought their infection was related to PPE and utilisation of common equipment (masks and gloves), either owing to inadequate provision of PPE or to insufficient protection provided by the PPE they had.

Exposure and post-exposure prophylaxis

Ten articles reported on exposure to injuries and PEP following injuries.

In Nigeria, 53.23% of the participants in one study had had cuts or punctures from needles and had used first aid in the laboratory (49). Although 94% of the laboratories had first aid boxes, only 28.78% of the staff made use of them (49). In Fadeyi et al.'s study (80), despite the fact that 79.2% of respondents were aware of the availability of PEP for HIV and HBV, only 1.5% positively responded to presenting themselves and had PEP following any laboratory accidents

(80). Half of the laboratory workers who participated in the study (81) had experienced needle pricks, and only 25.7% of exposures were reported to the staff clinic.

Four of the seven participants in Alemie's study (84) in Ethiopia had experienced accidents: needlestick injuries or exposure to blood or other body fluids, and their explanations for the accidents indicated that they were frequent. Many of the injuries/accidents were followed by commencement of wearing PEP, which, however, was mentioned by some to be less practised although they were well aware of it (84) (see Table 2.7).

No percentages of accidents were reported according to studies (88) and (89), but 83.4% and 89.3% of laboratories did not maintain any accident records, respectively. In Rabaan et al.'s study (64), about 31.3% of the participants had experienced a needlestick injury while recapping; however, only 24.2% of those who had experienced an injury were aware that they should use PEP.

A similar situation was noted in a Saudi study, where 74% of participants had a history of needlestick injuries, and only 21% of those had reported the injuries to the hospital authorities (91).

In India, 53.23% of the participants in one study had been injured by needles and sharp instruments. However, only 28.78% of them made use of first aid supplies after their injury (95).

A Cameroonian study's authors (106) reported exposure and PEP and the results of their study agreed with the results of the Indian study (95). This showed that a high proportion of participants (58%) had poor knowledge of PEP and 60.6% had a positive attitude towards PEP. About 50.9% of all participants had had at least one occupational exposure, but only 19.1% of PEP incidents were recorded among exposed participants.

The reported data on occupational accidents/injuries from the included studies rely on the participants' memories of past exposure, which may therefore make them susceptible to recall bias.

(4) Associations among knowledge, attitude and practice

The authors of only three of the included studies examined the associations/correlations among knowledge, attitudes and practices. One study found a significant correlation between knowledge and practice regarding IPC precautions ($r=0.76$, $p<0.001$) (88,89,102). The correlation between knowledge and attitude was significant (r: 0.12; $P<0.001$) (92), and there was an association between adherence to IPC guidelines and infection prevention practices (87).

(5) Barriers and facilitators to implementation

One quantitative and one qualitative study explored barriers and facilitators to the implementation of IPC guidelines.

It was found that the factors that positively promote consistent adherence were: education in standard precautions, providing facilities with PPE, and strong management support for safety. An increase in workplace demands and expectations negatively affected consistent adherence (97). In Mongolia, a qualitative study assessed perceptions of laboratory staff regarding the main barriers and challenges to the implementation of effective infection controls in the hospital. They found poor IPC education, limited laboratory capacity, poor disinfection and sterilisation, and low compliance with hand hygiene to be the major barriers to implementation (100) (see Table 2.7). Although the researchers examined issues from the participants' perceptions, the shortcomings in how this study was conducted could have been mitigated by use of large-scale quantitative and a mixed-method investigation.

Table 2.7: Summary of the results with the original quotes (OQ) from the studies included in review (exemplifying the themes of interest)

Theme	Original quotes
Knowledge of IPC guidelines	*"It is extremely difficult to convince people at the 'top' because they are non-medical [Military hospital doctor]."* [Ider et al., 2012] (OQ1)[100] "'*Are you really going to throw this money to garbage?'" asked our hospital financial officer about the budget proposal for syringe boxes [ICP]."* [Ider et al., 2012] (OQ2)[100]

	"At the medical university I trained to be a hygienist, most of our classmates now work as hygiene inspectors. It was quite challenging for me to decide to work at the hospital. When I started work, I had to learn [IC] *from scratch from our colleagues." [Hospital ICP]"* [Ider et al., 2012] (OQ3)[100] *"Those doctors and nurses who went for overseas training or those who have good English quite often bring me information about new modern hospital infection prevention methods… and disinfectants. Every time they explain something to me, I feel that I was supposed to be teaching them, not them teaching me [Hospital ICP]"* [Ider et al., 2012] (OQ4)[100]
Practice of IPC guidelines	*"Everybody knows when and how to wash their hands but they don't [Hospital manager]"* [Ider et al., 2012] (OQ5)[100] *"It [disinfection and sterilisation] is the most unattended area of infection control. What we do is just replace a few autoclaves in hospitals and that is it. We need to do a lot in this area [MoH]."* [Ider et al., 2012] (OQ7)[100]
Risk perception	*"Our hospital has to do the following activities in order to handle work related risk of HIV transmission: giving service to HIV patients in a separate place and taking extra care; training healthcare workers on infection prevention; and organizing a committee that can follow the use of universal precautions in the hospital (A 26-year-old medical laboratory technologist)"* [Alemie et al., 2012] (OQ11)[84]
Exposure and post-exposure prophylaxis	*"I know three laboratory technicians who sustained needle stick injuries and took post exposure prophylaxis. During the incident, one of them, a friend of mine, shouted and immediately burst into tears and he even tried to cut his finger (26-year-old medical laboratory technologist)"* [Alemie et al., 2012] (OQ12)[84]
Barriers and facilitators to implementation	"*Last year, our [hospital] budget for syringe boxes was cut by the financial people at the Ministry of Health and later in the Ministry of Finance. I was blamed… for not meeting these people and explaining properly for what and why this money was planned [ICP]*" [Ider et al., 2012] (OQ13)[100]

	"Most of my time I spend doing various administrative tasks plus dealing with waste disposal, cleaning, sterilization, sewage problems and even fighting against cockroaches and mice [Hospital ICP]" [Ider et al., 2012] (OQ14)[100] *"Most of our lab equipment is from the 60s and 70s… Often we face shortages of reagents and disks… We only do bacteriology tests … It is rare for anaerobic bacteria…We don't identify bacteria to species level. There are no national standards for laboratory methods… We have a very high workload [Tertiary hospital lab physician]"* [Ider et al., 2012] (OQ15)[100]

2.4 Discussion

This review has focused on the level of knowledge of, attitudes to and practice of IPC precautions/guidelines among staff working in laboratories in different countries.

The review was conducted by unpacking knowledge, attitude and practice in particular themes, and the definition of each theme was identified from the studies included in the review. Several differences in knowledge, attitude and practice were observed between and within countries. Generally, the available evidence shows that there was good[1] knowledge, good attitudes and moderate immunisation status, but still poor practice of IPC guidelines among laboratory workers. Evidence is lacking as to risk perceptions, and it was low based on the evidence from the available articles. Exposure to blood and body fluids through cuts or punctures from needles and sharp instruments was high among laboratory staff; despite high incident rates, the reporting of these accidents to management and use of PEP was low. A poor level of training was received by laboratory staff, and some studies revealed a strong association between training and knowledge and good IPC practices. Although the evidence was not abundant, there is a clear association among knowledge, attitude and practice. A lack of guidelines, poor access to PPE, a lack of training and education and the immense pressure of emergency situations were the main barriers highlighted in this review. The findings reveal a need to improve the availability of guidelines, enhance PPE availability, and provide regular training on IPC guidelines.

[1] Good = The majority of studies reported results >70%; Moderate = The majority of studies reported results that vary between >50% and <70%; Poor= The majority of studies reported results <70%.

Different definitions of knowledge were used in the studies, reflecting a lack of stable policies and guidelines; this may be attributable to different IPC recommendations being made by the CDC and the WHO. Similarly, different levels of knowledge were reported in the studies. However, some studies were considered to be of a low quality according to the JBI-CAT, and in addition the number of laboratory staff included in the review was very low. It is interesting to note that there is a positive improvement in the awareness in Nigeria, while the opposite is shown in KSA. This may be due to a lot of uncertainty among some staff regarding infection control policies and guidelines in their unit, which might contribute to carelessness in and lack of awareness of the application of procedures.

The findings on laboratory staff's attitudes towards IPC guidelines focused more on eating, drinking, storing food in refrigerators and using mobile phones. None of the researchers reported any reasons for this poor attitude. The question is, could this mean that laboratory staff do not understand the dangers of eating and drinking in the laboratory, or are there other factors convincing them that this behaviour is acceptable? Or is it another issue such as not having time to take a break and eat elsewhere? Yet there is clearly a need to clarify the reasons behind these risky behaviours and poor attitudes so they can be addressed to prevent the establishment of a poor work culture.

In line with the reasons for poor practice reported earlier, it should be clarified that most of the studies whose authors assessed practice in this review were limited by the self-reporting method, which may have produced a less favourable picture of practice than is actually the case, with some participants possibly overestimating the extent to which they practice and comply with IPC precautions. Using a combination of observation methods, interviews and a questionnaire to assess practice may produce more accurate results than asking about practices only in a questionnaire. Combining these methods may moreover help to reduce the likelihood of reporting bias and observer-induced changes in practice.

Evidence on risk perceptions was very low in this review, with few laboratory staff members included in the data from the studies making it difficult to draw meaningful conclusions. The same applies to the associations among knowledge, attitude and practice. Although a clear association was observed in this review, a definitive conclusion was not reached and more studies in this area are recommended

The lack of reporting on the incidence rate and on the use of PEP may be due to a lack of awareness of the importance of PEP, fears of stigmatisation and job insecurity (111). Therefore, hospital authorities should establish a continuing health education programme to inform laboratory staff on IPC measures, with particular attention paid to the immediate action required after injury, reporting injuries and the use of PEP. In addition, setting up a monitoring team is needed to actively continue monitoring all occupational injuries and exposures so as to guarantee their appropriate reporting and management.

The overall training level was poor, as shown on the aforementioned evidence that training programmes for laboratory staff can affect their adherence to, knowledge of, behavior towards and practice of IPC precautions. It is therefore recommended that they receive enough training on awareness, importance and practice of IPC guidelines and examination before gaining a license to practice a laboratory profession.

Similar to this review, a recent review of the occupational hazards among HCWs in Africa showed a lack of PPE as a common reason for poor practice (114). This indicated a need for national policies to address the low availability and in some cases the complete absence of PPE in many low-income countries. The findings of a Ghanaian study (42) highlighted how complying with IPC precautions sometimes interferes with HCWs' ability to provide care. The study reflected how a warmer climate means that HCWs are exposed to heat stress, which may limit their compliance, may make the use of PPE more uncomfortable than in cooler climates, and could even be life-threatening (115). Consequently, the standards for the production of PPE should take warmer climates into consideration to promote adherence.

There is a need for more mixed-methods studies to assess the knowledge, attitude and practice of laboratory staff to reduce biases during data collection and using a combination of interviews and a questionnaire may produce more accurate results than asking about attitudes and practices only in a questionnaire. Furthermore, larger-scale studies are needed to collect more evidence about risk perceptions among laboratory staff.

The review had a number of limitations. Firstly, some of the included studies in this review were focused on laboratory staff alone as participants, while others were focused on all HCWs such as nurses and doctors, in addition to laboratory staff; therefore, certainly a higher level of knowledge, attitude and practice may have been attained and reported in the ones that were only focused on laboratory staff than in the broader studies. Secondly, because a narrative synthesis approach was followed and insufficient numerical data were available, there was no assessment of publication bias because it does not allow funnel plots to be presented. Finally, only studies published in the English language were included. Thus, a potential language bias might be considered a limitation of this review.

2.5 Conclusion

This systematic review has shown a clear gap among knowledge, attitude and practice, which indicates that laboratory staff are at high risk of acquiring infections in the workplace. These findings suggest that training (including IPC precautions, safety policies, safety equipment and materials, safety activities, initial biohazard handling, ongoing monitoring and potential exposure) for laboratory staff to increase their knowledge of IPC precautions could improve their use of these precautions. It is also recommended that hospital administration and/or policy makers should provide a suitable action plan for the implementation of IPC guidelines.

The main purpose of completing this systematic review was to provide a clear overview of implementation and knowledge, attitude and practice of the IPC guidelines before conducting this mixed-methods research. Limited evidence for KSA (all were quantitative studies) included in this review suggested the need for such mixed-methods research to draw a comprehensive picture of the implementation of the IPC guidelines among laboratory staff in KSA.

Chapter 3 Aim and objectives

3.1 Aim of the study

This study aimed to explore the implementation of the IPC/biosafety programme in KSA from the laboratory staff, allied health professionals and infection control specialists' viewpoint and to assess knowledge, attitudes and practices of recommended polices and procedures. In so doing, it examined how knowledge related to risk perceptions affects actual practice among laboratory staff.

3.2 Objectives of the study

- To assess laboratory staff, allied health professionals and infection control specialists' knowledge, attitudes and practices of IPC/biosafety guidelines in KSA hospitals.
- To examine to what extent laboratory staff, allied health professionals and infection control specialists comply with IPC/biosafety guidelines in KSA hospitals.
- To examine the relationship between knowledge, attitudes and practices (compliance with IPC guidelines) and staff personal characteristics (i.e., age, gender, education, training, years of experience, etc.).
- To determine the laboratory staff, allied health professionals, and infection control specialists' opinions of the implementation of the IPC/biosafety guidelines and their association with staff personal characteristics (i.e., age, gender, education, training, years of experience, etc.).
- To assess the relationship between knowledge of risk perception and staff practices.
- To determine whether relevant facilities meet the laboratory requirements (supplies, equipment, etc.).
- To determine the factors that hindered and/or facilitated the successful implementation of the IPC/biosafety guidelines.

Chapter 4 Methodology

This chapter explains the methodology employed to seek answers to the research questions and meet the aim and objectives of the research, including the research design and the procedures that were used. The first section presents the study design, followed by the rationale behind choosing a mixed-methods approach. Thereafter, an explanation of and rational for the data collection instruments used are provided. The research process, including information about the study setting, the study participants, and the ethical considerations raised by the study, is also presented. This is followed by a detailed description of the method used for both the quantitative and qualitative data analysis. The final section gives a summary of the chapter.

4.1 Study Design

To achieve the aim and objectives of the study, an explanatory mixed method approach was employed, with two methodological designs utitised in parallel:

1. A quantitative study used a structured self-administered questionnaire to investigate the participants' socio-demographic characteristics, educational characteristics, work experiences, knowledge, attitudes towards, and perceptions and practices of IPC implementation.

2. A qualitative study deployed semi-structured interviews, drawing on Normalisation Process Theory (NPT), to examine the participants' behaviour, attitudes towards, and perceptions of the implementation of IPC guidelines, to identify any issues with the current programme and where improvements could be made, and give reasons for good, poor, or no compliance with the guidelines.

4.1.1 Mixed methods study

According to a paper by Johnson et al. (111, p.123), "*Mixed methods research is the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e. g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration.*". A mixed methods study design provides a more holistic understanding of the factors influencing the implementation of relevant guidelines among high-risk groups, allowing for a greater degree of comprehension than possible if a single method were used. Using multiple methods of data collection has been shown to improve the data's validity and reliability, as well as their interpretation (117).

This research employed a mixed-methods approach by combining quantitative and qualitative data for two primary reasons. Firstly, it is suitable for answering research questions concerning knowledge, attitudes, and practices regarding IPC guidelines; second, it is suitable for obtaining complementary extension data in order to fully understand the implementation process of IPC guidelines from various perspectives.

One aspect of quantitative research is that it "*is a set of strategies, techniques and assumptions used to study psychological, social and economic processes through the exploration of numeric patterns*" (118, p.2828). It was used in this study to obtain comprehensive data that provide a general understanding the personal knowledge, opinions and perceptions of laboratory staff and allied health professionals regarding the implementation of IPC guidelines by using a self-administered questionnaire that affords an assessment of knowledge, attitudes, practices, and perceptions of the implementation of IPC guidelines.

Qualitative research is useful in enabling a deeper understanding of a target group's experiences, values, behaviours, opinions, and contexts in this study regarding the implementation of IPC guidelines. Consequently, this qualitative dimension of the research explores the implementation of IPC guidelines using NPT (119), which fits in with the overall aim and objectives of the study.

The findings from the quantitative study were used to develop materials for the qualitative study, with the aim of exploring the reasons for poor knowledge, attitudes, or practices related to IPC guidelines, as reported in the quantitative study. In addition to the identification of any problems within the current program and highlight areas for improvement.

4.2 Study Setting

The study took place in tertiary care hospitals located in the Western (Makkah) and Central (Qassim) Regions of the KSA. Jeddah is the main port of entry for Makkah visitors, and it is the primary Saudi seaport (see Figure 4.1). In 2023, The estimated population was 3.7 million, of which 2.01 million were non-Saudis (120). The Saudi Arabian National Guard soldiers and their families receive health services provided by The Ministry of National Guard-Health Affair (MNG-HA) through the tertiary hospital (King Abdulaziz Medical City-Jeddah (KAMC)) with a 751-bed capacity and five primary healthcare centers. Approximately, over 5000 HCWs work there including 110 laboratory staff and 30 Infection Control Specialists (121).

Buraydah is the capital and largest city of Qassim Region, in the centre of the Kingdom (see Figure 4.1). In 2023, it had a population of 1.3 million, including 409,689 non-Saudis (120). King Fahad Specialist Hospital (KFSH) is one of the biggest tertiary hospitals in Buraydah, with a 574-bed capacity. It provides health services for all the community under the supervision of the MoH (122). Approximately, there are more than 2000 HCWs work there including 125 laboratory staff and six Infection Control Specialist.

Hayat National Hospital (HNH) is a private hospital, also located in Qassim Region and is managed by Hayat International Hospital Company and subject to regulation by MoH (123). It has around 265 beds and approximately 600 HCWs work there including 20 laboratory staff and four Infection Control Specialists.

Figure 4.1: Map of the KSA (underlining the location of the current study), (Source: ((124))

4.3 Study Population

The study participants, at the time of data collection, were recruited from KAMC, KFSH, and HNH. All laboratory staff (including: Admins, specialists, technicians, and laboratory assistants) working in all laboratory sections (such as haematology, biochemistry, serology, microbiology, molecular biology, blood bank, and blood sampling) were included in the study. In addition, allied health professionals responsible for collecting and delivering patients' samples from all hospital sections to the laboratories (for example, phlebotomists and nurses) in the selected hospitals were included. To be able to gather views from different stakeholders in the selected hospitals, Infection Control Specialists responsible for collecting and analysing data on healthcare-associated infections, identifying outbreaks, and using and encourage using of appropriate prevention strategies to prevent and control further spread of infection across all healthcare facilities' departments (125), were also included. Staff on maternity leave or annual vacation during the study period were excluded.

4.4 Quantitative Study

4.4.1 Study participants

The study participants during quantitative data collection (September 2021-January 2022) were recruited from KAMC, KFSH, and HNH. All laboratory staff and allied health professionals were included and were recruited through a stakeholder in each hospital (who was also included in the study).

4.4.2 Sampling

Sampling technique

A convenience sampling method was used to recruit participants and to obtain a population-based sample. It is a type of non-probability sampling where study participants are selected for inclusion in the study because they are easily accessible by the researcher (126). Taking into consideration the location of the hospitals, the availability of the participants, and cooperation from the hospitals, a convenience sampling method was deemed appropriate.

4.4.3 Study location of the quantitative study

An online survey software, Qualtrics, was utilised to administer the questionnaires. This approach was taken due to the restrictions on travel as a consequence of the COVID-19 pandemic.

4.4.4 Materials and resources

Questionnaires

Drawing upon the results from the systematic review of IPC guidelines, as well as utilised and validated questionnaires from prior research conducted throughout the world (103) and (127) with similar aims and objectives to this study, a structured self-administered questionnaire was developed in order to assess and measure the participants' knowledge, attitudes, and practices of IPC guidelines.

The questionnaire consisted of multiple-choice questions developed to be appropriate for the study participants. This approach has the advantages of greater reliability, greater suitability for assessing knowledge levels, and more standardised responses. The items' response options were designed to be as simple as feasible using ‘true’, ‘false’, and ‘don't know’ options.

Using an ordinal Likert scale, the participants were asked to express their personal perceptions and opinions regarding attitudes towards and perceptions of the implementation of IPC guidelines. They could express agreement or disagreement with statements on a 5-point scale: 5-strongly agree, 4-agree, 3-neutral, 2-disagree, 1-strongly disagree, and ‘I don't know’.

In order to assess the participants' practices of IPC guidelines, the adverbs of frequency options were used, including: ‘always’, ‘often’, ‘sometimes’, ‘never’, and ‘not relevant to my role’.

The questionnaire was translated into Arabic and then back-translated into English to guarantee lexical equivalence. An English- and Arabic-speaking translator edited the final questionnaire. In this sense, face validity served to guarantee translation authority. The research team members who were experts in the research and the medical fields (MP, GM, VM, and MA) also evaluated each question's clarity, relevance, simplicity, and consistency with the rest of the questions to determine whether it was legitimate in terms of material.

The final version of the questionnaire had 64 items, divided into five main sections, with the first 12 items detailing sociodemographic and personal traits such as gender, age, nationality, highest level of education, occupation, and others. The second section contained 18 items and was used to explore the participants' awareness and knowledge of IPC guidelines, including the level and source of information about IPC guidelines, general questions about IPC guidelines, and some questions related to knowledge of PEP. The third section measured attitudes by utilising 11 items on a five-point Likert scale to gauge behaviour and attitudes towards IPC guidelines. The fourth part encompassed 12 items assessing the participants' daily practices and use of IPC guidelines. The final section was about determining the participants perceptions regarding the implementation of IPC guidelines, which was evaluated using a five-point Likert scale on 11 items. In this section, questions were added from the NPT questionnaire (NoMad) to assess the implementation processes from the perspectives of the individuals involved in the implementation of IPC guidelines (128). The questions from the instrument were modified to be relevant to the study of interest (see Appendix C).

4.4.5 Pilot study

An online pilot study was conducted before the actual data collection in order to enhance the questionnaire's internal validity and reliability, anticipate any difficulties with the technique, data collection, and analysis, and determine whether or not changes were necessary. The study questionnaire was piloted with a small number of volunteers, all Saudi nationals employed at different hospitals at the MoH and the MNG-HA (eight laboratory staff and two Infection Control Specialists). They were selected to closely represent the target population in the study hospitals. The volunteers were asked to complete the questionnaire and then provide feedback in order to identify any problems with the questions, such as difficultly or vagueness. Their replies were also examined to assess whether each question gave an sufficient range of responses and whether they were presented in a logical order. Moreover, the time needed to finish the questionnaire was tracked and used to determine its reasonableness. After the pilot survey, a number of modifications were made, and some changes to the wording of the questions were made for clarification, without affecting the research objectives. Each participant took on average 25 minutes to complete the questionnaire. The final analysis did not include any data from the pilot study.

4.4.6 Data collection

The quantitative data were collected between September 2021 and January 2022. The participants were invited to participate with the help of a gatekeeper who was identified through the researcher's clinical networks in each hospital included in the study. The gatekeeper at KAMC was a part of the research team, a member of the laboratory staff at KFSH, and a manager at HNH. They had established communication links with the participants and distributed the study information sheet, consent form and Qualtrics questionnaire (see Appendix D). Documents were provided in either English or Arabic, depending on each participant's preference. Before starting the questionnaire, the participants were required to press the agree option in the consent form, indicating that they had read and comprehend the research information sheet in order to be enrolled in the study. They were informed that their responses and data would be anonymous and private, and their right to withdraw without opposition was confirmed.

When the participants completed and reached the questionnaire's final page, they were asked to provide their email address in order to receive a voucher, which was optional. In addition, the investigator's contact information was provided to the participants at the conclusion of the questionnaire in case they had any questions or concerns after completinon.

4.4.7 Data processing and entry

Questionnaire responses were transferred from Qualtrics into Microsoft Access to clean and prepare the data for statistical analysis. The titles of some columns were modified to be easy to read, and the wording of some self-reported answers was also modified to be matched for all participants. Next, the data were transferred to STATA statistical software to be analysed.

4.3.8 Data Analysis

Statistical plan

Statistical software for data science, STATA software 17.0, was used for all statistical analyses. Descriptive statistics were used to summarise the variables according to the normality of the data, mean, and SD, median, and inter-quartile range (IQR). Moreover, frequency tables with percentages were also used to describe the data. All items of knowledge, attitudes, practices, and perceptions of the implementation of IPC guidelines were added together to create one continuous variable representing the scores for each: ‘knowledge’, ‘attitudes’, ‘practices’ and ‘implementation’, and the frequency tables were used to describe each of them. All p-values were calculated with two tails, with p-values below 0.05 being considered significant. In addition, 95% confidence intervals (CI) were utilised and reported throughout the research.

The knowledge score was the sum total of correct responses to the questions; one point was given for a correct answer and zero for wrong answer or ‘I do not know’, and as the questions in the questionnaire were set with the choice ‘TRUE’ as the correct answer, if a participant chose ‘TRUE’ they were given one point, and if they chose ‘FALSE’ or ‘I don't know’, they were given zero, and the opposite for questions 4, 6 and 8. The data related to the level and source of IPC information, IPC general questions, and knowledge of PEP were presented using frequency tables with percentages.

The participants' attitudes towards and perceptions of IPC implementation scores were the sum of the level of agreement points; if a participant chose ‘strongly agree’, they were given five points; ‘agree’ = 4 points; ‘neither agree nor disagree’ = 3 points; ‘disagree’ = 2 points; ‘strongly disagree’ = 1 point; and 0 for ‘I don't know’. Frequency tables were also used to present that data.

The practice of IPC guidelines score was the sum of adverbs of frequency points; if a participant chose ‘always’, they were given 4 points; ‘often’ = 3 points; ‘sometimes’ = 2 points; ‘never’ = 1 point; and 0 for ‘not relevant to my role’.

To determine the influence on the knowledge, attitudes, practices and perceptions of implementation scores of the categorical variables for not normally distributed data, the Mann-Whitney U test (129) was utilised when there were two levels to the variable (such as gender), and the Kruskal-Wallis test (130) was utilised when there were more than two levels to the variable (such as nationality and highest level of education). The Pearson chi-square test was used as a replacement when the Mann-Whitney U test and Kruskal-Wallis test were inappropriate, especially for determining the influence of categorical variables on knowledge of PEP scores. For normally distributed data, the t-test was utilised when there were two levels to the variable (131), and the ANOVA was utilised when there were more than two levels to the variable (132).

Because data of age and years of experience were both not normally distributed, Spearman's rank correlation coefficient was utilised to test the associations with knowledge, attitudes, practices and perceptions of implementation scores of continuous variables with a normal distribution. For normally distributed data, Pearson's correlation was used.

To provide a visual representation of the relationships between knowledge, attitudes, practices, knowledge of PEP, perceptions of IPC implementation scores, and the other variables, and in order to allow the identification of potential confounders and biases, a Directed Acyclic Graph (DAG) was generated. DAGs offer scientists a straightforward and transparent method for identifying and demonstrating their knowledge, theories, and hypotheses regarding the relationships between variables (133).

Multivariable linear regression was run to investigate the potential predictors of knowledge, attitudes, practices, knowledge of PEP, and perceptions of IPC implementation separately as dependent variables. All associations with a significance level of $p<0.15$ based on the univariable analyses were included in the multivariable model. The modelling process used DAGs to avoid adjustment for mediators and to ensure adjustment for potential confounders.

The results of multivariable linear regression with independent significant variables were tested and adjusted for potential confounders. Then, interactions and directions between significant predictors were investigated using multivariable regression to develop the modelling framework, and any statistically significant interactions were documented. The likelihood ratio test was used to compare the interaction model with the main effects model to determine whether the addition of interaction terms substantially enhances the model's fit over the main effects model. In addition, the important assumptions of the final regression analysis such as linearity, multicollinearity, heteroskedasticity, and normality were examined.

There were missing data across all study categories (knowledge, attitudes, practices, knowledge of PEP, and perceptions of IPC implementation) that could lead to bias. This bias was taken into consideration by using logistic regression analysis to identify potential bias due to missing data in each category separately.

4.5 Qualitative Study

4.5.1 Study participants

At the time of the qualitative data collection (January 2023–April 2023), the participants were recruited through the same gatekeepers who were responsible for distributing the quantitative study questionnaires. These gatekeepers agreed to assist access to potential participants by explaining the study and obtaining their approval to share their contact information with the researcher in each hospital included in the study. Any eligible laboratory specialists, technicians, supervisors, managers, and allied health professionals (e.g., nurses, phlebotomists) were invited to participate. In addition, all infection prevention and control specialists in charge of implementing and organising IPC guidelines, as well as those with expertise developing them, were invited.

4.5.2 Selection of participants for interviews (Sampling)

There were six in-depth interviews with participants from each hospital. Due to time and availability constrains, only a small number of participants took part in the interviews. Nevertheless, the data saturation was achieved and enough data was collected to answer the interview questions and no new information were added from interviewing more participants (134). In all, 18 participants (six from each hospital) were interviewed over a four-month period. Purposive sampling (judgmental sampling) was used to select the interview participants, using the gatekeepers to target those with specialised knowledge and experience. Purposive sampling is used to obtain 'rich information' from a limited number of participants chosen for their ability to provide in-depth information about the topic of central interest to the study (135,136). The objective was to include diverse categories of staff in terms of profession (e.g., laboratory specialists, laboratory technicians and public health practitioners), and seniority (e.g., junior laboratory specialists, laboratory supervisors, senior public health directors) in order to investigate the breadth of perspectives among staff instrumental in the implementation of IPC guidelines.

4.5.3 Location of interviews

Due to challenges coordinating in-person interviews such as geographic location, the participants' workloads, and the researcher's personal circumstances, the interviews took place online via Zoom. Online interviews have the advantages of simple audio recording, saving time, ease of access to distant participants, and increased scheduling flexibility due to the nature of the participants' busy lives.

4.5.4 Materials and resources

Normalisation Process Theory

Several theories, models and frameworks are now used in implementation science. In this study, two frameworks in addition to the normalisation process theory (NPT) were considered such as Consolidated Framework for Implementation Research (CIFR) and Reach, Effectiveness, Adoption, Implementation, Maintenance (RE-AIM) (137). The CIFR is a determinant framework that combines several theories to classify and explain contextual factors in five domains including: Intervention characteristics, outer setting, inner setting, characteristics of the individuals involved, and the process of implementation (138). The CFIR's broad range of determinants within its domains serves as a foundation for systematically considering and examining the factors relevant to an implementation project (139). Since CFIR focuses only on evaluating which factors (organisational, individual, environmental, etc.) influence the success or failure of an implementation process, it was not considered relevant for use in this study. The RE-AIM is a framework that enables a comprehensive evaluation of both the individual and organisational impacts of a program or intervention and consists of five evaluation dimensions (Reach, Effectiveness, Adoption, Implementation, Maintenance) (137,140). The RE-AIM was initially designed to offer researchers an evaluation tool for assessing the public health or population-level impact of a program or policy, while accounting for indicators of both internal and external validity (140). Since RE-AIM focuses only on assessing the impact of an intervention at the population or public health level, by the use of a structured approach to evaluate factors such as long-term maintenance, effectiveness, and reach, it also was not considered the most suitable option for use in this study which focused on understanding how people make sense, value and implement IPC guidelines into practice.

The qualitative interviews were guided by normalisation process theory (NPT), which fitted in with the overall aim and objectives of the study. NPT is a leading social process theory that offers insights into the mechanisms explaining why the cognitive and social interactions of individuals and groups within their specific context are essential for successful implementation (139). The development of NPT began with the iterative development of a comprehensive, generic theory of implementation. This foundation led to the development of tools designed to help implementation practitioners and researchers consider and measure key aspects of implementation processes (141). NPT provides an explanatory framework and a set of useful conceptual tools to help understand the dynamics of implementation, embedding, and integration of complex interventions such as IPC guidelines (142). By focusing on the interactions between contexts (including organisational and technical structures), actors (both individuals and groups), and objects (such as clinical practices and procedures), it enables the analysis and understanding of the gap between evidence, policy, and practice (143). NPT is built up around four constructs: 'Coherence': the process of sense-making and comprehension that individuals and organizations engage in, which either facilitates or hinders the routine integration of a practice; 'Cognitive Participation': the work and activities individuals undertake to encourage engagement with the new practice; 'Collective Action': how individuals work together to implement practices effectively; and 'Reflexive Monitoring': how individuals assess the effects of a new intervention (144). Each construct consists of four sub-constructs, where the data is mapped as follows: for 'Coherence' the sub-constructs include Differentiation, Communal specification, Individual specification and Internalisation; for 'Cognitive Participation' they are Initiation, Enrolment, Legitimation and Activation; for 'Collective Action' the sub-constructs are interactional workability, Relational integration, Skill set workability and Contextual integration; and for 'Reflexive Monitoring' they are Systemisation, Communal appraisal, Individual appraisal and Reconfiguration (145).

The study team created a topic guide which was informed by the results of the systematic review, the online survey and the NPT constructs to achieve the aim of the research (see Appendix E). The first part of the topic guide consisted of questions concerning the participants' experience with IPC guidelines (profession, work experience, and the roles and responsibilities of their jobs). The second topic contained questions investigating the participants' awareness and risk perceptions of laboratory-associated infections (LAIs) (are LAIs problematic to them? Who is responsible for the management of LAIs? And are the standards related to LAIs available?) The third, fourth, fifth, and sixth parts contained questions based on the four components of NPT - Coherence; Cognitive Participation; Collective Action: and Reflexive Monitoring - in order to obtain an in-depth understanding of the implementation process of IPC guidelines from different perspectives within the target hospitals. The last part was focused on understanding barriers to adherence to IPC guidelines by asking the participants about the reasons that cause low staff compliance and what potential facilitators could be devised to improve compliance with the guidelines. The topic guide was made flexible by adding and removing some questions based on the participants' professions. For example, participants who worked as infection control practitioners were not asked about LAIs (see Section 3.5).

The interviews were designed using a semi-structured interview guide with open-ended questions in order to allow the interviewer to investigate and expand each interviewee's responses, and confirm that the exact questions were asked (146).

The interview topic guide was subjected to validity testing. The research team members who were experts in the research and the medical field (MP, GM and VM) also evaluated the validity of the content and modified the questions to ensure they were appropriate for the level of discussion. The questions were modified based on the recommendations of the panel (MP, GM and VM).

In-depth interviews

Interviews suited the aim and objectives of the study, especially when attempting to understand the implementation of IPC guidelines from different perspectives. In addition to enhancing the significance of meaning and individual narratives, interviews also permit the in-depth exploration of related structures or contextual elements in order to collect and capture lessons applicable to future interventions.

Eighteen in-depth interviews were conducted to obtain information about the implementation of IPC guidelines. The interviews were conducted in either English or Arabic (dependent on the choice of the interviewee) and lasted between 25 and 30 minutes. For the laboratory staff interviews, the final version of the topic guide contains 24 items classified under seven headings. The first section includes three items describing job experiences. The second section includes three items covering LAIs. The third section discusses the coherence construct in four items. The fourth section covers the cognitive participation construct in four items. The fifth section covers collective action in two items. The sixth section covers reflexive monitoring in five items. The last section covers barriers and facilitators to adherence to IPC guidelines in three items (see Appendix E). For the infection control practitioner interviews, the final version of the topic guide does not include the second section (LAI part), the third section discusses the coherence construct in three items, and the sixth section covers the reflexive monitoring construct in only four items (see Appendix F).

4.5.5 Pilot study

A pilot study was conducted to test participants engagement with the topic guide. One laboratory staff member from KFSH and one Infection Control Practitioner from KAMC were interviewed via Zoom. To increase the reliability and internal validity of the study instrument, these two volunteers were selected for their similarity to the target population.

In order to identify ambiguous or challenging questions, to determine whether all interview questions were understood, and to determine whether the interview was of an appropriate length and ensure that all the questions had been addressed, the pilot’s participants were asked for feedback. Additionally, the length of the interview was timed, and the supervisory team used that information to determine whether the interview time was appropriate or not.

Following the pilot study, minor phrasing adjustments were made to improve clarity and, as previously mentioned, to eliminate mediator presence bias. Without impacting the study's objectives, certain ambiguous questions were removed, and all comments provided by the interviewees in the pilot study were taken into account.

4.5.6 The interview process

Based on the language preference of the participants (Arabic or English), a letter was sent via email informing them of the research aim and the interview content. This letter was accompanied by an information sheet and a consent form that described the requirements for participating in the study. It was the same sheet and consent form that the survey participants received (see Appendix D).

The participants were welcomed during the interviews and asked to confirm they had read and fully understood the study information sheet and signed the consent form, which was a requirement before the interviews were allowed to start.

The participants were also notified about the audio recorded of the interview, retained in strict confidence, and accompanied by notes from the meeting in order to prevent any participants from being recognised. Before the interviews began, the participants had the opportunity to ask questions if they needed additional clarification. They were also allowed to stop at any time for a break during the interview.

The participants received the investigator's contact information after the interview, in case they had questions or concerns or wanted updates on the research. Finally, Amazon e-vouchers were emailed to all participants.

4.5.7 Qualitative interview transcription and translation

The interviews were verbatim transcribed after being reviewed and digitally recorded. The Arabic and English interviews were transcribed by the investigator using a transcription website (147). The Arabic interviews was translated into English and then back-translated into Arabic to ensure lexical equivalence. The translation was carried out by the investigator and an English- and Arabic-speaking translator.

4.5.8 Data analysis

The qualitative data were analysed manually using the technique of framework analysis (148), comprising the four NPT mechanisms and their sub-constructs. To initiate this procedure, the transcripts were read and reread to ensure there was a thorough understanding of the data. Next, a list of important elements were created and coded into potential themes, guided by NPT's components. The NPT toolkit was used to understand how well the data related to each main construct in this instance (149). Some data, such as information on barriers and facilitators, did not fit within the existing constructs of NPT. Since NPT does not explicitly address barriers and facilitators, the data was organized to highlight factors that may constrain staff engagement, as well as those that support it.

There was post-analysis discussion and confirmation of the themes. Two members of the research team (HA and GM) reread the data to investigate any connections between the codes to create coherent themes prior to refining, generating definitions, and distinguishing the content of each NPT construct. This was done to enhance analytical validity.

Finally, ongoing analysis was conducted to refine each theme, and themes were assigned distinct definitions in order to produce an analysis report. This repetitive process persisted until complete agreement was reached, resulting in the final/last formulation of the questions' answers. In order to guarantee the validity of the final list of themes, the extent of their representation in the transcribed data was examined.

4.6 Integration of quantitative and qualitative findings

Mixed methods research can be significantly enhanced by integrating quantitative and qualitative data (150). Use of quantitative data can contribute to creating a qualitative sample or explaining qualitative findings, and the validity of quantitative findings can be assessed by qualitative data.

This study conducted a narrative approach to combine the quantitative and qualitative findings (151). Areas of agreement and dissonance were identified. In addition, an explanation of how some of the quantitative findings could be considered as rational for some qualitative findings and vice versa was generated. The qualitative and quantitative data were also integrated using a map to show how they were matched, using differently coloured arrows, with each colour representing a specific match.

4.7 Philosophical Stance

The coherence of a research project depends on the awareness of the researcher's philosophical stance. Ontology concerns ‘What is there to know?’ (152). It entails the assumptions we make about reality and what exists (153). A realist ontology stands at one end of the ontology continuum, proposing an objective reality external to human experience which can be directly accessed through research, regardless of human knowledge of it (154). At the other end of the spectrum, a relativistic ontology posits that reality cannot be separated from human interpretation and knowledge (154). While I value both realistic and relativistic aspects, I do not claim to be on either side of the ontology continuum. My philosophy holds that there is a reality independent of our knowledge and understanding of it, as well as socially constructed dimensions of reality that depend on social and contextual factors (155). In short, the two versions of ontology need not be mutually exclusive.

Epistemology explores the question of 'What can we know and how?' (152). According to Moon and Blackman (2017), epistemology deals with various aspects related to the validity, scope, and methods of obtaining knowledge. This includes a) what qualifies as a claim of knowledge, b) the processes through which knowledge can be gained or created, and c) how to evaluate the extent to which it can be applied in different contexts (153). I believe knowledge is subjective and is acquired through interpretation of the social world. Therefore, in my perspective, reality does not possess a one truth, but rather encompasses various truths that emerge via the process of interpretation. As a consequence, I have approached the research from a critical realist perspective, based on my ontological and epistemological beliefs.

In critical realism, an independent reality exists, but its knowledge is not directly accessible (156). It is assumed that our understanding of the real world is incomplete since what we understand and learn is not an indicative of what is occurring directly, instead proposing an interpretation of it (157). Peoples' experiences and views are subjective because they can only be understood and recognised via the interpretation or meaning they are given by the individuals. In exploring participants views and experiences in the implementation of IPC guidelines. I, as a researcher, aim to interpret the stories the participants construct about IPC implementation. I acknowledge my contributions by using a structured topic guide to ensure consistency across all interviews and integrating the findings with data from the questionnaires used in the quantitative study.

4.8 Reflexivity

In qualitative research, the researcher's function and relationship with the research design are crucial factors (158). The researcher's role revolves around an insider's and an outsider's viewpoint of the research object. Having been born and raised in the KSA, I have an insider's perspective which afforded me the ability to investigate/examine with a native's eye in a context where extensive personal and professional experience is important (159). As a result, participating healthcare practitioners (particularly laboratory personnel and infection control professionals) may have felt more comfortable expressing their opinions, as they appeared to value the comprehension of those around them. Being an insider also provided additional insights into the participants' perspectives, having been a laboratory trainee at KFSH at various stages in my life. This was especially crucial for interpreting the research data. There are drawbacks to being an insider. In particular, familiarity with and knowledge of the people and system under investigation may result in the unintentional exclusion of some potentially significant research-related data because they are too 'obvious' to include. However, through precision and consistency in research methods, elimination of ethical bias can be possible. Moreover, since Newcastle University is my 'research home', this may have afforded me some 'distance' from the research object.

In order to gather and analyse data effectively, researchers should reflect upon their professional backgrounds and personal characteristics (160), in addition to consider of the impact of the researcher's professional background on the interaction between him/her as a researcher and the participants (161). The participants perceptions of the researcher's role may influence the interview content. Despite the researcher being introduced to the participants as a university researcher, having been a laboratory trainee in one of the hospitals meant that the researcher's name was familiar to some of the participants. Therefore, those participants who knew that the researcher was originally a clinician may have felt more comfortable answering the questions, leading to detailed information regarding the situation in their hospital, including frank discussion of the possible solutions to what they deemed poor attitudes towards IPC guidelines. In contrast, those participants who only know the researcher as a university researcher may have provided information that answered the interview questions more narrowly, failing to elaborate in more depth. Both groups of participants contributed sound and solid data, but the additional information acquired from those who knew the researcher as a clinician may be deemed to have helped inform future research.

4.9 Administration Aspects and Ethical Considerations

Ethical approval was obtained from the Faculty of Medical Science, Ethics Committee, Newcastle University No. (9143/2020) (see Appendix G). Ethical approval was also obtained from the Research Committee and the Ethics Committee of the MNG-HA (represented by King Abdullah International Medical Research Centre (KAIMRC)), KAIMRC No. (roj-data/om/2021/rc/264) (see Appendix H). In addition, the research was approved by the local Research Ethics Committee of the MoH to conduct the study at KFSH-Buraydah No. (1442-

2157821) (see Appendix I). Verbal approval was obtained from the administration of HNH to start the data collection there.

The confidentiality and anonymity of participants and staff were strictly maintained. All collected data were handled with utmost privacy, and the identities of participants were kept confidential.

Finally, the investigator prepared the data collection materials, distributed and set up the questionnaires, arranged Zoom interviews with the participants, and designed and purchased vouchers.

This chapter has discussed issues related to the collection and analysis of data. It has described the methodological route followed throughout the study's investigation and provided a comprehensive overview of the data collection strategy used. The research tools and methodology were emphasised, and a mixed-method approach used was proposed and defended.

Chapter 5 Results of Quantitative Research

This chapter presents the results of the questionnaire. The findings concerning the participants' knowledge, attitudes, practices, knowledge of PEP and perceptions of IPC implementation are presented in this chapter. The sociodemographic characteristics of the study participants, their occupational characteristics, immunisation status, training, as well as their scores regarding knowledge, attitudes, practices, knowledge of PEP and perceptions of IPC implementation are also reported.

5.1 Sociodemographic characteristics

Out of 295 staff members working across the three hospitals, only 110 completed the study questionnaire: 43 from KAMC, 44 from KFSH, and 23 from HNH (see Table 5.3), resulting in a response rate of approximately 37.3%. The majority of the participants were aged 31-40 years and had more than 10 years of working experience in the field (see Table 5.1). The median age of the participants was 36 years old (inter-quartile range 32-41). The median length of relevant work experience was 11 years (inter-quartile range 6-16).

Table 5.1: Sociodemographic characteristics (1) (n=110)

Characteristics	Frequency	%
Age (years)		
>30	22	20.00
31-40	59	53.64
42<	29	26.36
Years of experience (years)		
>10	50	45.45
11-20	46	41.82
21<	14	12.73

As shown in Table 5.2, more than half of the participants were male, about three-quarters of the participants were Saudis while a quarter were from other nationalities.

Table 5.2: Sociodemographic characteristics (2) (n=110)

Characteristics	Frequency	%
Gender		
Female	47	42.37
Male	63	57.27
Nationality		
Saudi	77	70
Filipino	12	10.91
Sudanese	5	4.55
Egyptian	4	3.64
Indian	4	3.64
Jordanian	3	2.73
Others[1]	5	4.55

Others[1](F): European (1), Pakistani (1), Yemen (1), Missing (2).

5.2 Occupational characteristics

Sixty percent of the participants were bachelor's degree holders, and the majority were laboratory specialists (see Table 5.3).

Table 5.3: Educational and job characteristics (n=110)

Characteristics	Frequency	%
Highest level of education		
PhD	10	9.09
Masters	23	20.91
Bachelor	66	60
Diploma	9	8.18
Others[1]	2	1.82
Location of practice		
King Abdulaziz Medical City	43	39.09
King Fahad Specialist Hospital	44	40.00
Hayat National Hospital	23	20.91
Occupation		
Laboratory Specialist	56	50.91
Laboratory Technician	19	17.27
Infection Control Specialist	10	9.09
Laboratory Consultant Doctor	6	5.45
Nurse	5	4.55
Admin	3	2.73
Phlebotomist	2	1.82
Others[2]	9	8.18
Specialty		

Medical Laboratory[1]	69	62.71
Public Health	6	5.45
Infection Control	5	4.55
Health Management	4	3.64
Nurse	3	2.73
Laboratory Medicine	2	1.82
Others[3]	6	5.46
Missing[1]	15	13.64
Position		
Laboratory Staff	43	39.09
Laboratory Supervisor	8	7.27
Infection Control Practitioner	8	7.27
Laboratory Consultant	6	7.23
Quality Officer	5	5.45
Admin	3	2.73
Public Health Nurse	3	2.73
Assistant Consultant Infection Control	2	1.82
Others[4]	5	5.55
Missing[2]	27	24.55

Others[1](F): Secondary (1), Fellowship (1).
Others[2] (F): Environmental Health Specialist (2), Health Management Specialist (2), Physician (1), Quality Manager (1), Missing (3).
Medical Laboratory[1](F): Microbiology (11), Hematology (7), Biochemistry (6), Immunology (4), Blood Bank (4), Phlebotomy (3), Pathology (2), Histopathology (2), Parasitology (1), Virology (1), Serology (1), Molecular Genetics (1), Cytogenetics (1), reported medical laboratory as a specialty (24).
Others[3](F): Environmental Health (2), Preventive Medicine (4).
Others[4](F): Public Health Supervisor (1), Emergency Nurse (1), Environmental Health Specialist (2), Vice President (1).

5.3 Training in IPC guidelines

More than three-quarter of the participants had received training in IPC guidelines, 39 of whom have received on-the-job training while a similar proportion had received both on-the-job training and formal mandatory training (see Table 5.4).

Table 5.4: Training in IPC guidelines (n=110)

Item	Frequency	%
1-Have you received training in IPC guidelines?		
Yes	92	83.64
No	18	16.36
2-Type of workplace training received		
On-the-job training	39	35.45
Formal mandatory training	7	6.36
Both	38	34.55
None	18	16.36
Missing[1]	8	7.27
3-What type of training you have attended?		
Generic local induction health and safety training	72	65.45
National training	12	10.91
None	18	16.36
Missing[2]	8	7.27
4-Any specific training?		
1-Biological hazard groups	40	47.62
2-Personal protective equipment	67	79.76
3-Risk assessment training	40	47.62
4-Sharps training	43	51.19
5-Decontamination training	39	46.43
6-Spillage training	60	71.43
7-Post exposure prophylaxis training	25	29.76
None	18	16.36
Other[1]	3	3.57
Missing[3]	8	7.27
Note: the responses were not mutually exclusive.		

Missing[1&2&3] (F): 8 participants did not answer these questions in the survey
Other(F): Employee health, infectious diseases and epidemiology (1), fire safety (1), patient safety (1).

5.4 Competence assessment for health and safety

More than three-quarters of the participants reported the availability of a competence assessment process for health and safety in their laboratories, and 62.73% out of 78 who reported this said that this process is reviewed and re-assessed annually (see Table 5.5).

Table 5.5: Competence assessment for health and safety (n=110)

Item	Frequency	%
1-Is there any process of competence assessment for health and safety?		
Yes	78	70.91
No	24	21.82
Missing[1]	8	7.27
2-Is this reviewed and re-assessed annually?		
Yes	69	62.73
No	6	5.45
None	24	21.82
Missing[1]	11	10.00

Missing[1](F): 8 participants did not answer the question in the survey.
Missing[2](F): 11 participants did not answer these questions in the survey

5.5 Immunisation status

As shown in Table 5.6, most of the participants received a pre-employment health assessment for previous immunisation records when they joined their current workplace (N=86), and were offered vaccinations. Only three did not take any vaccinations. The majority completed three doses of HBV vaccine (N=72). In contrast, only one participant indicated that they had received a typhoid vaccine.

Table 5.6: Immunisation status (n=110)

Item	Frequency	%
1-Pre-employment health assessment for previous immunization records when joined current workplace		
Yes	86	78.18
No	13	11.82
Missing[1]	11	10.00

2-Have you been offered vaccination(s)?		
Yes	95	86.36
No	4	3.64
Missing[2]	11	10.00
3-If you have been offered vaccination(s), did you take it?		
Yes	92	83.64
No	3	2.73
None	4	3.64
Missing[3]	11	10.00
4-Vaccines received as part of occupational health vaccination		
1- Completed three doses of HBV vaccine	72	78.26
2- Influenza vaccine	66	71.74
3-Two doses of MMR[2] vaccine	19	20.65
5-Meningococcal vaccine	23	25.00
6-Rabis vaccine	2	2.17
7-Tetanus diphtheria vaccine	4	4.35
8-Hepatitis A vaccine	8	8.70
9-Tetanus diphtheria Acellular pertussis	6	6.52
10-Typhoid vaccine	1	1.09
11-BCG[3] vaccine	9	9.78
12-Varicella vaccine	9	9.78
13-Polio vaccine	8	8.70
14-Cholera vaccine	2	2.17
None	7	6.37
Missing[4]	11	10.00
Note: the responses were not mutually exclusive.		

Missing[1&2&3&4](F): 11 participants did not answer these questions in the survey.

[2] Measles, mumps and rubella
[3] Bacillus Calmette-Guérin

5.6 Exposure to injury and PEP

Only 13 participants reported that they had an injury while working in the laboratory, and most were injured through a needle stick (n=9). Exposure to blood was the highest exposure type reported by the participants (N=10). Among those who have been exposed via an injury, only six indicated that they took PEP following the exposure (see Table 5.7).

Table 5.7: Exposure to injury and PEP (n=110)

Item	Frequency	%
1-Have you been exposed to any injury?		
Yes	13	11.82
No	79	71.82
Missing[1]	18	16.36
2-Through which of the following you have been exposed?		
1-Needle stick	9	69.23
2-Sharp instrument	4	30.77
N/A	79	71.82
Other[1]	2	15.38
Missing[2]	18	16.36
3-To what of the following have you been exposed?		
1-blood	10	76.92
2-other body fluids	2	15.38
3-body tissues	3	23.08
4-body secretions	3	23.08
4-Did you take PEP following the exposure?		
Yes	6	5.45
No	7	6.36
N/A	79	71.82
Missing[3]	18	16.36

Missing[1&2&3](F): 18 participants did not answer these questions in the survey.
Other[1](F): Coronavirus (1), Glass (1).

5.7 Participants’ awareness and knowledge of the IPC guidelines

Almost all the participants expressed having knowledge of IPC guidelines. While over half said they had ‘enough’ knowledge, 35 said their knowledge was ‘not enough’ (see Table 4.8).

Table 5.8: Knowledge level and source of information (n=110)

Knowledge level and source of information	Frequency	%
1-Do you think you have information about IPC guidelines?		
Yes, enough	52	47.27
Yes, but not enough	35	31.82
No	0	0
Missing[1]	23	20.91
2-Main source of knowledge		
1-TV/Radio	11	12.64
2-Newspaper/magazine	5	5.75
3-Internet	37	42.53
4-Colleagues	41	47.13
5-Education	42	48.28
6-Family	3	3.45
7-Hospital/laboratory standard operating procedures	52	59.77
8-Hospital/laboratory policies	68	78.16
9-Occupational training courses	29	33.33
10-National guidelines[1]	8	9.20
12-International guidelines[2]	11	12.64
Note: the responses were not mutually exclusive.		

Missing[1](F): 23 participants did not answer the question in the survey.
National guidelines[1](F): MoH Policy (4), MoH Policy and CDC (1), MoH Policy and CBAHI accreditation standards (1), CBAHI accreditation standards (1), Public Health Authority and General Administration for IPC of Health Facilities at MoH (1).
International guidelines[2](F): CDC (4), APIC (1), WHO (1), CAP guidelines (1), CDC and WHO (1), JCI and CAP guidelines (1), CDC, APIC and OSHA (1), CDC, WHO, CAP and JCIA accreditation standards (1).

The participants' responses to knowledge questions are shown in Table 5.9. The vast majority of the answers are correct, although 23 did not answer any of the knowledge questions.

Table 5.9: Knowledge about IPC guidelines (n=110)

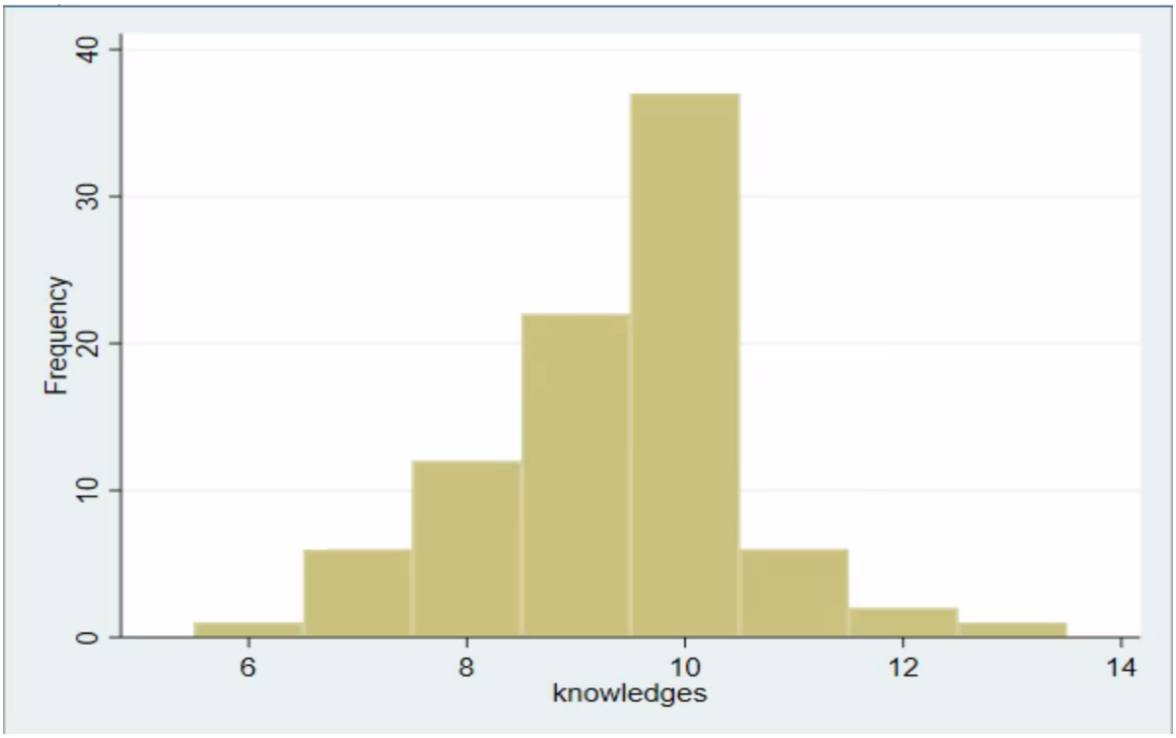
Knowledge of IPC guidelines	Frequency	%
1-IPC guidelines should apply to situations that might lead to contact with blood		
TRUE	84	76.36
FALSE	2	1.82
I don't know	1	0.91
2-IPC guidelines are not necessary for situations that might lead to contact with saliva		
TRUE	5	4.55
FALSE	79	71.82
I don't know	3	2.73
3-IPC guidelines are not applied to patients with HIV and hepatitis only.		
TRUE	77	70.00
FALSE	10	9.09
I don't know	0	0
4-IPC guidelines should not apply to situations that might lead to contact with urine or faeces.		
TRUE	7	6.36
FALSE	77	70.00
I don't know	3	2.73
5-IPC guidelines should be applied to all persons regardless of their infectious status.		
TRUE	83	75.45
FALSE	4	3.64
I don't know	0	0
6-For decontamination of equipment and devices, washing with the usual detergent is enough.		
TRUE	14	12.73
FALSE	70	63.64
I don't know	3	2.73

7-Blood spills should be cleaned up promptly with the hospital-approved disinfectant.		
TRUE	68	61.82
FALSE	17	15.45
I don't know	2	1.82
8-A face mask should be worn for all procedures where blood and body fluids may splash.		
TRUE	80	72.73
FALSE	7	6.36
I don't know	0	0
9-Gloves should be worn for all procedures that may involve contact with blood and body fluids.		
TRUE	86	78.18
FALSE	1	0.91
I don't know	0	0
10-Eye protection should be worn for all procedures where blood and body fluids may splash.		
TRUE	81	73.64
FALSE	3	2.73
I don't know	3	2.73
11-Hands should always be washed after gloves are removed.		
TRUE	84	76.36
FALSE	2	1.82
I don't know	1	0.91
12-Used needles and sharp instruments should be disposed of separately from other waste.		
TRUE	87	79.09
FALSE	0	0
I don't know	0	0
13- Used needles should *not* be recapped.		
TRUE	59	53.64
FALSE	26	23.64
I don't know	2	1.82
Missing[1] in all items	23	20.91

Missing[1](F): 23 participants did not answer these questions in the survey.

The knowledge score is the sum of correct responses to the questions; one point is given for the correct answer and zero for a wrong answer or "I do not know". As the questions were set with the choice TRUE as the correct answer, if a participant chose TRUE, they were given one point, and if they chose FALSE or "I don't know", they were given zero, except for questions 4, 6 and 8. Only one participant recorded the highest score, and only one recorded the lowest score, while 37 of the participants had a score of 10 (see Figure 5.1). The mean knowledge score was 9.36 (SD1.22).

Figure 5.1: Participants' scores for knowledge of IPC guidelines.



The knowledge score variable is normally distributed based on the results of skewness and kurtosis tests (P= 0.29).

5.8 Knowledge of PEP

The participants' responses to knowledge of PEP questions are shown in Table 5.10. Most participants answered the questions correctly, while only 23 did not answer any of the questions.

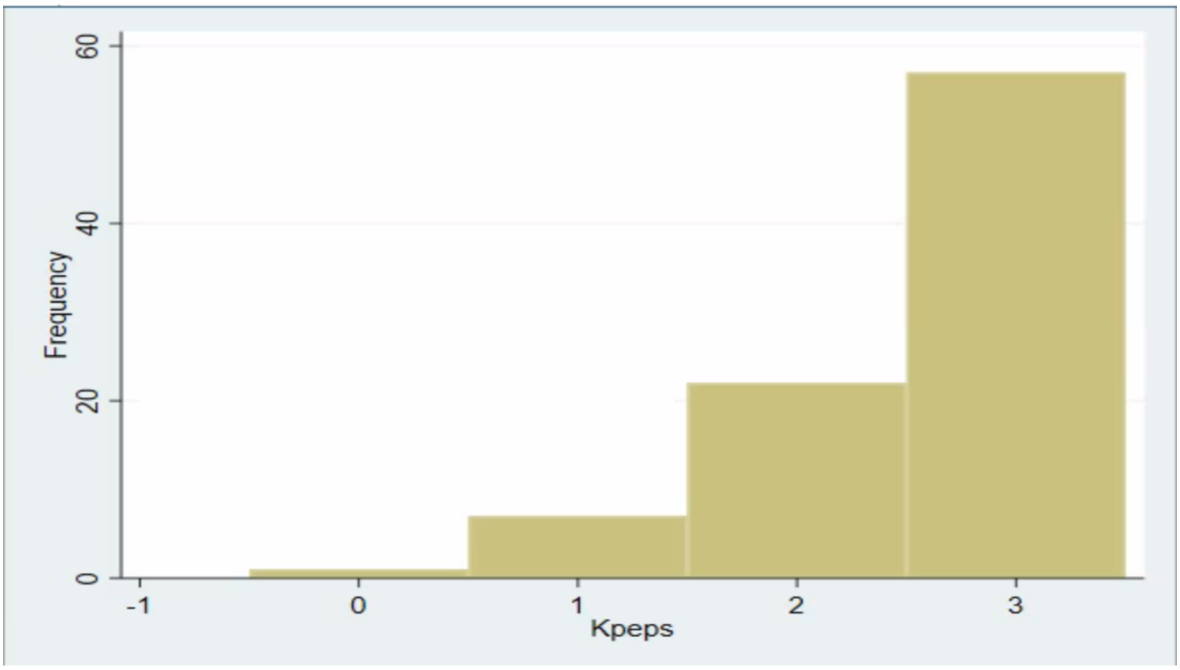
Table 5.10: Knowledge of PEP (n=110)

Knowledge of PEP	Frequency	%
1-First aid measure that should be applied immediately following a needle stick injury		
Wash thoroughly with soap and water	72	65.45
Bandage appropriately	3	2.73
I don't know	12	10.91
2-Mucocutaneous and non-intact skin exposures should be irrigated with water or appropriate eyewash.		
TRUE	66	60.00
FALSE	6	5.45
I don't know	15	13.64
3-After applying the first aid, the line manager or supervisor should be informed.		
TRUE	84	76.36
FALSE	2	1.82
I don't know	1	0.91
Missing[1] in all items	23	20.91

Missing[1](F): 23 participants did not answer the question in the survey.

A score of 0 was recorded for one participant only, while most of the participants had a score of 3 (see Figure 5.2). The median score of participant knowledge of PEP was 3 (inter-quartile range 2-3).

Figure 5.2: Participants' scores for knowledge of PEP



The knowledge of PEP score variable is not normally distributed based on the results of skewness and kurtosis tests (P<0.001).

5.9 Participants' attitudes towards the IPC guidelines

The participants' responses to attitude questions are shown in Table 5.11. With few exceptions, the participants agreed that IPC guidelines are useful and HCWs must be aware of all IPC guidelines. Furthermore, most participants agreed that laboratory staff should be immunised against HBV. When the participants were asked about their perceptions of whether staff can eat, drink and store food and water in a laboratory refrigerator, approximately a quarter of them stated they would disagree and the majority reported that they cannot apply cosmetics and smoke in the laboratory. Most of the participants agreed on that staff should wear protective equipment, should not pipet with their mouth, training on IPC guidelines should always be provided and it is essential to take post-exposure prophylaxis after exposure to potential HIV or HBV infections.

Table 5.11: Attitudes towards IPC guidelines (n=110)

Attitudes towards IPC guidelines	Frequency	%
1-IPC guidelines are useful in protecting against hazards in the workplace.		
Strongly agree	75	68.18
Agree	7	6.36
Neither agree nor disagree	2	1.82
Disagree	0	0.0
Strongly disagree	0	0.0
I don't know	0	0.0
2- HCWs must be aware of all the IPC guidelines applicable to their work.		
Strongly agree	81	73.64
Agree	3	2.73
Neither agree nor disagree	0	0.0
Disagree	0	0.0
Strongly disagree	0	0.0
I don't know	0	0.0
3-Staff should take immunisation against HBV		
Strongly agree	76	69.09
Agree	8	7.27
Neither agree nor disagree	0	0.0
Disagree	0	0.0
Strongly disagree	0	0.0
I don't know	0	0.0
4-Do you think staff cannot eat, and drink and use a mobile phone in the laboratory?		
Strongly agree	28	25.45
Agree	17	15.45
Neither agree nor disagree	16	14.55
Disagree	4	3.64
Strongly disagree	19	17.27
I don't know	0	0.0

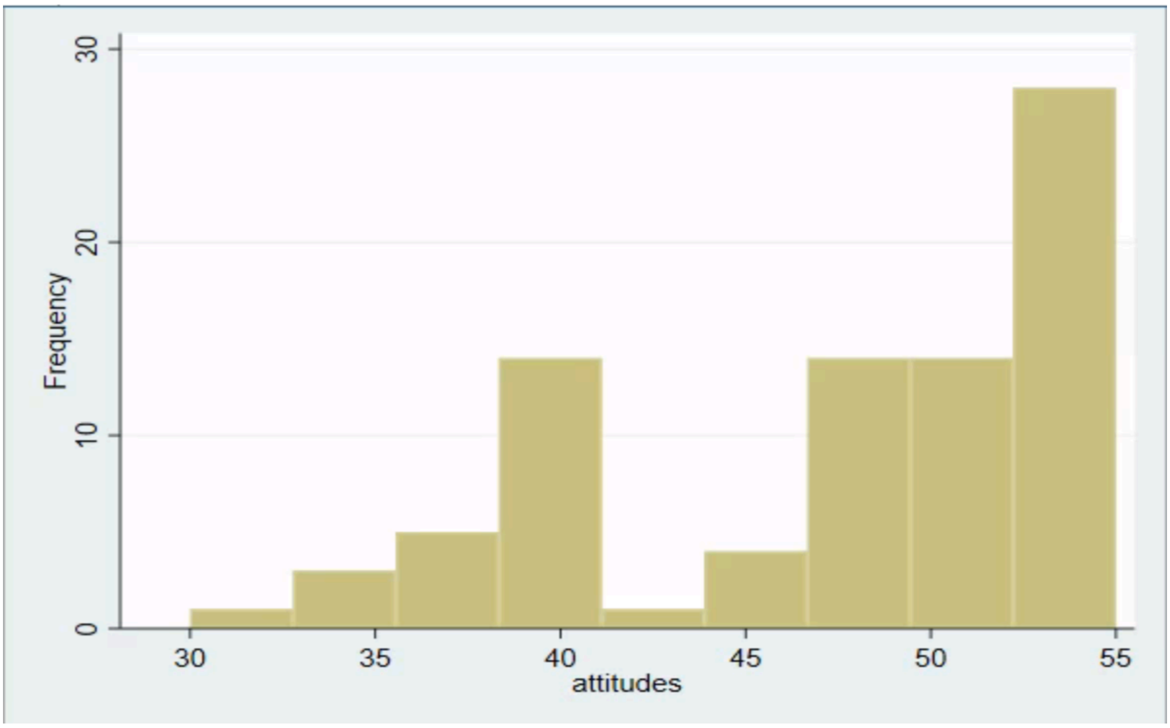
5-Do you think staff cannot store food and water in the refrigerator for body fluids, drugs, chemicals or other specimens?		
Strongly agree	49	44.55
Agree	10	9.09
Neither agree nor disagree	1	0.91
Disagree	0	0.0
Strongly disagree	23	20.91
I don't know	1	0.91
6-Do you think staff cannot apply cosmetics and smoke in the laboratory?		
Strongly agree	44	40.00
Agree	15	13.64
Neither agree nor disagree	1	0.91
Disagree	1	0.91
Strongly disagree	22	20.00
I don't know	1	0.91
7-Do you think staff should wear protective equipment to limit touching their face/nose/ear during work?		
Strongly agree	46	41.82
Agree	32	29.09
Neither agree nor disagree	2	1.82
Disagree	2	1.82
Strongly disagree	2	1.82
I don't know	0	0.0
8-Do you think staff cannot pipet with their mouth?		
Strongly agree	47	42.73
Agree	9	8.18
Neither agree nor disagree	1	0.91
Disagree	4	3.64
Strongly disagree	19	17.27
I don't know	4	3.64
9-Do you believe that employers should always provide training in IPC guidelines?		
Strongly agree	65	59.09
Agree	16	14.55
Neither agree nor disagree	1	0.91

Disagree	1	0.91
Strongly disagree	1	0.91
I don't know	0	0.0
10-Do you believe that proper disinfection of all materials is an essential measure for prevention of and protection against disease transmission in the laboratory?		
Strongly agree	70	63.64
Agree	13	1.82
Neither agree nor disagree	0	0.0
Disagree	1	0.91
Strongly disagree	0	0.0
I don't know	0	0.0
11-Do you believe it is essential to take PEP after exposure to HIV or HBV infections?		
Strongly agree	64	58.18
Agree	15	13.64
Neither agree nor disagree	0	0.0
Disagree	1	0.91
Strongly disagree	2	1.82
I don't know	2	1.82
Missing[1] in all items	26	23.64

*Missing[1](F): 26 participants did not answer these questions in the survey.

Based on the original questions in the questionnaire, if the participant chose 'strongly agree', they were given 5 points; 'agree' = 4 points; 'neither agree nor disagree' = 3 points; 'disagree' = 2 points; 'strongly disagree' = 1 point and 0 for 'I don't know'. As shown in Figure 5.3, only 14 participants had the maximum score of 55. The median score was 49.5 (inter-quartile range 40-53).

Figure 5.3: Participants scores on attitude questions towards IPC guidelines.



The attitude score variable is not normally distributed based on the results of skewness and kurtosis tests (P= 0.005).

5.10 Participants' practices of the IPC guidelines

The participants' responses to the practice questions are shown in Table 5.12. The majority of the participants always practiced IPC guidelines including disposing all blood-contaminated items into a suitable waste bag, covering their wound(s) or lesion(s) with a plaster or bandage before coming to work, changing damaged gloves, taking extra care when using scalpels, needles, razors, or other sharp objects, and reporting injuries and spills accidents. More than half of the participants wear gloves, a face mask and a laboratory coat when dealing with blood and body-fluids samples, wash their hands after removing gloves, and decontaminate surfaces and devices after use. Of the participants, 41.82% do not recap needles after use and 40% reported wearing eye protection (goggles/glasses) whenever there is a possibility of blood or other body fluids splashing. Twenty-seven participants did not answer the questions in the survey.

Table 5.12: Practices of IPC guidelines (n=110)

Practices of IPC guidelines	Frequency	%
1-I dispose of all blood-contaminated items into a bag or bucket designated for disposal.		
Always	71	64.55
Often	3	2.73
Sometimes	2	1.82
Never	0	0.0
Not relevant to my role	7	6.36
2-I wear gloves when I am exposed to body fluids or blood products.		
Always	68	61.82
Often	7	6.36
Sometimes	1	0.91
Never	0	0.0
Not relevant to my role	7	6.36
3-I cover any wound(s) or lesion(s) that might come in contact with patients' blood and other body fluids with plaster or bandage before coming to work.		
Always	72	65.45
Often	4	3.64
Sometimes	2	1.82
Never	0	0.0
Not relevant to my role	5	4.55
4-I wash my hands immediately after the removal of disposable gloves.		
Always	63	57.27
Often	11	10.00
Sometimes	5	4.55
Never	0	0.0
Not relevant to my role	4	3.64
5-I change gloves when they are damaged.		
Always	72	65.45
Often	7	6.36
Sometimes	0	0.0

Never	0	0.0
Not relevant to my role	4	3.64
6-I decontaminate surfaces and devices after use.		
Always	58	52.73
Often	15	13.64
Sometimes	6	5.45
Never	0	0.0
Not relevant to my role	4	3.64
7-I wear a disposable facemask whenever there is a possibility of blood or other body fluids splashing in my face.		
Always	63	57.27
Often	10	9.09
Sometimes	4	3.64
Never	1	0.91
Not relevant to my role	5	4.55
8-I wear a laboratory coat whenever there is a possibility of blood or other body fluids splashing on my clothes.		
Always	50	45.45
Often	9	8.18
Sometimes	14	12.73
Never	3	2.73
Not relevant to my role	7	6.36
9-I do not recap needles after use		
Always	46	41.82
Often	2	1.82
Sometimes	4	3.64
Never	15	13.64
Not relevant to my role	16	14.55
10-I wear eye protection (goggles/glasses) whenever there is a possibility of blood or other body fluids splashing in my face.		
Always	44	40.00
Often	10	9.09
Sometimes	7	6.36
Never	13	11.82
Not relevant to my role	9	8.18
11-I take extra care when using scalpels, needles, razors, or other sharp objects.		

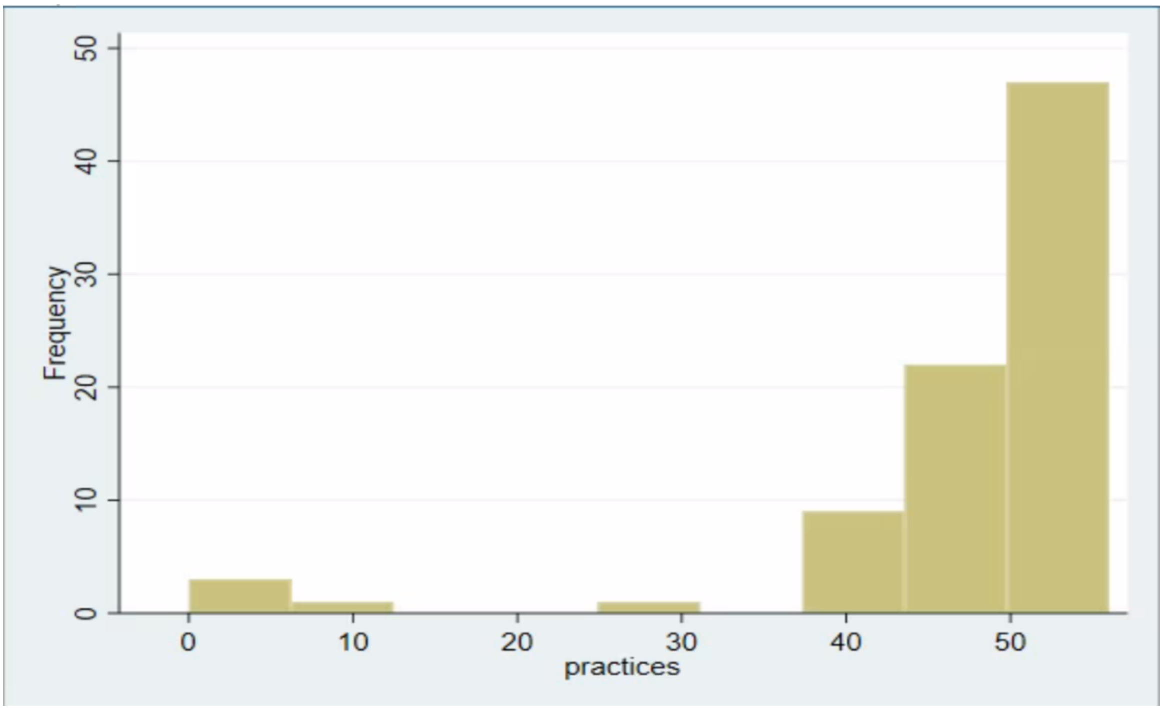
Always	70	63.64
Often	3	2.73
Sometimes	0	0.0
Never	0	0.0
Not relevant to my role	10	9.09
12-I report injuries and spills accidents.		
Always	70	63.64
Often	8	7.27
Sometimes	4	3.64
Never	0	0.0
Not relevant to my role	1	0.91
Missing[1] in all items	27	24.5

Missing[1](F): 27 participants did not answer these questions in the survey.

Based on the practice questions in the questionnaire, if a participant chose ‘always’, they were given 4 points; ‘often’ = 3 points; ‘sometimes’ = 2 points; ‘never’ = 1 point; and 0 for ‘not relevant to my role’.

A 0 score was recorded for one participant only, and the maximum score of 56 points was recorded for 17 participants (see Figure 5.4). The median score was 51 (inter-quartile range 45-55).

Figure 5.4: Participants scores on the practice questions towards IPC guidelines.



The practice score variable is not normally distributed based on the results of skewness and kurtosis tests (p<0.001).

5.11 Participants' perceptions of the implementation of the IPC guidelines

The participants' responses to questions concerning perceptions of the implementation of IPC guidelines are shown in Table 5.13. More than half agreed that the staff at their organisations have the same understanding of the purpose of IPC guidelines and that certain key people drive the guidelines forward and get others involved. Furthermore, most participants agreed that IPC guidelines have some potential value for their work and believe that participating in them is a legitimate part of their role. Almost half of the participants reported that sufficient training is provided and they have sufficient resources and necessary equipment to enable staff to implement the guidelines, and this is accompanied by management support and the use of feedback about IPC guidelines to improve them in the future. When asked about their perceptions of whether IPC guidelines disrupt working relationships, 30% of the respondents stated they agree, the same proportion said they disagree and 13.64% were neutral. A total of 30 participants did not answer these questions in the survey.

Table 5.13: Perceptions of the implementation of IPC guidelines (n=110

Perceptions of the implementation of IPC guidelines	Frequency	%
1-Staff at this organisation have the same understanding of the purpose of IPC guidelines.		
Strongly agree	32	29.09
Agree	27	24.55
Neither agree nor disagree	14	12.73
Disagree	2	1.82
Strongly disagree	2	1.82
I don't know	3	2.73
2-I can see the potential value of the IPC guidelines for my work.		
Strongly agree	47	42.73
Agree	27	24.55
Neither agree nor disagree	5	4.55
Disagree	0	0.0
Strongly disagree	1	0.91
I don't know	0	0.0
3-There are key people who drive the IPC guidelines forward and get others involved.		
Strongly agree	36	32.73
Agree	33	30.00
Neither agree nor disagree	10	9.09
Disagree	0	0.0
Strongly disagree	1	0.91
I don't know	0	0.0
4-I believe that participating in the IPC guidelines is a legitimate part of my role.		
Strongly agree	52	47.27
Agree	27	24.55
Neither agree nor disagree	1	0.91
Disagree	0	0.0
Strongly disagree	0	0.0

I don't know	0	0.0
5-I will continue to support the IPC guidelines.		
Strongly agree	56	50.91
Agree	24	21.82
Neither agree nor disagree	0	0.0
Disagree	0	0.0
Strongly disagree	0	0.0
I don't know	0	0.0
6-The IPC guidelines disrupt working relationship (e.g., creating additional communication barriers or leading to misunderstandings between team members).		
Strongly agree	10	9.09
Agree	23	20.91
Neither agree nor disagree	15	13.64
Disagree	12	10.91
Strongly disagree	19	17.27
I don't know	1	0.91
7-Sufficient training is provided to enable staff to implement IPC guidelines.		
Strongly agree	36	32.73
Agree	28	25.45
Neither agree nor disagree	10	9.09
Disagree	4	3.64
Strongly disagree	1	0.91
I don't know	1	0.91
8-Sufficient resources and necessary equipment are available to support IPC guidelines.		
Strongly agree	36	32.73
Agree	33	30.00
Neither agree nor disagree	7	6.36
Disagree	4	3.64
Strongly disagree	0	0.0
I don't know	0	0,0
9-Management adequately supports the IPC guidelines.		
Strongly agree	35	31.82
Agree	34	30.91

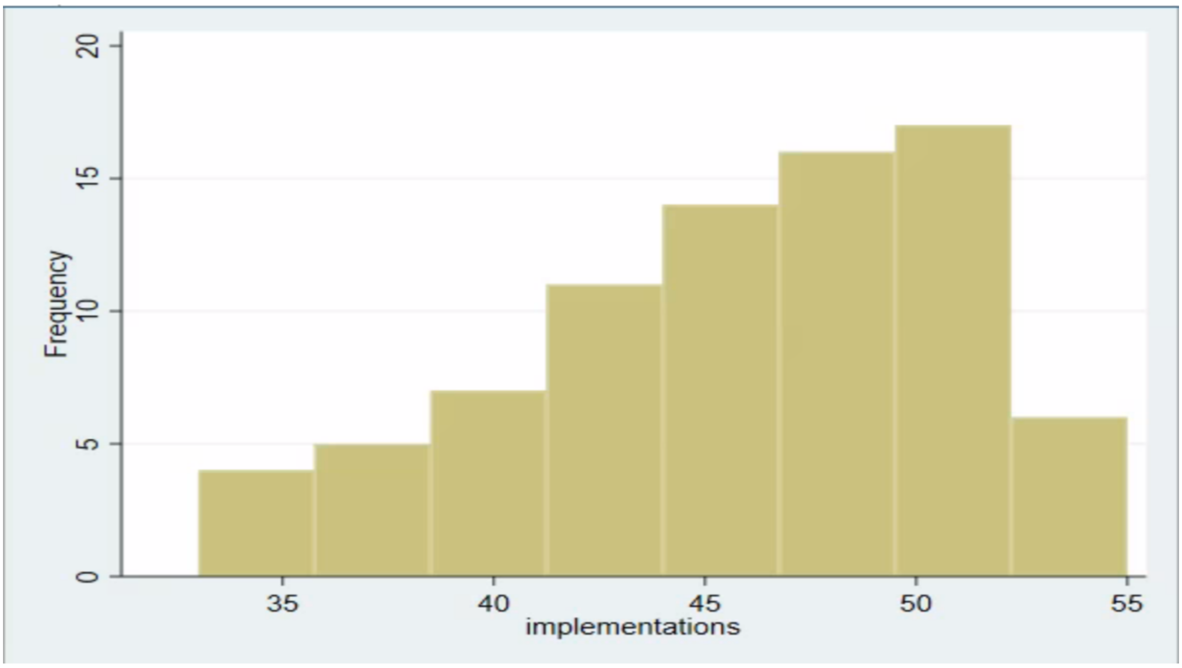
Neither agree nor disagree	8	7.27
Disagree	1	0.91
Strongly disagree	0	0.0
I don't know	2	1.82
10-Feedback about the IPC guidelines can be used to improve them in the future.		
Strongly agree	36	32.73
Agree	27	24.55
Neither agree nor disagree	11	10.00
Disagree	4	3.64
Strongly disagree	2	1.82
I don't know	0	0.0
11-I can modify how I work with the IPC guidelines.		
Strongly agree	25	22.73
Agree	37	33.64
Neither agree nor disagree	16	14.55
Disagree	1	0.91
Strongly disagree	0	0.0
I don't know	1	0.91
Missing[1] in all items	30	27.27

Missing[1](F): 30 participants did not answer these questions in the survey.

Based on the original questions in the questionnaire, if the participant chose 'strongly agree', they were given 5 points; 'agree = 4 points; 'neither agree nor disagree' = 3 points; 'disagree' = 2 points; 'strongly disagree' = 1 point; and 0 for 'I don't know'.

The majority of the participants scored 51 points, with only four getting the maximum of 55 (see Figure 5.5). The mean score of participants' perceptions of the implementation of IPC guidelines was 45.66 (SD5.46).

Figure 5.5: Participants' scores for perceptions of the implementation of IPC guidelines



The perceptions of the variable for the IPC implementation scores are normally distributed based on the results of skewness and kurtosis tests (p= 0.17).

5.12 IPC knowledge score and sociodemographic characteristics

A Spearman's correlation was run to assess the relationship between the participants' knowledge of IPC scores with their age and years of experience. There was a very weak positive correlation between the knowledge score and age, with IPC knowledge increasing with age. There was a very weak negative correlation between the knowledge score and years of experience. Neither result was statistically significant (see Table 5.14).

Table 5.14: IPC knowledge score, age and years of experience

Characteristic	Spearman's correlation coefficient	p-value*
Age	0.02	0.83
Years of experience	-0.07	0.53

* Based on Spearman's correlation test

A t-test was run on the data with a 95% confidence interval (CI) to compare the differences between the participants' IPC knowledge scores with gender and training. As shown in Table 5.15, both gender and training results were non-statistically significant.

Table 5.15: IPC knowledge score, gender and training

Characteristic	Mean	SD	t-value	p-value*
Gender				
Female	9.49	1.12	0.82	0.41
Male	9.27	1.30		
Training				
No	9.21	1.53	-0.51	0.61
Yes	9.39	1.16		

* Based on t-test

A one-way ANOVA was conducted to determine if IPC knowledge scores differed based on nationality, highest level of education, location of practice, occupation, specialty and position or skill level. There were statistically significant differences between participants from different locations of practice, with those working at KAMC getting the highest mean knowledge scores (p=0.003). No significant differences between the groups in the other variables on knowledge scores were determined by the one-way ANOVA (p= 0.84, 0.74, 0.55,0.09, 0.53, respectively) (see Table 5.16).

Table 5.16: IPC knowledge score, nationality, highest level of education, location of practice, occupation, specialty and position or skill level

Characteristic	Mean	F	p-value*
Nationality			
Saudi	9.30	0.45	0.84
Filipino	9.55		
Indian	10.33		
Egyptian	9.5		
Jordanian	9		
Sudan	9.5		
Others	9.5		
Highest level of education			
PhD	9.5	0.49	0.74
Masters	9.63		
Bachelor	9.27		
Diploma	9		
Others	10		
Location of practice			
King Abdulaziz Medical City	9.81	6.04	0.003
King Fahad Specialist Hospital	8.85		
Hayat National Hospital	9.55		
Occupation			
Laboratory Specialist	9.28	0.83	0.55
Laboratory Technician	9.57		
Infection Control Specialist	10		
Nurse	9.6		
Phlebotomist	10		
Others	9.22		
Specialty			
Medical Laboratory	9.30	1.94	0.09
Public Health	10.2		
Infection Control	10		
Health Management	8		

Nurse	9.33		
Laboratory Medicine	9		
Others	10		
Position or skill level			
Laboratory Staff	9.42	0.89	0.53
Laboratory Supervisor	8.8		
Infection Control Practitioner	9.57		
Laboratory Consultant	9		
Quality Officer	9.2		
Admin	10		
Public health nurse	9.66		
Assistant consultant infection control	10		
Others	10.4		

* Based on ANOVA

5.12.1 Knowledge scores and sources of information

As shown in Table 5.17, there was no difference in IPC knowledge scores between those who had enough information about IPC guidelines and those who believed they did not have sufficient information ($p > 0.05$). In addition, there were no differences in the knowledge scores based on the main source of information.

Table 5.17: IPC knowledge score and sources of information

Knowledge level and source of information	Mean	SD	t-value	p-value*
1-Do you think you have information about IPC guidelines?				
Yes, enough	9.42	1.39	-0.51	0.60
Yes, but it is not enough	9.28	0.92		
The main source of knowledge				
1-TV/Radio	9.36	1.29	0.01	0.99
2-Newspaper/magazine	9.2	0.84	0.31	0.75
3-Internet	9.32	1.25	0.28	0.78
4-Colleagues	9.19	1.36	1.25	0.21
5-Education	9.48	0.18	-0.79	0.43
6-Families	10	0	-0.91	0.36
7-Hospital/laboratory standard operating procedures	9.35	1.27	0.20	0.84
8-Hospital/laboratory policies	9.32	1.29	0.63	0.52
9-Occupational training courses	9.27	1.06	0.49	0.62
10-National guidelines	9.5	0.92	-0.32	0.75
11-International guidelines	9.55	0.88	-0.48	0.63

* Based on t-test

5.13 Knowledge of PEP and sociodemographic characteristics

A Spearman's correlation was run to assess the relationship between the participants' knowledge of PEP scores, age and years of experience. There was a very weak positive correlation between PEP scores, age and years of experience, with PEP knowledge increasing with age and years of experience. Neither was statistically significant p= 0.37 and p= 0.70, respectively (see Table 5.18).

Table 5.18: Knowledge of PEP scores, age and years of experience

Characteristic	Spearman's correlation coefficient	p-value*
Age	0.09	0.37
Years of experience	0.05	0.70

* Based on Spearman's correlation test

A Pearson Chi-Square test revealed a significant association between knowledge of PEP scores and gender (p= 0.006), with females scoring higher than males. Meanwhile, there was no significant association between knowledge of PEP scores and training (p= 0.19) (see Table 5.19).

Table 5.19: Knowledge of PEP scores, gender and training

Characteristic	Knowledge of PEP scores				Overall	p-value*
	0	1	2	3	N (%)	
Gender						
Female	1	0	6	32	39 (44.82%)	0.006
Male	0	7	16	25	48 (55.20%)	
Training						
No	0	3	2	9	14 (16.09%)	0.19
Yes	1	4	20	48	73 (83.90%)	

*Based on Pearson Chi-Square

As shown in Table 5.20, a Pearson Chi-square test revealed no significant association between knowledge of PEP scores and nationality, highest level of education, location of practice, occupation, specialty and position (p > 0.05).

Table 5.20: IPC knowledge of PEP scores, nationality, highest level of education, location of practice, occupation, specialty and position or skill level

Characteristic	Knowledge of PEP scores				Overall	p-value*
	0	1	2	3	N (%)	
Nationality						
Saudi	1	7	20	43	62 (71.26%)	0.83
Egyptian	0	0	1	3	4 (4.59%)	
Filipino	0	0	1	8	9 (10.34%)	
Indian	0	0	0	3	3 (3.44%)	
Jordanian	0	0	0	1	1 (1.14%)	
Sudan	0	0	0	4	4 (4.59%)	
Others	0	0	0	4	4 (4.59%)	
Highest level of education						
PhD	0	0	2	6	8 (9.19%)	0.85
Masters	1	2	3	13	19 (21.83%)	
Bachelor	0	5	16	33	54 (62.06%)	
Diploma	0	0	1	4	5 (5.74%)	
Others	0	0	0	1	1 (1.14%)	
Location of practice						
King Abdulaziz Medical City	0	1	8	23	32 (36.78%)	0.11
King Fahad Specialist Hospital	1	5	12	17	35 (40.22%)	
Hayat National Hospital	0	1	2	17	20 (22.98%)	
Occupation						
Laboratory Specialist	0	6	14	26	46 (52.87%)	0.15
Laboratory Technician	0	0	3	11	14 (16.09%)	
Infection Control Specialist	1	0	0	6	7 (8.04%)	
Nurse	0	0	0	5	5 (5.74%)	
Phlebotomist	0	0	0	1	1 (1.14%)	
Laboratory Consultant Doctor	0	0	1	4	14 (16.09%)	
Others	0	1	4	4	9 (10.34%)	
Specialty						

Medical Laboratory	0	4	15	34	53 (60.91%)	0.13
Public Health	1	0	0	4	5 (5.74%)	
Infection Control	0	0	0	4	4 (4.59%)	
Health Management	0	1	2	1	4 (4.59%)	
Nurse	0	0	0	3	3 (3.44%)	
Laboratory Medicine	0	0	0	1	1 (1.14%)	
Others	0	0	2	4	6 (6.90%)	
Position or skill level						
Laboratory Staff	0	3	7	23	33 (37.93%)	0.60
Laboratory Supervisor	0	0	3	2	5 (5.74%)	
Infection Control Practitioner	1	0	1	5	7 (8.04%)	
Laboratory Consultant	0	0	2	5	7 (8.04%)	
Quality Officer	0	1	1	3	5 (5.74%)	
Admin	0	0	1	0	1 (1.14%)	
Public Health Nurse	0	0	0	3	3 (3.44%)	
Assistant Consultant Infection Control	0	0	0	2	2 (2.29%)	
Others	0	0	1	4	5 (5.74%)	

* Based on Pearson Chi-Square

5.13.1 Knowledge of PEP scores and having injury

There was no statistically significant association between knowledge of PEP scores and having an injury while working in the laboratory (p= 0.15) (Table 5.21).

Table 5.21: Knowledge of PEP scores and having injury

Characteristic	Knowledge of PEP scores				Overall	p-value*
	0	1	2	3	N (%)	
Have you been exposed to any injuries?						
No	1	3	21	44	69 (85.18%)	0.15
Yes	0	1	0	11	12 (14.81%)	

*Based on Pearson Chi-Square

5.14 IPC attitude scores and sociodemographic characteristics

A Spearman's correlation was run to assess the relationship between the participants' scores on attitudes towards IPC guidelines, age and years of experience. There was a weak negative correlation between the attitude scores, age and years of experience, with attitudes becoming more positive with lower ages and years of experience. Neither was statistically significant, at p= 0.50 and p= 0.20, respectively (see Table 5.22).

Table 5.22: IPC attitude scores, age and years of experience

Characteristic	Spearman's correlation coefficient	p-value*
Age	-0.08	0.50
Years of experience	-0.14	0.20

* Based on Spearman's correlation test

A Mann-Whitney U test was conducted to determine if the attitudes towards IPC scores differed between males and females and between those who had had training in IPC guidelines and those who had not (see Table 5.23). The results showed no statistically significant difference between males and females in attitude scores (p= 0.10). Similar results were found for those who had had training in IPC guidelines and those who had not (p= 0.17).

Table 5.23: IPC attitude scores, gender and training

Characteristic	Median (IQR)	p-value*
Gender		
Female	45.5, (39-53)	0.10
Male	51, (47-53)	
Training		
No	47, (39-51)	0.17
Yes	50, (41-54)	

* Based on Mann-Whitney U test

A Kruskal-Wallist Test was performed to determine if the participants' attitude scores were the same across the different nationalities and level of education, location of practice, occupation, specialty and position of participant. There was a significant association between attitudes towards IPC scores, nationality and location of practice. The Indian and Jordanian median attitude score, at 54, was higher than for other nationalities and the median of HNH participants (53.5) was higher than participants working at the other hospitals. There were no statistically significant associations between the attitudes towards IPC scores and highest levels of education, occupation, specialty and position were found (p> 0.05) (Table 5.24).

Table 5.24: IPC attitude scores, nationality, highest level of education, location of practice, occupation, specialty and position or skill level

Characteristic	Median (IQR)	p-value*
Nationality		
Saudi	50 (44-53)	0.02
Egyptian	52.5 (49-55)	
Filipino	39 (39-41)	
Indian	54 (52-55)	
Jordanian	54 (54-54)	
Sudan	52 (45-54)	
Others	39 (36.5-45.5)	
Highest level of education		
PhD	53 (39-55)	0.35
Masters	50.5 (44-55)	
Bachelor	48.5 (40-53)	
Diploma	47 (45-50)	
Others	55 (55-55)	
Location of practice		
King Abdulaziz Medical City	39 (38-42)	0.0001
King Fahad Specialist Hospital	52 (48-53)	
Hayat National Hospital	53.5 (49-55)	
Occupation		

Laboratory Specialist	51.5 (48-53)	0.17
Laboratory Technician	43 (39-50)	
Infection Control Specialist	52 (44-55)	
Nurse	44 (39-44)	
Phlebotomist	47 (47-47)	
Laboratory Consultant Doctor	55 (48-55)	
Others	43 (38.5-51)	
Specialty		
Medical Laboratory	51 (41-53)	0.52
Public Health	44 (44-52)	
Infection Control	53.5 (45.5-55)	
Health Management	49.5 (42.5-53.5)	
Nurse	39 (34-55)	
Laboratory Medicine	38 (38-38)	
Others	44 (39-47)	
Position or skill level		
Laboratory Staff	48.5 (40-53)	0.31
Laboratory Supervisor	54 (54-55)	
Infection Control Practitioner	53 (44-55)	
Laboratory Consultant	48 (39-55)	
Quality Officer	39 (38-52)	
Admin	47 (47-47)	
Public Health Nurse	39 (39-44)	
Assistant Consultant Infection Control	39 (39-39)	
Others	47.5 (39.5-52.5)	

* Based on Kruskal Wallis test

5.15 IPC practice scores and sociodemographic characteristics

A Spearman's correlation was run to assess the relationship between the participants' scores in practice of IPC guidelines, age and years of experience. There was a weak positive correlation between practice scores, age and years of experience, with IPC practice increasing with age and years of experience. Neither was statistically significant ($p = 0.37$ and $p = 0.60$, respectively; see Table 5.25).

Table 5.25: IPC practice scores, age and years of experience

Characteristic	Spearman's correlation coefficient	p-value*
Age	0.09	0.37
Years of experience	0.05	0.60

* Based on Spearman's correlation test

A Mann-Whitney U test was conducted to determine if the practice of IPC scores differed between males and females and between those who had had training in IPC guidelines and those who had not (Table 5.26). The results showed no statistically significant difference between males and females in practice scores (p= 0.07); however, there was a statistically significant difference between those who had had training in IPC guidelines and those who had not, with the former getting the highest median scores (52.0) (p=0.01), at a significance level of 0.05.

Table 5.26: IPC practice scores, gender and training

Characteristic	Median (IQR)	p-value*
Gender		
Female	53, (46-56)	0.07
Male	49, (45-53)	
Training		
No	45, (44-49)	0.01
Yes	52, (47-55)	

* Based on Mann-Whitney U test

A Kruskal-Wallist Test was performed to determine if the participants' practice of IPC scores were the same across the different nationalities and level of education, location of practice, occupation, specialty and position of participant. There was no statistically significant association between practice of IPC scores and nationality, highest level of education, location of practice, occupation, specialty or position (p> 0.05; see Table 5.27).

Table 5.27: IPC practice scores, nationality, highest level of education, location of practice, occupation, specialty and position or skill level

Characteristic	Median (IQR)	p-value*
Nationality		
Saudi	51, (45-54)	0.32
Egyptian	52.5, (45.5-56)	
Filipino	53, (50-56)	
Indian	54, (50-56)	
Jordanian	8, (8-8)	
Sudan	49, (45-54)	
Others	51.5, (46-55.5)	
Highest level of education		
PhD	53.5, (53-56)	0.24
Masters	49.5, (43-54)	
Bachelor	51, (45-55)	
Diploma	48, (44-48)	
Others	48, (48-48)	
Location of practice		
King Abdulaziz Medical City	53.5, (48-56)	0.06
King Fahad Specialist Hospital	50.5, (44 -54)	
Hayat National Hospital	50, (43-53)	
Occupation		
Laboratory Specialist	50, (45-53)	0.67
Laboratory Technician	52.5, (48-55)	
Infection Control Specialist	56, (31-56)	
Nurse	55, (44-56)	
Phlebotomist	54, (54-54)	
Laboratory Consultant Doctor	53, (49-53)	
Others	48, (26-55)	
Specialty		
Medical Laboratory	52, (46-55)	0.19
Public Health	55, (31-56)	

Infection Control	53, (49-56)	
Health Management	22, (2 -47)	
Nurse	44, (43-55)	
Laboratory Medicine	47, (47-47)	
Others	56, (48-56)	
Position or skill level		
Laboratory Staff	52, (46-55)	0.56
Laboratory Supervisor	53, (49-54)	
Infection Control Practitioner	55, (43-56)	
Laboratory Consultant	53, (53-54)	
Quality Officer	45, (40-47)	
Admin	6, (56-56)	
Public Health Nurse	55, (44-56)	
Assistant Consultant Infection Control	48, (48-48)	
Others	54.5, (48-56)	

* Based on Kruskal Wallis test

5.16 IPC perceptions of implementation scores and sociodemographic characteristics

A Spearman's correlation was run to assess the relationship between the participants' perceptions of implementation of IPC scores, age and years of experience. As shown in Table 5.28, there was a weak positive correlation between perceptions of implementation scores and age and years of experience. Both results were statistically significant: p= 0.02 and p= 0.04, respectively.

Table 5.28: IPC perceptions of implementation score, age and years of experience

Characteristic	Spearman's correlation coefficient	p-value*
Age	0.25	0.02
Years of experience	0.23	0.04

* Based on Spearman's correlation test

A t-test was run on the data with a 95% CI to compare the differences between the participants' scores of perceptions regarding IPC implementation, gender and training. As shown in Table 5.29, the null hypothesis of no difference between males and females in terms of perceptions of implementation scores is accepted, and there was a difference between those who had received training and those who had not, with the former reporting the highest mean scores (46.26), (p= 0.02).

Table 5.29: IPC perceptions of implementation scores, gender and training

Characteristic	Mean	SD	t-value	p-value*
Gender				
Female	46.86	4.59	1.85	0.07
Male	44.62	5.98		
Training				
No	42.25	5.77	-2.41	0.02
Yes	46.26	5.23		

* Based on t-test

A one-way ANOVA was conducted to determine if perceptions of implementation of IPC scores differed based on nationality, highest level of education, location of practice, occupation, specialty and position or skill level. There were no statistically significant differences between nationality, highest level of education and position (p= 0.20, 0.20 and 0.14, respectively). There was a statistically significant difference between occupation groups; Infection Control Specialists had the highest perception scores (p=0.002). There was also a statistically significant difference between location of practice groups; the participants working at KAMC had the highest perception scores (mean=48.03), (p=0.01) (Table 5.30).

Table 5.30: IPC perceptions of implementation scores, nationality, highest level of education, location of practice, occupation, specialty and position or skill level

Characteristic	Mean	F	p-value*
Nationality			
Saudi	44.85	1.45	0.20
Filipino	47.33		
Indian	47		
Jordanian	43		
Sudan	44.25		
Others	51.75		
Highest level of education			
PhD	49.25	1.57	0.20
Masters	46.23		
Bachelor	44.71		
Diploma	46.2		
Others	51		
Location of practice			
King Abdulaziz Medical City	48.03	4.42	0.01
King Fahad Specialist Hospital	44.45		
Hayat National Hospital	44.26		
Occupation			
Laboratory Specialist	43.31	4.10	0.002
Laboratory Technician	47.21		
Infection Control Specialist	49.86		
Nurse	49.6		
Phlebotomist	10		
laboratory Consultant Doctor	47		
Others	48		
Specialty			
Medical Laboratory	45.06	2.18	0.06
Public Health	48		
Infection Control	49		
Health Management	46.25		

Nurse	53.70		
Laboratory Medicine	44		
Others	48.6		
Position or skill level			
Laboratory Staff	45.1	1.62	0.14
Laboratory Supervisor	48.5		
Infection Control Practitioner	49.57		
Laboratory Consultant	46.8		
Quality Officer	46.8		
Admin	51		
Public Health Nurse	49.66		
Assistant Consultant Infection Control	51		
Others	43.75		

* Based on ANOVA

5.17 Knowledge scores, attitude and practice scores.

A Spearman's correlation was run to assess the relationship between the knowledge of IPC, attitude and practice scores. There was a weak negative correlation between the knowledge and attitude scores (result not statistically significant: $p > 0.05$) and a moderate positive correlation between the knowledge and practice scores, and the result was statistically significant: $p = 0.003$ (Table 5.31).

Table 5.31: Knowledge scores, attitude and practice scores

Characteristic	Spearman's correlation coefficient	p-value*
Attitude scores	-0.11	0.31
Practice scores	0.32	0.003

* Based on Spearman's correlation test

The same test was run to assess the relationship between the practice of IPC score and attitude towards IPC score. There was a weak negative correlation between practice and attitude scores, and the result was not statistically significant: $p > 0.05$ (Table 5.32).

Table 5.32: Practice scores and attitude scores

Characteristic	Spearman's correlation coefficient	p-value*
Attitude scores	-0.09	0.37

* Based on Spearman's correlation test

A Pearson's correlation was run to assess the relationship between knowledge scores and perception of IPC implementation scores. There was a weak positive correlation between knowledge scores and perception of IPC implementation scores, r= 0.223, $p < 0.05$ (Table 5.33).

Table 5.33: Knowledge scores and perceptions of IPC implementation scores

Characteristic	Pearson's correlation coefficient	p-value*
Perceptions of IPC implementation scores	0.22	0.04

* Based on Pearson's correlation test

5.18 Potential predictors of IPC knowledge, attitude, practice, knowledge of PEP and perceptions of IPC implementation (Simple linear regression)

Simple linear regression analysis was run for each category (knowledge, attitude, practice, knowledge of PEP and perceptions of IPC implementation) separately as dependent variables and age, years of experience, gender, nationality, highest level of education, occupation, specialty, position, training and competence assessment separately as independent variables to assess the association between each potential predictor variable and knowledge, attitude, practice, knowledge of post exposure prophylaxis and perceptions of IPC implementation.

5.18.1 Potential predictors of IPC knowledge

The results show a significant association between IPC knowledge scores and location of practice (see Table 5.34). Participants from KFSH had an average lower IPC knowledge score than participants from KAMC (-0.95 points lower).

Table 5.34: Independent determinants of IPC knowledge scores (simple linear regression)

Variable	Coefficient	95%CI	P-value (T)	P-value (F)	R^2
Age	0.008	-0.03 0.03	0.70	0.70	0.002
Years of experience	0.002	-0.03 0.038	0.90	0.90	0.0003
Gender				0.41	0.007
Male	-0.21	-0.74 0.30	0.41		
Nationality (ref: Egyptian)				0.84	0.03
Filipino	0.55	-0.93 2.04	0.50		
Indian	1.33	-0.55 3.22	0.16		
Jordanian	-4.49	-2.77 2.77	1.00		
Others	0.5	-1.25 2.25	0.57		
Saudi	0.30	-0.97 1.58	0.63		
Sudanese	0.5	-1.25 2.25	0.57		
Highest level of education (ref: Bachelor)				0.74	0.02
Diploma	-0.30	-1.42 0.87	0.63		
Master	0.35	-0.30 1.00	0.27		
Others	0.72	-1.75 3.20	0.56		
PhD	0.22	-0.70 1.15	0.63		
Location of practice (ref:King Abdulaziz Medical City)				0.003*	0.12
King Fahad Specialist Hospital	-0.95	-1.51 -0.40	0.001		
Hayat National Hospital	-0.30	-0.91 0.40	0.43		
Occupation (ref: Admin)				0.55	0.06
Infection Control Specialist	-1.10	-2.61 2.61	1.000		
Laboratory Specialist	-0.071	-3.18 1.75	0.56		
Laboratory Technician	-.428	-2.95 2.10	0.73		
Nurse	-0.4	-3.07 2.27	0.76		
Others	-0.777	-3.35 1.79	0.55		
Phlebotomist	0 (omitted)				
Laboratory Consultant Doctor	-1.4	-4.07 1.27	0.30		
Specialty (ref: Infection Control)				0.09	0.144
Health Management	-2	-3.61 -0.38	0.02		
Laboratory Medicine	-1	-3.55 1.55	0.44		
Medical Laboratory	-0.69	-1.88 0.48	0.24		
Nurse	-0.70	-2.41 1.07	0.45		
Others	-4.14	-1.47 1.47	1.00		
Public Health	0.2	-1.33 1.73	0.77		
Position or skill level (ref: Admin)					
Assistant Consultant Infection Control	-4.53	-2.78 2.78	1.00	0.53	0.110

Infection Control Practitioner					
Laboratory Consultant	-0.43	-2.85 1.99	0.72		
Laboratory Staff	-1	-3.48 1.48	0.42		
Laboratory Supervisor	-0.57	-2.87 1.72	0.62		
Others	-1.2	-3.68 1.28	0.34		
Public Health Nurse	0.4	-2.08 2.88	0.75		
Quality Officer	-0.33	-2.95 2.28	0.80		
	-0.8	-3.28 1.68	0.52		
Training				0.61	0.003
Yes	0.02	-0.52 0.89	0.61		
Competence assessment				0.12	0.03
Yes	0.48	-0.13 1.09	0.12		

Asterisks (*) used to identify all significant p-values

5.18.2 Potential predictors of knowledge of PEP

Based on linear regression, there is a significant association between knowledge of PEP scores and gender (p=0.007), location of practice (p=0.01), and competence assessment (p=0.03). The male participants had an average lower knowledge of PEP score than females (-0.04 points lower). Furthermore, those participants who reported having a process of competence assessment for health and safety were more likely to have a better knowledge of PEP score than those who did not (0.39 points higher). In addition, participants working at KFSH had an average lower knowledge of PEP score than participants from KAMC (-0.40 points lower) (see Table 5.35).

Table 5.35: Independent determinants of IPC knowledge of PEP scores (simple linear regression)

Variable	Coefficient	95%CI	P-value (T)	P-value (F)	R^2
Age	0.007	-0.01 0.02	0.45	0.45	0.006
Years of experience	0.004	-0.01 0.02	0.65	0.65	0.002
Gender				0.007*	0.08
Male	-0.04	-0.68 -0.10	0.008		
Nationality (ref: Egyptian)				0.10	0.12
Filipino	0.14	-0.70 0.94	0.73		
Indian	0.25	-0.80 1.27	0.63		
Jordanian	0.25	-1.25 1.75	0.74		
Others	0.25	-.70 1.20	0.60		
Saudi	-0.35	-1.04 0.34	0.32		
Sudan	0.25	-0.70 1.20	0.60		

Highest level of education (ref: Bachelor)					0.73	0.02
Diploma	0.28	-0.37	0.93	0.39		
Master	-0.04	-0.41	0.32	0.81		
Others	0.48	-0.92	1.89	0.49		
PhD	0.23	-0.29	0.80	0.39		
Location of practice (ref: King Abdulaziz Medical City)					0.01*	0.10
King Fahad Specialist Hospital	-0.40	-0.72	-0.07	0.01		
Hayat National Hospital	0.11	-0.30	0.50	0.55		
Occupation (ref: Admin)					0.33	0.08
Infection Control Specialist	-0.43	-1.90	1.04	0.56		
Laboratory Specialist	-0.56	-1.95	0.82	0.42		
Laboratory Technician	-0.21	-1.63	1.20	0.76		
Nurse	-6.99	-1.50	1.50	1.00		
Others	-0.66	-2.11	0.80	0.36		
Phlebotomist	0 (omitted)					
Laboratory Consultant Doctor	-0.2	-1.70	1.30	0.79		
Specialty (ref: Infection Control)					0.38	0.09
Health Management	-1	-1.95	-0.04	0.04		
Laboratory Medicine	-2.32	-1.50	1.50	1.00		
Medical Laboratory	-0.43	-1.13	0.26	0.22		
Nurse	-2.83	-1.03	1.03	1.00		
Others	-0.33	-1.20	0.53	0.45		
Public Health	-0.6	-1.50	0.30	0.19		
Position or skill level (ref: Admin)					0.85	0.06
Assistant Consultant Infection Control	1	-0.71	2.71	0.25		
Infection Control Practitioner	0.43	-1.07	1.92	0.57		
Laboratory Consultant	0.6	-0.93	2.13	0.44		
Laboratory Staff	0.60	-0.81	2.03	0.39		
Laboratory Supervisor	0.4	-1.13	1.93	0.60		
Others	0.8	-0.73	2.33	0.30		
Public Health Nurse	1	-0.62	2.62	0.22		
Quality Officer	0.4	-1.13	1.93	0.60		
Training					0.47	0.006
Yes	0.15	-0.25	0.55	0.47		
Competence assessment					0.03*	0.05
Yes	0.39	0.04	0.73	0.02		

Asterisks (*) used to identify all significant p-values

5.18.3 Potential predictors of attitudes towards IPC guidelines

As shown in Table 5.36, there is a significant association between attitude scores and gender (p=0.01), nationality (p= 0.006), and location of practice (p<0.001). Male participants had significantly higher attitude scores than females, scoring 0.07 points higher. Also, Filipino and participants under the category of 'Others' had an average lower attitude score than Egyptian participants, scoring -10.66 and -11 points lower, respectively. Furthermore, participants working at KFSH and at HNH had an average higher attitude towards IPC score than participants from KAMC, scoring 10.30 and 11.33 higher, respectively.

Table 5.36: Independent determinants of IPC attitude scores (simple linear regression)

Variable	Coefficient	95%CI	P-value (T)	P-value (F)	R^2
Age	-0.12	-0.32 0.07	0.22	0.22	0.02
Years of experience	-0.14	-0.34 0.05	0.15	0.15	0.02
Gender				0.01*	0.07
Male	3.57	0.70 6.44	0.01		
Nationality (ref: Egyptian)				0.006*	0.20
Filipino	-10.66	-18.18 -3.14	0.006		
Indian	1.66	-7.90 11.22	0.73		
Jordanian	2	-11.99 15.99	0.80		
Others	-11	-19.84 -2.15	0.02		
Saudi	-3.93	-10.40 2.53	0.23		
Sudan	-2.5	-11.34 6.34	0.57		
Highest level of education (ref: Bachelor)				0.70	0.03
Diploma	0.06	-6.34 6.45	0.97		
Master	1.61	-2.125 5.35	0.39		
Others	8.06	5.73 21.85	0.25		
PhD	1.56	-3.63 6.74	0.55		
Location of practice (ref: King Abdulaziz Medical City)				<0.001*	0.60
King Fahad Specialist Hospital	10.30	8.08 12.52	<0.001		
Hayat National Hospital	11.33	8.80 13.90	<0.001		
Occupation (ref: Admin)				0.18	0.10
Infection Control Specialist	-1.54	-9.31 6.22	0.69		
Laboratory Specialist	-1.47	-7.73 4.80	0.64		
Laboratory Technician	-5.9	-12.81 1.01	0.09		
Nurse	-6.2	-14.60 2.20	0.14		
Others	-6.02	-13.60 1.54	0.12		

Phlebotomist	-3.4	-17.93	11.13	0.64		
Laboratory Consultant	0(omitted)					
Doctor						
Specialty (ref: Infection Control)					0.48	0.08
Health Management	-2.25	-12.08	7.60	0.65		
Laboratory Medicine	-12.25	-27.80	3.30	0.12		
Medical Laboratory	-2.17	-9.40	5.05	0.55		
Nurse	-7.58	-18.20	3.04	0.16		
Others	-6.25	-15.60	3.08	0.17		
Public Health	-3.45	-12.80	5.90	0.46		
Position or skill level (ref: Admin)					0.43	0.13
Assistant Consultant	-8	-25.70	9.70	0.37		
Infection Control						
Infection Control	2.43	-12.99	17.85	0.75		
Practitioner	0.2	-15.60	16.00	0.98		
Laboratory Consultant	-0.31	-14.96	14.34	0.97		
Laboratory Staff	4.2	-11.60	20.00	0.59		
Laboratory Supervisor	-1	-17.13	15.13	0.90		
Others	-6.33	-22.99	10.32	0.45		
Public Health Nurse	-3.2	-19.00	12.60	0.69		
Quality Officer						
Training					0.29	0.01
Yes	2.18	-1.90	6.25	0.29		
Competence assessment					0.40	0.008
Yes	-1.48	-5.01	2.04	0.40		

Asterisks (*) used to identify all significant p-values

5.18.4 Potential predictors of IPC practice

The results show a significant association between practice scores and gender (P=0.05), nationality (P=0.01), specialty (P=0.001) and training (P=0.009). Male participants had an average lower practice score than females, scoring -4.80 points lower. Jordanian participants had an average lower practice score than Egyptian participants, at -42.75 points lower. In addition, those participants who specialised in Health Management had an average lower practice score than those working in Infection Control, scoring -28 points lower. Those participants who had received IPC training had significantly higher practice scores than those who had not, scoring 8.76 points higher (see Table 5.37).

Table 5.37: Independent determinants of IPC practice scores (simple linear regression)

Variable	Coefficient	95%CI		P-value (T)	P-value (F)	R^2
Age	0.006	-0.33	0.34	0.97	0.97	0.00
Years of experience	0.02	-0.31	0.35	0.89	0.89	0.0002
Gender					0.05*	0.04
Male	-4.80	-9.64	0.03	0.05		
Nationality (ref: Egyptian)					0.01*	0.18
Filipino	1.25	-11.37	13.90	0.84		
Indian	2.58	-13.50	18.62	0.75		
Jordanian	-42.75	-66.23	-19.26	0.001		
Others	6.49	-14.85	14.85	1.00		
Saudi	-3.31	-14.20	7.54	0.54		
Sudan	-3	-17.85	11.85	0.69		
Highest level of education (ref: Bachelor)					0.34	0.05
Diploma	-7.63	-18.08	2.82	0.15		
Master	-2.15	-8.26	3.96	0.48		
Others	-0.43	-22.95	22.09	0.97		
PhD	5.19	-3.30	13.70	0.23		
Location of practice (ref: King Abdulaziz Medical City)					0.07	0.06
King Fahad Specialist Hospital	-4.90	-10.40	0.60	0.08		
Hayat National Hospital	-6.96	-13.40	-0.54	0.03		
Occupation (ref: Admin)					0.30	0.09
Infection Control Specialist	-5.74	-18.74	7.30	0.38		
Laboratory Specialist	-2.16	-12.65	8.33	0.68		
Laboratory Technician	0.26	-11.31	11.82	0.96		
Nurse	0.2	-13.84	14.24	0.98		
Others	-11.35	-24.01	1.31	0.09		
Phlebotomist	3.4	-20.93	27.73	0.78		
Lab Consultant Doctor	0 (omitted)					
Specialty (ref: Infection Control)					0.001*	0.28
Health Management	-28	-42.97	-13.02	0.00		
Laboratory Medicine	-5.5	-29.20	18.17	0.64		
Medical Laboratory	-2.98	-13.98	8.02	0.59		
Nurse	-5.16	-21.33	11.00	0.53		
Others	0.3	-13.90	14.50	0.96		
Public Health	-12.1	-26.30	2.10	0.09		

Position or skill level (ref: Admin)					0.28	0.16
Assistant Consultant infection Control	-8	-31.10	15.10	0.49		
Infection Control Practitioner	-6.57	-26.74	13.60	0.52		
Laboratory Consultant	-4.4	-25.06	16.30	0.67		
Laboratory Staff	-5.70	-24.90	13.50	0.55		
Laboratory Supervisor	-12	-32.70	8.70	0.25		
Others	-4	-25.09	17.09	0.70		
Public Health Nurse	-4.33	-26.12	17.45	0.69		
Quality Officer	-17.8	-38.50	2.90	0.09		
Training					0.009*	0.08
Yes	8.76	2.23	15.30	0.009		
Competence assessment					0.70	0.001
Yes	1.13	-4.85	7.12	0.70		

Asterisks (*) used to identify all significant p-values

5.18.5 Potential predictors of perceptions of implementation of IPC guidelines

Table 5.38 shows a significant association between perceptions of implementation of IPC guidelines scores and years of experience (p=0.05), location of practice (p=0.01), occupation (p=0.002) and training (p=0.02). Years of experience has a positive coefficient (0.16) which indicates a positive association between perceptions of implementation of IPC guidelines scores and years of experience. Moreover, participants working at KFSH and at HNH had an average lower score in perceptions of implementation of IPC guidelines than participants from KAMC, at -3.60 and -3.80 points lower, respectively. Additionally, Laboratory Specialists were significantly more likely to have lower perception of implementation scores than those working in general admin (-6.28 points lower). Those participants who had received training in IPC had significantly higher scores in perceptions of implementation of IPC guidelines than those who had not, scoring 4.01 points higher.

Table 5.38: Independent determinants of scores for perceptions of implementation of IPC guidelines (simple linear regression)

Variable	Coefficient	95%CI	P-value (T)	P-value (F)	R^2
Age	0.15	-0.003 0.31	0.06	0.06	0.04
Years of experience	0.16	-0.006 0.31	0.055	0.05*	0.05
Gender				0.07	0.04
Male	-2.24	-4.64 0.20	0.07		
Nationality (ref: Egyptian)				0.20	0.10
Filipino	-0.66	-7.10 5.80	0.83		
Indian	-1	-9.20 7.20	0.80		
Jordanian	-5	-16.98 6.98	0.40		
Others	3.75	-3.82 11.32	0.33		
Saudi	-3.14	-8.70 2.40	0.26		
Sudan	-3.75	-11.32 3.82	0.33		
Highest level of education (ref: Bachelor)				0.19	0.08
Diploma	1.48	-3.55 6.52	0.56		
Master	1.52	-1.50 4.54	0.32		
Others	6.28	-4.60 17.13	0.25		
PhD	4.53	0.44 8.63	0.03		
Location of practice (ref: King Abdulaziz Medical City)				0.01*	0.10
King Fahad Specialist Hospital	-3.60	-6.30 -0.90	0.01		
Hayat National Hospital	-3.80	-6.90 -0.70	0.01		
Occupation (ref: Admin)				0.002*	0.22
Infection Control Specialist	0.26	-5.60 6.08	0.93		
Laboratory Specialist	-6.28	-11.00 -1.60	0.01		
Laboratory Technician	-2.38	-7.60 2.80	0.36		
Nurse	0 (omitted)				
Others	-1.6	-7.30 4.07	0.57		
Phlebotomist	0 (omitted)				
Laboratory Consultant Doctor	-2.6	-8.90 3.70	0.41		
Specialty (ref: Infection Control)				0.06	0.17
Health Management	-2.75	-9.63 4.13	0.43		
Laboratory Medicine	-5	-15.90 5.90	0.36		
Medical Laboratory	-3.94	-9.007 1.13	0.13		
Nurse	4.67	-2.80 12.10	0.21		
Others	-.4	-6.93 6.13	0.90		
Public Health	-1	-7.53 5.53	0.76		
Position or skill level (ref: Admin)				0.14	0.19
Assistant Consultant Infection Control	-6.54	-11.07 11.07	1.00		

Infection Control Practitioner	-1.43	-11.09	8.24	0.77		
Laboratory Consultant	-4.2	-14.10	5.70	0.39		
Laboratory Staff	-5.9	-15.09	3.30	0.20		
Laboratory Supervisor	-2.5	-12.61	7.61	0.62		
Others	-7.25	-17.40	2.90	0.16		
Public Health Nurse	-1.33	-11.80	9.11	0.79		
Quality Officer	-4.2	-14.10	5.70	0.39		
Training					0.02*	0.07
Yes	4.01	0.70	7.32	0.02		
Competence assessment					0.21	0.02
Yes	1.92	-1.10	4.95	0.21		

Asterisks (*) used to identify all significant p-values

5.19 Potential predictors of IPC knowledge, attitude, practice, knowledge of PEP and perceptions of IPC implementation.

Multivariable regression analysis was run for each category (knowledge, attitudes, practices, knowledge of PEP and perceptions of IPC implementation) separately as dependent variables and all associations with a significance level of $p<0.15$ were included in the multivariable model.

5.19.1 Potential predictors of knowledge of IPC guidelines

Multivariable regression was run to investigate the potential predictors of knowledge of IPC guidelines. Variables included in the initial model were specialty and competence assessment (see Table 5.39). The results show that those participants who specialised in Health Management had an average lower knowledge score than those working in Infection Control, scoring -2 points lower.

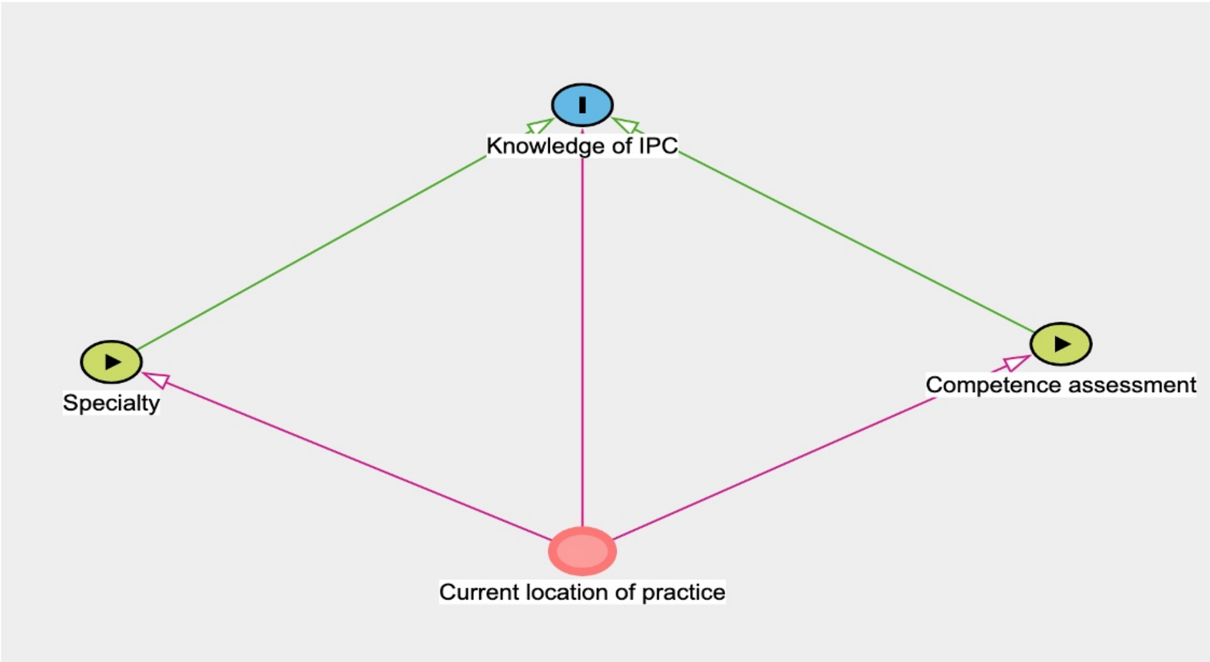
Table 5.39: Independent determinants of knowledge of IPC guidelines scores (multivariable regression)

Variable	Coefficient	95% C.I		P-value (T)
Specialty (ref: Infection Control)				
Health Management	-2	-3.58	-0.41	0.01*
Laboratory Medicine	-1.16	-3.67	1.35	0.36
Medical Laboratory	-0.74	-1.90	0.42	0.21
Nurse	-0.82	-2.54	0.89	0.34
Others	-0.05	-1.50	1.39	0.94
Public Health	0.29	-1.21	1.80	0.69
Competence assessment				
Yes	0.64	-0.02	1.29	0.06

Asterisks (*) used to identify all significant p-values

Multivariable regression analysis was conducted to produce adjusted regressions for knowledge of IPC guidelines adjusted for location of practice (hospital). Those participants working at KFSH had an average lower knowledge score than those working at KAMC (-0.62 points lower). Location of practice as a variable was considered a confounder to all other variables included in the model as the coefficients were changed by more than 10% (see Table 5.40). To provide a visual representation of the relationships between IPC knowledge scores and the other variables, and in order to allow the identification of potential confounders and biases, a DAG was generated. The node for specialty and competence assessment variables connected to the node of knowledge of IPC variable by green directed edges, indicating that specialty and competence assessment were predictors of knowledge of IPC. The node for current location of practice variable connected to the node of knowledge of IPC, specialty and competence assessment variables by pink directed edges, indicating that location of practice was considered a confounder to specialty and competence assessment variables (see Figure 5.6).

Figure 5.6: DAG for the relationship between IPC knowledge scores and other variables



*The dependent variable (knowledge of IPC)
* Predictors of (knowledge of IPC)
* Confounder

Table 5.40: Independent determinants of IPC knowledge scores (Multivariable regression adjusted for hospital).

Variable	Coefficients	95% C.I		P-value (T)
Specialty (ref: Infection Control)				
Health Management	-1.70	-3.27	-0.12	0.03*
Laboratory Medicine	-1.49	-3.98	0.99	0.23
Medical Laboratory	-0.81	-1.95	0.32	0.16
Nurse	-0.95	-2.65	0.74	0.27
Others	-0.18	1.61	1.26	0.80
Public Health	0.23	-1.24	1.71	0.75
Competence assessment				
Yes	0.65	0.01	1.29	0.05*
Location of practice (ref: King Abdulaziz Medical City)				
King Fahad Specialist Hospital	-0.62	-1.22	-0.03	0.04*
Hayat National Hospital	-0.072	-0.78	0.63	0.84

Asterisks (*) used to identify all significant p-values

5.19.2 Potential predictors of knowledge of PEP

Multivariate regression was run to investigate the potential predictors of knowledge of PEP. Variables included in the initial model were gender, nationality and competence assessment. As shown in Table 5.41, no significant association between knowledge of PEP scores and all of the independent variables included in the regression model was found.

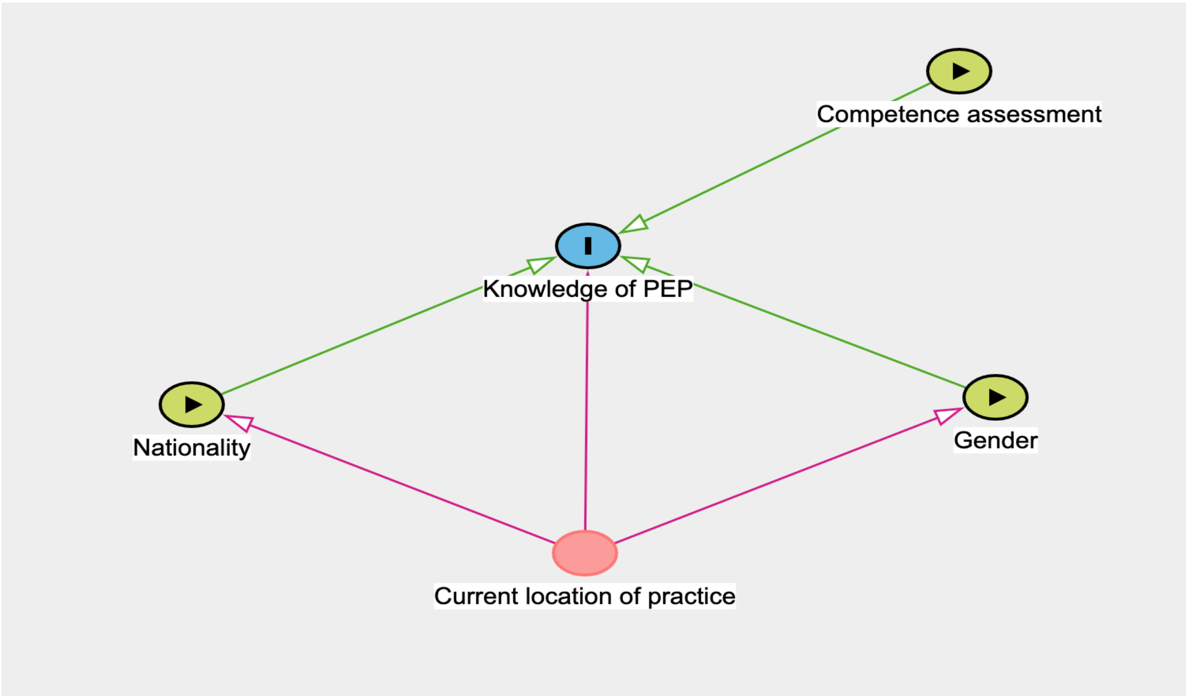
Table 5.41: Independent determinants of knowledge of PEP scores (multivariable regression)

Variable	Coefficient	95% C.I	P-value (T)
Gender (ref: Female)			
Male	-0.26	-0.58 0.06	0.11
Nationality (ref: Egyptian)			
Filipino	0.12	-0.66 0.91	0.75
Indian	0.35	-0.68 1.37	0.50
Jordanian	0.43	-1.06 1.93	0.57
Others	0.31	-0.61 1.24	0.50
Saudi	-0.17	-0.87 0.54	0.64
Sudanese	0.31	-0.61 1.24	0.501
Competence assessment (ref: No)			
Yes	0.31	-0.02 0.65	0.07

Asterisks (*) used to identify all significant p-values

Multivariable regression analysis was conducted to produce adjusted regressions for knowledge of PEP adjusted for location of practice (hospital). The results show no association between knowledge of PEP and gender, competence assessment, and location of practice. Location of practice as a variable was considered a confounder to all other variables included in the model. However, the competence assessment variable was not affected (see Table 5.42). In addition, the results of the Breuch-Pagan test suggested that there was a potential issue of heteroscedasticity in the knowledge of PEP model, at $P<0.001$. In order to address the issue of heteroscedasticity, robust standard errors were used. To provide a visual representation of the relationships between knowledge of PEP scores and the other variables, and in order to allow the identification of the potential confounders and biases, a DAG was generated. The node for nationality, gender and competence assessment variables connected to the node of knowledge of PEP variable by green directed edges, indicating that nationality, gender and competence assessment were predictors of knowledge of PEP. The node for current location of practice variable connected to the node of knowledge of PEP, nationality and gender variables by pink directed edges, indicating that location of practice was considered a confounder to nationality and gender. No pink directed edge connected location of practice to competence assessment node, indicating that location of practice was not considered a confounder to competence assessment (see Figure 5.7).

Figure 5.7: DAG for the relationship between knowledge of PEP scores and other variables



*The dependent variable (knowledge of PEP)
* Predictors of (knowledge of PEP)
* Confounder

Table 5.42: Independent determinants of knowledge of PEP scores (multivariable regression adjusted for hospital).

Variable	Coefficients	Robust standard error	95% C.I	P-value (T)
Gender (ref: Female)				
Male	-0.18	0.19	-0.56 0.20	0.34
Nationality (ref: Egyptian)				
Filipino	-0.04	0.29	-0.62 0.54	0.89
Indian	0.10	0.34	-0.59 0.79	0.77
Jordanian	0.01	0.38	-0.75 0.78	0.97
Others	0.20	0.28	-0.37 0.77	0.49
Saudi	-0.29	0.29	-0.87 0.30	0.34
Sudan	0.007	0.31	-0.62 0.63	0.98
Competence assessment (ref: No)				
Yes	0.35	0.21	-0.07 0.77	0.10
Location of practice (ref: King Abdulaziz Medical City)				
King Fahad Specialist Hospital	-0.27	0.19	-0.66 0.11	0.17
Hayat National Hospital	0.17	0.17	-0.18 0.51	0.34

Asterisks (*) used to identify all significant p-values

5.19.3 Potential predictors of attitudes towards IPC guidelines

Multivariable regression was run to investigate the potential predicators of attitudes to IPC guidelines. Variables included in the initial model were gender and nationality (see Table 5.43). The results show no significant association between attitude scores and gender. Also, Filipino and participants under others category had an average lower attitude score than Egyptian participants, scoring -10.98 and -11.70 points lower, respectively.

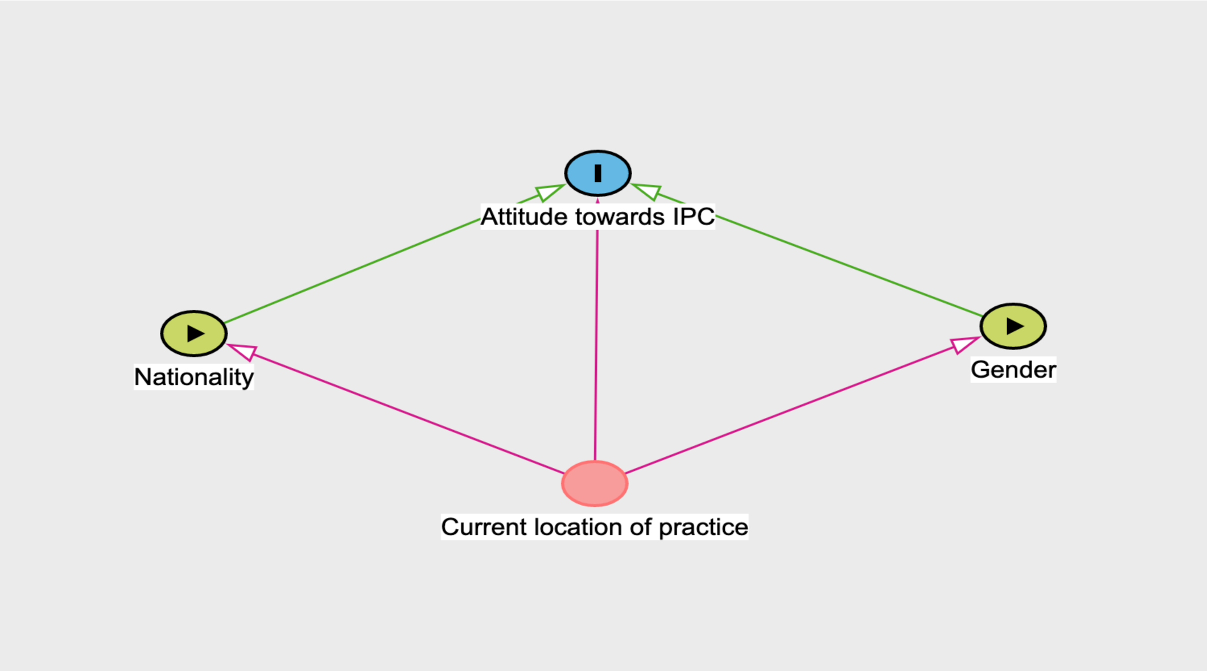
Table 5.43:Independent determinants of attitude scores (multivariable regression)

Variable	Coefficient	95% C.I		P-value (T)
Gender				
Male (ref: Female)	2.83	-0.25	5.92	0.07
Nationality (ref: Egyptian)				
Filipino	-10.98	-18.39	-3.56	0.004*
Indian	-0.22	-9.86	9.42	0.96
Jordanian	-0.83	-14.96	13.29	0.90
Others	-11.70	-20.46	-2.95	0.009*
Saudi	-5.85	-12.55	0.85	0.09
Sudanese	-3.20	-11.96	5.54	0.47

Asterisks (*) used to identify all significant p-values

Multiple regression analysis was conducted to produce adjusted regressions for attitudes to IPC guidelines adjusted for location of practice (hospital). The results show no association between attitudes and gender and nationality after adjustment for location while a significant association between attitude and location of practice was identified. The participants working at both KFSH and HNH had higher average attitude scores than those working at KAMC, scoring 9.29 and 10.10 points higher, respectively. Location of practice as a variable was considered a confounder to all other variables included in the model as their coefficients were changed by more than 10% (see Table 5.44). Moreover, the results of the Breuch-Pagan test suggest that there was the potential issue of heteroscedasticity in the attitude model, at P=0.020. In order to address this issue, robust standard errors were used. To provide a visual representation of the relationships between attitude scores and the other variables, and in order to identify the potential confounders and biases, a DAG was generated. The node for gender and nationality variables connected to the node of attitude towards IPC variable by green directed edges, indicating that gender and nationality were predictors of attitude towards IPC variable. The node for current location of practice variable connected to the node of attitude towards IPC variable, gender and nationality variables by pink directed edges, indicating that location of practice was considered a confounder gender and nationality variables (see Figure 5.8).

Figure 5.8: DAG for the relationship between attitude scores and other variables



*The dependent variable (attitude towards IPC)
* Predictors of (attitude towards IPC)
* Confounder

Table 5.44:Independent determinants of attitude scores (Multivariable regression adjusted for hospital).

Variable	Coefficients	Robust standard error	95% C.I		P-value (T)
Gender					
Male (ref: Female)	0.71	1.26	-1.81	3.24	0.57
Nationality (ref: Egyptian)					
Filipino	-3.40	2.45	-8.29	1.50	0.17
Indian	0.86	2.14	-3.41	5.13	0.70
Jordanian	0.68	2.40	-4.07	5.44	0.80
Others	-4.003	2.77	-9.53	1.53	0.15
Saudi	-1.38	2.06	-5.49	2.72	0.50
Sudan	-0.75	2.33	-5.41	3.90	0.74
Location of practice (ref: King Abdulaziz Medical City)					
King Fahad Specialist Hospital	9.29	1.61	6.08	12.51	<0.001*
Hayat National Hospital	10.10	1.64	6.82	13.37	<0.001*

Asterisks (*) used to identify all significant p-values

5.19.4 Potential predictors of IPC practices

Multivariable regression was run to investigate the potential predictors of IPC practices. The variables included in the initial model were gender, nationality, specialty and training (see Table 5.45). The results show no significant association between practice scores and gender and specialty while there a significant association between practice scores and nationality and training was found. The Jordanian participants had an average lower practice score than their Egyptian counterparts, scoring -36.76 points lower. Furthermore, those participants who had received IPC training had significantly higher practice scores than those who had not, at 7.06 points higher.

Table 5.45: Independent determinants of practice scores (multivariable regression)

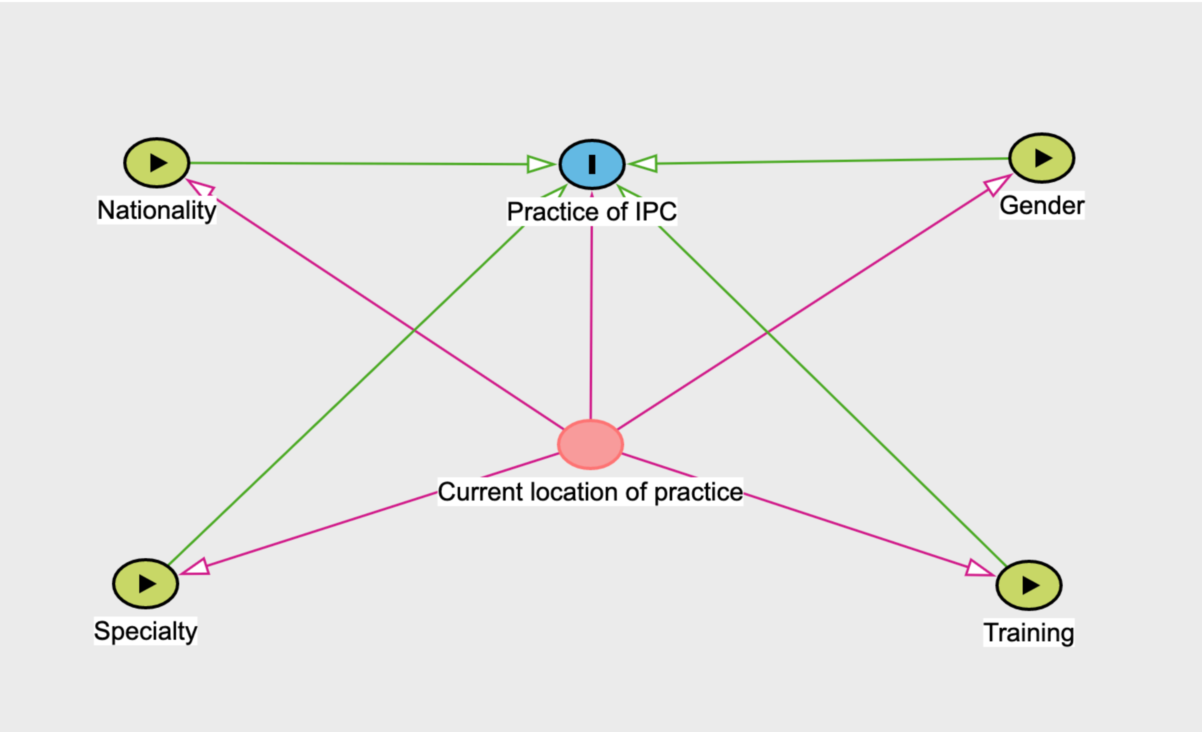
Variable	Coefficient	95% C.I	P-value (T)
Gender			
Male (ref: Female)	-4.24	-10.00 1.52	0.15
Nationality (ref: Egyptian)			
Filipino	4.58	-8.14 17.31	0.47
Indian	13.33	-3.72 30.39	0.12
Jordanian	-36.76	-58.69 -14.83	0.001*
Others	12.31	-7.17 31.79	0.21
Saudi	5.18	-6.60 16.96	0.38
Sudan	-1.18	-15.40 13.03	0.87
Specialty (ref: Infection Control)			
Health Management	-15.69	-32.79 1.42	0.07
Laboratory Medicine	-0.95	-23.15 21.24	0.93
Medical Laboratory	6.22	-7.32 19.77	0.36
Nurse	-3.02	-17.57 11.52	0.68
Others	10.19	-5.95 26.33	0.21
Public Health	-6.08	-20.75 8.59	0.41
Training			
Yes (ref: No)	7.06	0.67 13.45	0.03*

Asterisks (*) used to identify all significant p-values

Multiple regression analysis was conducted to produce adjusted regressions for IPC practices adjusted for location of practice (hospital). The Jordanian participants had average lower practice scores than the Egyptian participants, at -27.53 points lower, while the Indian participants had higher average practice score than the Egyptian participants, scoring 20.19 points higher. No significant association between practice and location of practice was found.

Location of practice as a variable was considered a confounder to all other variables included in the model as the coefficients were changed by more than 10% (see Table 5.46). In addition, the results of a Breuch-Pagan test suggested that there was a potential issue of heteroscedasticity in the practice model, at P<0.001. In order to address this issue, robust standard errors were used. To provide a visual representation of the relationships between practice scores and the other variables, and in order to allow the identification of the potential confounders and biases, a DAG was generated. The node for gender and nationality, training and specialty variables connected to the node of practice of IPC variable by green directed edges, indicating that gender and nationality, training and specialty were predictors of practice of IPC variable. The node for current location of practice variable connected to the node of practice of IPC variable, gender and nationality, training and specialty variables by pink directed edges, indicating that location of practice was considered a confounder gender and nationality, training and specialty variables (see Figure 5.9).

Figure 5.9: DAG for the relationship between practice scores and other variables.



*The dependent variable (practice of IPC)
* Predictors of (practice of IPC)
* Confounder

Table 5.46: Independent determinants of practice scores (multivariable regression adjusted for hospital)

Variable	Coefficient	Robust standard error	95% C.I		P-value (T)
Gender					
Male (ref: Female)	-5.26	3.35	-11.99	1.46	0.12
Nationality (ref: Egyptian)					
Filipino	6.26	5.02	-3.81	16.34	0.21
Indian	20.19	9.90	0.35	40.03	0.04*
Jordanian	-27.53	8.30	-44.15	-10.92	0.002*
Others	14.05	8.03	-2.04	30.15	0.08
Saudi	7.67	5.45	-3.26	18.60	0.16
Sudanese	5.95	6.22	-6.52	18.42	0.34
Specialty (ref: Infection Control)					
Health Management	-16.65	12.90	-42.51	9.20	0.20
Laboratory Medicine	-2.30	4.90	-12.04	7.44	0.64
Medical Laboratory	7.05	5.62	-4.23	18.32	0.21
Nurse	-4.19	3.25	-10.71	2.33	0.20
Others	8.43	5.85	-3.29	20.16	0.15
Public Health	-6.57	8.40	-23.35	10.21	0.43
Training					
Yes (ref: No)	6.41	4.07	-1.80	14.60	0.12
Location of practice (ref: King Abdulaziz Medical City)					
King Fahad Specialist Hospital	0.32	2.37	-4.43	5.07	0.893
Hayat National Hospital	-7.87	4.03	-15.95	0.20	0.056

Asterisks (*) used to identify all significant p-values

5.19.5 Potential predictors of perceptions of the implementation of IPC guidelines

Multivariable regression was run to investigate the potential predictors of perceptions of the implementation of IPC guidelines. The perceptions model showed a multicollinearity problem based on the results of variance inflation factors (mean = 12.16). The result of calculating the correlation coefficients showed the age and years of experience variables to be highly correlated (correlation coefficients = 0.893). Therefore, in order to solve the multicollinearity problem, only the years of experience variable was included. The variables included in the initial model were years of experience, gender, occupation, specialty, position and training (see Table 5.47). The results show a significant association between perceptions of the implementation of IPC guidelines scores and years of experience only. Years of experience was a positive coefficient (0.21), indicating a positive association between perceptions of the implementation of IPC guidelines scores and years of experience.

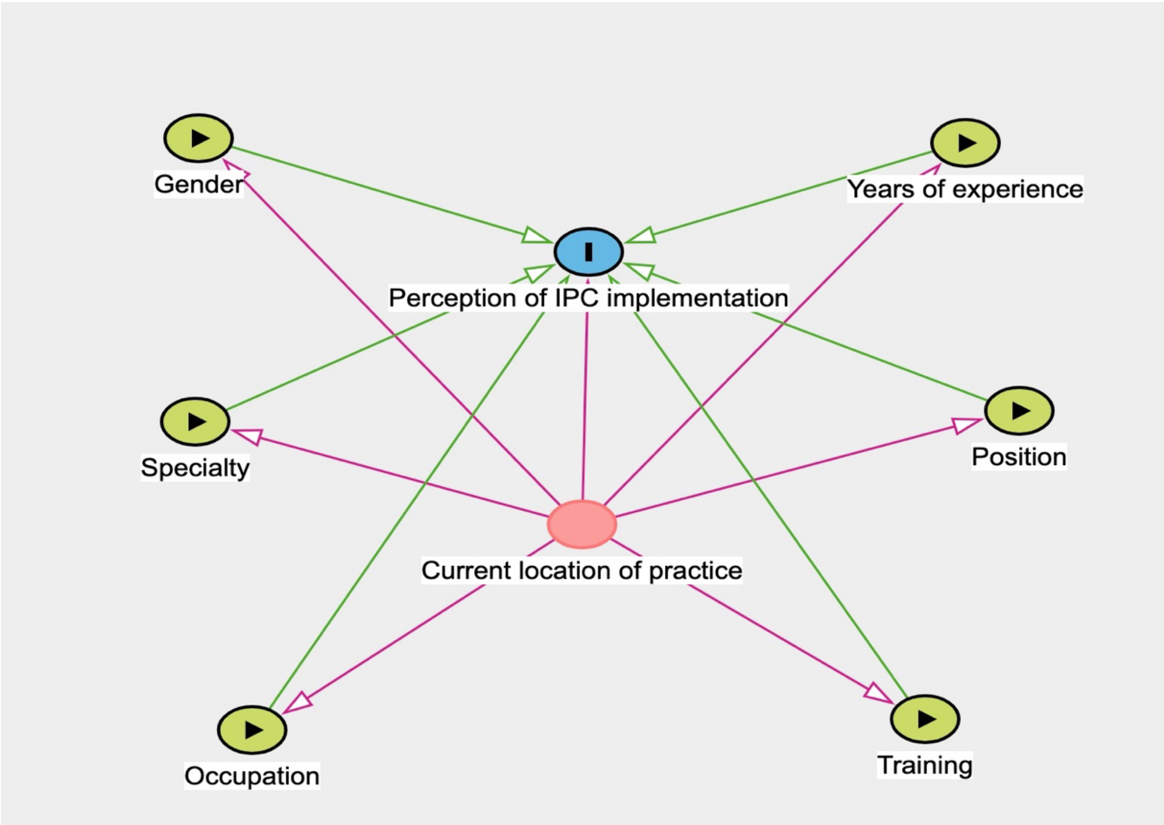
Table 5.47: Independent determinants of perceptions of the implementation of IPC guidelines scores (multivariable regression)

Variable	Coefficient	95% C.I	P-value (T)
Years of experience	0.21	0.005 0.42	0.044*
Gender			
Male (ref: Female)	-1.81	-4.94 1.32	0.24
Occupation (ref: Admin)			
Infection Control Specialist	0 (omitted)		
Laboratory Specialist	-5.08	-15.71 5.55	0.33
Laboratory Technician	-2.38	-13.78 9.01	0.70
Nurse	2.63	-6.87 12.14	0.60
Others	-0.89	-12.23 10.44	0.87
Phlebotomist	0 (omitted)		
Laboratory Consultant Doctor	-3.88	-16.71 8.94	0.54
Specialty (ref: Infection Control)			
Health Management	6.45	-6.29 19.2	0.31
Laboratory Medicine	1.70	-11.90 15.28	0.80
Medical Laboratory	2.10	-12.34 9.19	0.70
Nurse	0.29	-9.38 9.96	0.95
Others	0.41	9.35 10.18	0.93
Public Health	-4.44	-14.97 6.07	0.40
Position or skill level (ref: Admin)			
Assistant Consultant Infection Control	-2.15	-14.13 9.82	0.94
Infection Control Practitioner	-2.71	-16.83 11.40	0.83
Laboratory Consultant	-6.62	-21.31 8.07	0.57
Laboratory Staff	-5.25	-18.56 8.04	0.82
Laboratory Supervisor	-5.41	-19.22 8.40	0.82
Others	-8.09	-20.19 4.009	0.36
Public Health Nurse	-1.34	-18.90 16.20	0.73
Quality Officer	-5.50	-20.12 9.14	0.69
Training			
Yes (ref: No)	3.82	-0.70 8.36	0.096

Asterisks (*) used to identify all significant p-values

Multiple regression analysis was conducted to produce adjusted regressions for perceptions of the implementation of IPC precaution scores adjusted for location of practice. A significant association between the scores for perceptions of the implementation of IPC guidelines and location of practice. Participants working at KFSH had an average lower score than their counterparts at KAMC, at -4.36 points lower. Location of practice as a variable was considered a confounder to all other variables included in the model as their coefficients were changed by more than 10% (see Table 5.48). To provide a visual representation of the relationships between the scores for perceptions of the implementation of IPC guidelines and the other variables, and in order to allow the identification of the potential confounders and biases, a DAG was generated. The node for gender, specialty, occupation training, position and years of experience variables connected to the node of perceptions of IPC implementation variable by green directed edges, indicating that gender, specialty, occupation training, position and years of experience were predictors of perceptions of IPC implementation variable. The node for current location of practice variable connected to the node of perceptions of IPC implementation variable, gender, specialty, occupation training, position and years of experience variables by pink directed edges, indicating that location of practice was considered a confounder gender, specialty, occupation training, position and years of experience variables (see Figure 5.10).

Figure 5.10: DAG for the relationships between perceptions of the implementation of IPC guidelines scores and other variables



*The dependent variable (perception of IPC implementation)
* Predictors of (perception of IPC implementation)
* Confounder

Table 5.48: Independent determinants of perceptions of the implementation of IPC scores (multivariable regression adjusted for hospital)

Variable	Coefficient	95% C.I		P-value
Years of experience	0.17	-0.05	0.40	0.13
Gender				
Male (ref: Female)	0.16	-3.26	3.60	0.92
Occupation (ref: Admin)				
Infection Control Specialist	0 (omitted)			
Laboratory Specialist	-7.88	-18.71	2.94	0.14
Laboratory Technician	-5.91	-17.54	5.71	0.30
Nurse	5.02	-4.26	14.31	0.30
Others	-3.20	-14.19	7.78	0.55
Phlebotomist	0 (omitted)			
Laboratory Consultant Doctor	-2.16	-14.58	10.25	0.72

Specialty (ref: Infection Control)				
Health Management	9.77	-2.72	22.26	0.12
Laboratory Medicine	2.63	-10.62	15.89	0.69
Medical Laboratory	4.10	-6.30	14.52	0.43
Nurse	-1.87	-11.30	7.55	0.69
Others	-0.04	9.37	9.29	0.99
Public Health	-5.56	-15.65	4.52	0.30
Position or skill level (ref: Admin)				
Assistant Consultant Infection Control	-6.26	-18.20	5.67	0.29
Infection Control Practitioner	-3.83	-17.34	9.68	0.57
Laboratory Consultant	-12.17	-26.95	2.60	0.10
Laboratory Staff	-8.68	-21.80	4.43	0.19
Laboratory Supervisor	-9.80	-23.48	3.88	0.15
Others	-10.44	-22.15	1.27	0.08
Public Health Nurse	-7.29	-24.79	10.21	0.40
Quality Officer	-8.25	-22.62	6.12	0.25
Training				
Yes (ref: No)	3.86	-0.51	8.24	0.08
Location of practice (ref: King Abdulaziz Medical City)				
King Fahad Specialist Hospital	-4.36	-8.11	-0.62	0.02*
Hayat National Hospital	-1.30	-5.29	2.67	0.39

Asterisks (*) used to identify all significant p-values

5.20 Interaction tests between the independent determinants

The interaction between the independent determinants in the final model of IPC knowledge score were investigated (see Table 5.49). The interaction between location of practice and specialty showed a different association between IPC knowledge scores and specialty between the different hospitals, and that the effect of specialty on IPC knowledge scores depends on hospital type. After testing for differences in the effect of specialty on IPC knowledge scores at different hospitals and stratification of analyses for the different hospitals, we can see that no significant effect was reported at the 0.05 level in all hospitals (see Table 5.50). Additionally, there were negative associations between specialty (Laboratory Medicine, Medical Laboratory, and Nurses) and IPC knowledge scores for the participants from KAMC, Health Management, Medical Laboratory, Public Health workers and others, for the participants from KFSH's Public Health workers, and for the Medical Laboratory specialty for the participants from HNH. There were positive associations between IPC knowledge scores and Public Health and others for the participants from KAMC, in Nursing for the participants from KFSH, and in Public Health for the participants from HNH. The strongest associations were found for KAMC and KFSH. No statistically significant relationships were found.

Table 5.49: Interaction between independent determinants in the final model for IPC knowledge

Interaction	Interaction P-value*
Specialty and location of practice	0.04
Competence assessment and location of practice	0.25

*Based on Likelihood ratio test

Table 5.50: Regression of specialty against IPC knowledge stratified by location of practice

Variable	B	95% C.I	P value
Infection Control	Reference for all specialties		
King Abdulaziz Medical City			
Laboratory Medicine	-1.00	-3.25 1.25	0.40
Medical Laboratory	-0.40	-2.00 1.26	0.64
Nursing	-1.00	-2.95 0.95	0.30
Others	0.25	-1.53 2.03	0.80
Public Health	0.5	-1.45 2.45	0.60
King Fahad Specialist Hospital			
Health Management	-2.00	-4.28 0.28	0.08
Medical Laboratory	-1.00	-2.95 0.95	0.30
Nurse	1.30	-3.23 3.23	1.00
Others	-0.5	-3.13 2.13	0.70
Public Health	-1.5	-4.13 1.13	0.25
Hayat National Hospital			
Medical Laboratory	-0.71	-3.26 1.83	0.55
Public Health	3.00	-0.47 6.47	0.08

The interaction between the independent determinants in the final model for knowledge of PEP scores were also investigated (see Table 5.51). The relationship between location of practice and availability of competence assessment indicated a different association between knowledge of PEP scores and availability of competence assessment across the different hospitals, with the impact of the availability of competence assessment on knowledge of PEP scores depending on hospital type and vice versa. After testing for differences in the effects of the availability of competence assessment on knowledge of PEP scores at the different hospitals and stratification of analyses, we see that the availability of competence assessment effect for the participants from KFSH was significant at the 0.05 level (see Table 5.52). Additionally, there was a negative association between the availability of competence assessment and knowledge of PEP scores for the participants from KAMC. While there were positive associations between the availability of competence assessment and knowledge of PEP scores for the workers from KFSH and HNH. The strongest association is in KFSH. No other statistically significant interactions were found.

Table 5.51: Interaction between independent determinants in the final model of knowledge of PEP

Interaction	Interaction P-value*
Gender and location of practice	0.69
Nationality and location of practice	0.97
Competence assessment and location of practice	0.0007

*Based on Likelihood ratio test

Table 5.52: Regression of availability of competence assessment against knowledge of PEP stratified by location of practice

Variable	B	95% C.I		P value
No competence	Reference for Yes there is competence			
King Abdulaziz Medical City	-0.40	-0.90	0.09	0.11
King Fahad Specialist Hospital	1.01	0.43	1.60	0.001*
Hayat National Hospital	0.43	-0.07	0.93	0.09

The associations between the independent determinants in the final model for IPC attitude scores were investigated (see Table 5.53). The interaction between location of practice and gender indicated a different association between IPC attitude scores and gender across the different hospitals, with the effect depending on hospital type and vice versa. After testing for differences in the effect of gender on attitude scores at the different hospitals and stratification of analyses, we see that the effect at KAMC was significant at the 0.05 level (see Table 5.54). Additionally, there were negative associations between gender and IPC attitude scores for the participants from KFSH and HNH while there was a positive association between gender and IPC attitude scores for the participants from KAMC. The strongest association was for KFSH. No other statistically significant interactions were found.

Table 5.53: Interaction between independent determinants for the final model of attitudes towards implementation of IPC guidelines

Interaction	Interaction P-value*
Gender and location of practice	0.007
Nationality and location of practice	0.43

*Based on Likelihood ratio test

Table 5.54: Regression of gender against IPC attitudes stratified by location of practice

Variable	B	95% C.I		P value
Female	Reference for male			
King Abdulaziz Medical City	4.83	0.72	8.94	0.02*
King Fahad Specialist Hospital	-0.46	-3.42	2.49	0.75
Hayat National Hospital	-2.42	-5.17	0.32	0.08

The interaction between the independent determinants in the final model of IPC practice scores was investigated (see Table 5.55). The association between location of practice and specialty indicated a different relationship between IPC practice scores and specialty across the different hospitals, with the effect depending on hospital type and vice versa. After testing for differences in the effects of specialty on practice scores at the different hospitals and stratification of analyses, we see that the effect for the participants specialising in Health Management at KFSH and for the participants specialising in Public Health at HNH was significant at the 0.05 level (see Table 5.56). Additionally, there were negative associations between IPC practice scores and Laboratory Medicine workers from KAMC, for Health Management, Medical Laboratory, Public Health and others at KFSH, and for the Medical Laboratory and Public Health specialties at HNH. There was a positive association between Medical Laboratory, Nursing, Public Health and others and IPC practice scores for workers from KAMC only. The strongest association was reported for KAMC. No other statistically significant interactions were found.

Table 5.55: Interaction between independent determinants in the final model of IPC practices

Interaction	Interaction P-value*
Gender and location of practice	0.26
Nationality and location of practice	0.70
Specialty and location of practice	0.0063
Training and location of practice	0.23

*Based on Likelihood ratio test

Table 5.56:Regression of specialty against IPC practices stratified by location of practice

Variable	B	95% C.I		P value
Infection Control	Reference for all specialties			
King Abdulaziz Medical City				
Laboratory Medicine	-1.00	-15.05	13.05	0.88
Medical Laboratory	4.30	-5.92	14.48	0.40
Nurse	1.5	-10.66	13.66	0.80
Others	2.70	-8.80	14.13	0.63
Public Health	7.5	-4.66	19.66	0.21
King Fahad Specialist Hospital				
Health management	-31.5	-50.66	-12.33	0.002*
Medical Laboratory	-6.05	-22.50	10.40	0.455
Nurse	-13.00	-40.10	14.10	0.332
Others	-3.62	-22.13	22.13	1.000
Public Health	-12.5	-34.63	9.63	0.255
Hayat National Hospital				
Medical Laboratory	-4.92	-32.28	22.43	0.70
Public Health	-46.00	-83.28	-8.71	0.02*

The interaction between the independent determinants in the final model of participants' perceptions of the implementation of IPC guidelines was investigated (see Table 5.57). The results show no statistically significant interactions between the independent determinant variables (see Table 5.57).

Table 5.57: Interaction between independent determinants in the final model of perceptions of implementation of IPC guidelines scores

Interaction	Interaction P-value*
Years of experience and location of practice	0.90
Gender and location of practice	0.39
Occupation and location of practice	0.90
Specialty and location of practice	0.63
Position or skill level and location of practice	0.23
Training and location of practice	0.36

*Based on Likelihood ratio test

5.21 Assumptions of final regression model

The important assumptions of the final regression analysis - linearity, multicollinearity, heteroskedasticity, and normality - were examined.

Assessment of the linearity of the dependent variables with the independent variables in the final models was not appropriate since all the included independent variables were categorical. However, only the implementation scores model included two continuous variables (age and years of experience). The linearity of implementation scores with age was assessed using fractional polynomials, and no evidence of non-linearity was found. The linearity of implementation scores with years of experience was assessed using fractional polynomials with a likelihood ratio test by comparing the models with and without the fractional polynomials term. The likelihood ratio test P-value was greater than 0.05, suggesting that the models are not significantly different in terms of linearity.

Using variance inflation factors, none of the models showed a multicollinearity problem except the implementation scores model, which had a mean of >10, suggesting that at least two variables in the model highly correlated with each other (see Table 5.58). Calculating the correlation coefficients revealed the age and years of experience variables to be highly correlated (correlation coefficients = 0.893). Therefore, in order to solve the multicollinearity problem, only one of them was included in the models.

Table 5.58:Multicollinearity for knowledge, knowledge of PEP, attitudes, practices and implementation models

Model	Mean VIF
Knowledge scores	1.95
Knowledge of PEP scores	2.18
Attitude scores	2.30
Practice scores	3.28
Implementation scores	12.16*

The results of the Breuch-Pagan test suggested that there was potential issue of heteroscedasticity in the models for knowledge of PEP, attitudes and practices, at P<0.001, P=0.020, and P<0.001, respectively (see Table 5.59). In order to address the issue of heteroscedasticity, robust standard errors were used.

Table 5.59:Heteroscedasticity for the knowledge, knowledge of PEP, attitudes, practices and implementation models

Model	P value*
Knowledge scores	0.26
Knowledge of PEP scores	P<0.001
Attitude scores	0.02
Practice scores	P<0.001
Implementation scores	0.06

* Bases on Breuch-Pagan test

Eventually, since most of the data included in the models were categorical, no major violations of normality of residuals were found.

5.22 Bias due to missing data

Missing data can occur for a variety of reasons. In this study, the participants may have chosen not to provide information or to complete the questionnaire of the study for various reasons, such as lack of interest, time constraints or missing knowledge. A total of 30 participants did not fully complete the questionnaire, of whom 23 did not answer the questions related to knowledge of IPC and knowledge of PEP, 26 did not answer the questions related to attitudes towards IPC, 26 did not answer the questions related to IPC practices, and all of the 30 did not answer the questions relate to perceptions of IPC implementation. In terms of hospital, a total of 15 out of 43 participants from KAMC, 11 out of 44 from KFSH, and four out of 23 from HNH did not complete the questionnaire.

It should be emphasised that missing data may introduce bias and affect the validity of a study's statistical analysis; it is important to address the missing data appropriately in order to obtain reliable and accurate results.

To assess the bias related to missing data, logistic regression was undertaken for the missing data in each category (knowledge, attitudes, practices, perceptions and knowledge of PEP) separately as dependent variables and age, years of experience, gender, nationality, highest level of education, occupation, specialty, position, training and competence assessment separately as independent variables. If any association between the dependent and independent variables was found, this means that there may have been a bias in the results due to the missing data.

Based on the logistic regression results, a systematic difference between the participants with missing data and those without missing data ($p=0.05$) was identified. In comparison to admin staff with missing data, the odds of knowledge scores among those working as Laboratory Technicians and Infection Control Specialists with missing data were significantly three and four times higher, respectively (see Table 5.60).

Table 5.60:Bias due to missing data in IPC knowledge scores.

Variable	OR (95% C.I)	P value
Age	1.03 (0.97 1.09)	0.26
Years of experience	1.01 (0.95 1.08)	0.59
Gender		0.38
Male	1.52 (0.58 3.96)	
Nationality (ref: Egyptian)		0.54
Filipino	1.01 (-)	
Indian	1.01 (-)	
Jordanian	6.04 (-)	
Others	75 (-)	
Saudi	73 (-)	
Sudanese	75 (-)	
Highest level of education (ref: Bachelor)		0.43
Diploma	3.6 (0.83 15.43)	
Master	0.94 (0.27 3.29)	
Others	4.5 (0.26 77.13)	
PhD	1.125 (0.21 5.98)	
Occupation (ref: Admin)		0.05*
Infection Control Specialist	4.39 (-)	
Laboratory Specialist	2.23 (-)	
Laboratory Technician	3.66 (-)	
Nurse	1 (omitted)	
Others	1 (omitted)	
Phlebotomist	1.03 (-)	
laboratory Consultant Doctor	2.05 (-)	
Specialty (ref: Infection Control)		0.83
Health Management	1 (omitted)	
Laboratory Medicine	4 (0.11 136.95)	
Medical Laboratory	1.20 (0.12 11.58)	
Nurse	1 (omitted)	
Others	1(omitted)	
Public Health	0.8 (0.03 17.19)	
Position or skill level (ref: Admin)		0.40
Assistant Consultant Infection Control	1(omitted)	
Infection Control Practitioner	0.07 (0.00 1.72)	
Laboratory Consultant	0.1 (0.00 2.50)	
Laboratory Staff	0.15 (0.01 1.85)	
Laboratory Supervisor	0.3 (0.01 4.90)	
Others	1 (omitted)	
Public Health Nurse	1(omitted)	
Quality Officer	1(omitted)	
Training		0.88
Yes	0.91 (0.26 3.08)	

Competence assessment		0.76
Yes	0.82 (0.23 2.86)	

Asterisks (*) used to identify all significant p-values

Based on logistic regression results, there is a systematic difference between the participants with missing data and those without missing data (p=0.05). Compared to admin staff with missing data, the odds of knowledge of PEP scores among those working as Laboratory Technicians and Infection Control Specialists with missing data were three and four times higher, respectively (see Table 5.61).

Table 5.61:Bias due to missing data in knowledge of PEP scores.

Variable	OR (95% C.I)	P value
Age	1.03 (0.97 1.09)	0.26
Years of experience	1.01 (0.95 1.08)	0.59
Gender		0.38
Male	1.52 (0.58 3.96)	
Nationality (ref: Egyptian)		0.54
Filipino	1.01(-)	
Indian	1.01(-)	
Jordanian	6.04(-)	
Others	75(-)	
Saudi	73(-)	
Sudanese	75(-)	
Highest level of education (ref: Bachelor)		0.43
Diploma	3.6 (0.83 15.43)	
Master	0.94 (0.27 3.29)	
Others	4.5 (0.26 77.13)	
PhD	1.125 (0.21 5.98)	
Occupation (ref: Admin)		0.05*
Infection Control Specialist	4.39 (-)	
Laboratory Specialist	2.23 (-)	
Laboratory Technician	3.66 (-)	
Nurse	1 (omitted)	
Others	1 (omitted)	
Phlebotomist	1.03 (-)	
Laboratory Consultant Doctor	2.05 (-)	
Specialty (ref: Infection Control)		0.83
Health Management	1 (omitted)	
Laboratory Medicine	4 (0.11 136.95)	
Medical Laboratory	1.20 (0.12 11.58)	

Nurse	1 (0.03 17.19)	
Others	1 (omitted)	
Public Health	0.8 (omitted)	
Position or skill level (ref: Admin)		0.40
Assistant Consultant Infection Control	1 (omitted)	
Infection Control Practitioner	0.07 (0.00 1.72)	
Laboratory Consultant	0.1 (0.00 2.50)	
Laboratory Staff	0.15 (0.01 1.85)	
Laboratory Supervisor	0.3 (0.01 4.90)	
Others	1 (omitted)	
Public Health Nurse	1 (omitted)	
Quality Officer	1 (omitted)	
Training		0.88
Yes	0.91 (0.26 3.08)	
Competence assessment		0.76
Yes	0.82 (0.23 2.86)	

Asterisks (*) used to identify all significant p-values

Based on the logistic regression results, no association between having data for the IPC attitude scores and any of the independent variables was included in the model, Therefore, the problem of missing data did not introduce bias into the analysis (see Table 5.62).

Table 5.62:Bias due to missing data in IPC attitude scores.

Variable	OR (95% C.I)	P value
Age	1.02 (0.96 1.08)	0.44
Years of experience	1.01 (0.95 1.07)	0.68
Gender		0.33
Male	1.56 (0.62 3.89)	
Nationality (ref: Egyptian)		0.58
Filipino	38 (-)	
Indian	38 (-)	
Jordanian	2.30 (-)	
Others	28 (-)	
Saudi	35 (-)	
Sudanese	28 (-)	
Highest level of education (ref: Bachelor)		0.58
Diploma	2.97 (0.70 12.55)	
Master	1.03 (0.32 3.26)	
Others	3.71 (0.21 63.18)	
PhD	0.92 (0.17 4.87)	
Occupation (ref: Admin)		0.09
Infection Control Specialist	6.25 (-)	
Laboratory Specialist	3.98 (-)	
Laboratory Technician	5.21 (-)	
Nurse	1 (-)	
Others	1.82 (-)	
Phlebotomist	1.46 (-)	
laboratory Consultant Doctor	2.92 (-)	
Specialty (ref: Infection Control)		0.88
Health Management	1 (omitted)	
Laboratory Medicine	4 (0.11 136.95)	
Medical Laboratory	1.41 (0.14 13.47)	
Nurse	1 (omitted)	
Others	0.80 (0.03 17.19)	
Public Health	0.80 (0.03 17.19)	
Position or skill level (ref: Admin)		0.55
Assistant Consultant Infection Control	1 (omitted)	
Infection Control Practitioner	0.07 (0.00 1.72)	
Laboratory Consultant	0.1 (0.00 2.50)	

Laboratory Staff	0.17 (0.01 2.08)	
Laboratory Supervisor	0.3 (0.01 4.90)	
Others	0.12 (0.00 3.22)	
Public Health Nurse	1 (omitted)	
Quality Officer	1 (omitted)	
Training		0.65
Yes	0.76 (0.24 2.40)	
Competence assessment		0.64
Yes	0.76 (0.24 2.40)	

Asterisks (*) used to identify all significant p-values

Based on logistic regression results, no association between having data on the IPC practice scores and any of the independent variables was included in the model, Therefore, the problem of missing data did not introduce bias into the analysis (see Table 5.63).

Table 5.63:Bias due to missing data in IPC practice scores.

Variable	OR (95% C.I)	P value
Age	1.01 (0.96 1.07)	0.57
Years of experience	1.00 (0.94 1.06)	0.84
Gender		0.25
Male	1.68 (0.68 4.19)	
Nationality (ref: Egyptian)		0.58
Filipino	29 (-)	
Indian	29 (-)	
Jordanian	1.74 (-)	
Others	21 (-)	
Saudi	28 (-)	
Sudanese	21 (-)	
Highest level of education (ref: Bachelor)		0.62
Diploma	2.72 (0.64 11.42)	
Master	0.94 (0.30 2.97)	
Others	3.4 (0.20 57.66)	
PhD	0.85 (0.16 4.43)	
Occupation (ref: Admin)		0.10
Infection Control Specialist	6.98 (-)	
Laboratory Specialist	4.92 (-)	
Laboratory Technician	5.81 (-)	
Nurse	1 (-)	
Others	2.04 (-)	
Phlebotomist	1.63 (-)	
Laboratory Consultant Doctor	3.26 (-)	
Specialty (ref: Infection Control)		0.86
Health Management	1 (omitted)	
Laboratory Medicine	4 (0.11 136.95)	
Medical Laboratory	1.52 (0.15 14.48)	
Nurse	1 (omitted)	
Others	0.80 (0.03 17.19)	
Public Health	0.80 (0.03 17.19)	

Position or skill level (ref: Admin)		0.55
Assistant Consultant Infection Control	1 (omitted)	
Infection Control Practitioner	0.07 (0.00 1.72)	
Laboratory Consultant	0.1 (0.00 2.50)	
Laboratory Staff	0.17 (0.01 2.08)	
Laboratory Supervisor	0.3 (0.01 4.90)	
Others	0.12 (0.00 3.22)	
Public health nurse	1 (omitted)	
Quality Officer	1 (omitted)	
Training		0.73
Yes	0.81 (0.26 2.54)	
Competence assessment		0.37
Yes	0.6 (0.19 1.80)	

Asterisks (*) used to identify all significant p-values

Based on the logistic regression results, no association between having data on the scores for perceptions of the implementation of IPC guidelines and any of the independent variables was included in the model. Therefore, the problem of missing data did not introduce bias into the analysis (see Table 5.64).

Table 5.64:Bias due to missing data in perception of IPC implementation scores.

Variable	OR (95% C.I)	P value
Years of experience	0.99 (0.94 1.05)	0.94
Gender		0.22
Male	1.72 (0.71 4.13)	
Nationality (ref: Egyptian)		0.55
Filipino	35 (-)	
Indian	35 (-)	
Jordanian	2.13 (-)	
Others	26 (-)	
Saudi	42 (-)	
Sudanese	26 (-)	
Highest level of education (ref: Bachelor)		0.72
Diploma	2.30 (0.55 9.59)	
Master	1.01 (0.34 3.00)	
Others	2.88 (0.17 48.65)	
PhD	0.72 (0.13 3.73)	
Occupation (ref: Admin)		0.09
Infection Control Specialist	6.31 (-)	
Laboratory Specialist	5.39 (-)	
Laboratory Technician	5.26 (-)	
Nurse	1 (omitted)	
Others	1.84 (-)	
Phlebotomist	1 (omitted)	
laboratory Consultant Doctor	2.95 (-)	
Specialty (ref: Infection Control)		0.80
Health Management	1 (omitted)	
Laboratory Medicine	4 (0.11 136.95)	
Medical Laboratory	1.75 (0.18 16.61)	
Nurse	1 (omitted)	
Others	0.8 (0.03 17.19)	
Public Health	0.8 (0.03 17.19)	

Position or skill level (ref: Admin)		0.38
Assistant Consultant Infection Control	1(omitted)	
Infection Control Practitioner	0.07 (0.00 1.72)	
Laboratory Consultant	0.1 (0.00 2.50)	
Laboratory Staff	0.21 (0.01 2.60)	
Laboratory Supervisor	0.5 (0.00 3.22)	
Others	0.12 (omitted)	
Public Health Nurse	1 (omitted)	
Quality Officer	1 (omitted)	
Training		0.53
Yes	0.70 (0.23 2.08)	
Competence assessment		0.12
Yes	0.43 (0.15 1.22)	

Asterisks (*) used to identify all significant p-values

In summary, this chapter has identified a number of differences between participants across between and within hospitals. Different levels of knowledge, attitude and practice reported between hospitals. Potential predictors of dependent variables were identified and location of practice was the most common predictor, except for knowledge of PEP and practice variables. The important assumptions of the regression analysis were examined and required teste were performed. Finally, logistic regression was conducted for assessing the potential bias due to missing data. By using descriptive and inferential statistics of the data gathered from questionnaires, the chapter has provided a clear picture of the knowledge, attitude and practice of IPC guidelines at three selected hospitals and highlighted some differences at these hospitals.

Chapter 6 Results of Qualitative Research

The findings regarding the participants' risk perceptions of LAIs gathered from the qualitative component of the research and their different views on the implementation process are presented in this chapter. The number and characteristics of the participants from the selected hospitals in the in-depth interviews are shown Table 6.1. Below that are the NPT constructs with the related themes and sub-themes.

Table 6.1:Number and characteristics of the participants from the in-depth interviews from the selected hospitals

Site	Number of interviews	Interviewees
1. **King Abdulaziz Medical City (KAMC)**	6	Infection Control Practitioner n=2 (Both females) Nurse/Infection Control Practitioner n=1 (Male) Laboratory Specialist n=2. (Both males) Laboratory Specialist/Supervisor n=1 (Female)
2. **King Fahad Specialist Hospital (KFSH)**	6	Laboratory Specialist/Supervisor n=1 (Male) Laboratory Technician/Quality Officer n=1 (Female) Laboratory Specialist/Supervisor of Technicians n=1 (Male) Laboratory Technician n=1 (Male) Infection Control Practitioner n=1 (Female) Infection Control Coordinator n=1 (Female)
3. **Hayat National Hospital (HNH)**	6	Laboratory Specialist n=3 (All Females) Infection Control Director n=1 (Female) Nurse/Infection Control Coordinator n=1 (Male) Laboratory Specialist/Supervisor of Technicians n=1 (Male)

The data under each sub-theme was mapped to the sub-construct of the NPT (Table 6.2). Some sub-constructs were not prevalent in the data such as systemisation, and skill set workability, and including data under those sub-constructs would lead to repetition.

Table 6.2: Mapping of sub-themes to the sub-constructs of the NTP

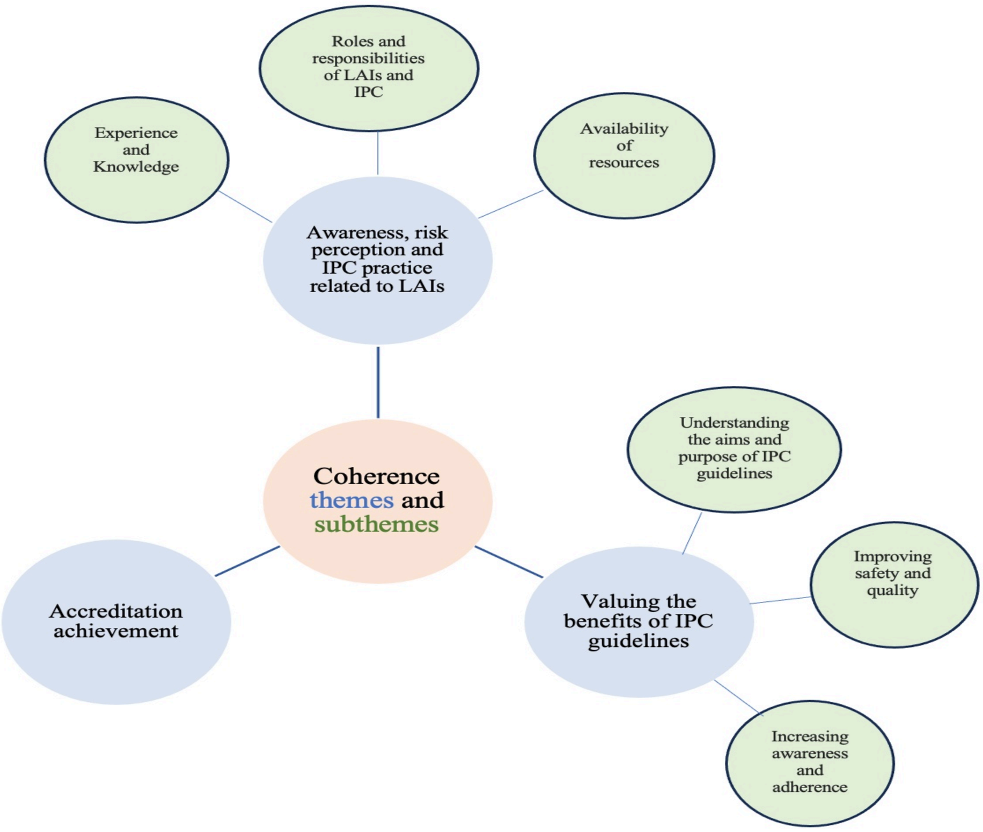
Construct	**Coherence**	**Cognitive participation**	**Collective action**	**Reflexive monitoring**
Sub-construct	**1-Differentiation** Is there a clear understanding of how the IPC implementation differs from existing practice?	**1- Initiation** Are there key people who drive the implementation of IPC forward and get others involved?	**1- Interactional workability** Does the implementation of IPC make people's work easier?	**1-Systemisation** Are participants aware of reports about the effects of the IPC implementation?
Sub-theme	*- Experience and Knowledge* *- Availability of resources*	*- Lack of organisational support and effective leadership*	*- Sharing experiences and learning*	None
Sub-construct	**2- Communal specification** Do individuals have a shared understanding of the aims, objectives and expected benefits of the IPC guidelines?	**2- Enrolment** Are participants open to working with others in new ways for the purposed of implementation of IPC?	**2- Relational integration** Does being involved in implementation of IPC disrupt working relationships?	**2- Communal appraisal** Do participants agree that IPC implementation is worthwhile?
Sub-theme	*- Understanding the aims and purposes of IPC guidelines*	*- Ease of access* *- Adherence to and compliance with IPC practices*	*- Relationship in the workplace*	*- Awareness and education* *- Rewards and penalties*
Sub-construct	**3- Individual specification** Do individuals have a clear understanding of their specific tasks and responsibilities in the implementation of IPC guidelines?	**3- Legitimation** Do participants believe that being involved in the implementation of IPC is a legitimate part of their role?	**1- Skill set workability** Is sufficient training provided to enable participants to enact IPC implementation?	**3- Individual appraisal** Do participants value the effects IPC implementation has on their work?
Sub-theme	*- Roles and responsibilities of LAIs and IPC*	*- Workload pressures and employees needs* *- Communication and language*	None	*- Strictness and experience in guideline implementation*

Sub-construct	**4- Internalisation** Do individuals understand the value, benefits and importance of IPC guidelines?	**4- Activation** Are participants willing to support implementation of IPC?	**4- Contextual integration** Do management adequately support IPC implementation?	**4- Reconfiguration** Is feedback about IPC implementation used to improve it in the future?
Sub-theme	*- Improving safety and quality* *- Increasing awareness and adherence*	*- Staff engagement in IPC guidelines improvement*	*- A need for change and improvement*	*- Break room availability*

6.1 Coherence

In normalisation process theory, coherence refers to how staff make sense of IPC guidelines. Three themes and six subthemes were identified under this construct (Figure 6.1).

Figure 6.1: Themes and subthemes of coherence construct



6.1.1 Awareness, risk perceptions and IPC practices related to LAIs

The participants' level of knowledge and experience, their perceptions of roles and responsibilities related to the management of LAIs and their understanding of the resources available to prevent LAIs are the main factors reported for assessing awareness and risk perceptions of infections.

Experience and Knowledge

The process through which the participants shared and created knowledge of LAIs differed across hospitals. All staff agreed that there were no previous injuries or laboratory-based infections based on their previous experiences. However, it seems the situation changed during the COVID-19 era. as commented: *"It is not a problem we have at work; there were no previous injuries. Even during the time of Corona, almost our department was the only one where all the infections that occurred there came from the family, not from the laboratory."* (Site.1, Laboratory Specialist/Supervisor)

In general, the theme highlights that hospital laboratory injuries were uncommon, with neither of the COVID-19 cases being related to laboratory work.

Roles and responsibilities of LAIs and IPC

During the interviews, the participants acknowledged that laboratory management of LAIs was the responsibility of a safety officer in the laboratory, asreported: *"we have a safety officer, and if any injury or accident happens, we report it to him and follow the required precautions."* (Site.1, Laboratory Specialist 2)

A participant from KFSH highlighted a slightly different structure as they have staff member from the laboratory who has the responsibility for infection control and the coordination between the Infection Control Department with the laboratory: "*We only have one employee coordinator associated with the Infection Control Department in the hospital. The role of this employee is to coordinate between the Infection Control Department and the Laboratory Department, meaning that the implementation of any instructions and regulations approved by the Infection Control Department is the responsibility of this employee."* (Site.2, Laboratory Specialist/Supervisor of Technicians)

However, some participants at KFSH felt that the management of laboratory-associated infections was not effective, and e only becomes active during rare official visits from the Infection Control Department. This sporadic engagement means that there is no ongoing routine or continuous support for infection control practices. With one worth quoting at length: "*There is only one employee, and his role is not effective at all. He is an Infection Control Coordinator related to the infection control team responsible for infection control. The visits of the Infection Control Department us are rare, and if there are official visits, he starts his work, inspects, and gives notes, and there is no continuous routine."* (Site.2, Laboratory Specialist/Supervisor)

A similar view was expressed by a Laboratory Specialist from HNH: *"In the laboratory, we have a person from infection control who is completely without any role, and he also fails to understand his job and responsibilities."* (Site.3, Laboratory Specialist 2)

When asking the participants who is responsible for implementing IPC guidelines, the participants across all the hospitals agreed that it is the responsibility of every single staff member, in addition to the hospital's Infection Control Department. As reported: *"We are the Infection control practitioners. We are the ones who make an implementation of it, and we are the ones who make sure that it is applied in all departments and everyone applies it."* (Site.1, Infection Control Practitioner 1)

However, some participants from KFSH expressed different views in relation to the role and responsibilities of the Infection Control Department at the hospitals. One participant felt that the infection control team was more actively engaged with the hospital's other departments rather than the laboratory, claiming: *"It is strange that we see the efforts of the Infection Control Department in other departments in the hospital, but with regard to the laboratory, they are of no importance."* (Site.2, Laboratory Specialist/Supervisor)

Similarly, another participant from the same hospital reported that there was no formal engagement between the laboratory and the Infection Control Department and their interactions are limited to bureaucratic paperwork rather than meaningful collaboration: *"The Infection Control Department comes to the Microbiology Department only because, as you know, samples from emergency and the ICU are cultivated in it, so there must be a report on infection control. But as a laboratory, they have nothing to do with us. What is between us is only the* *paper work regarding policies. The last time they visited us was 2019, and they only held training."* (Site.2, Laboratory Technician/Quality Officer)

To sum up, the theme signifies that, despite some concerns related to the limited engagement with the Infection Control Department at the various hospitals, laboratory-based staff members understand their own and others' roles in controlling LAIs and implementing IPC guidelines.

Availability of resources

The data under this theme reveal different organisational responses regarding the availability of hospital resources (i.e., policies or guidelines) related to laboratory-associated infections. Some staff reported that hospital resources were available and anyone within the hospital can access them easily. As commented: *" Anyone can get it easily, and in our department there is a corner for these resources."* (Site.2, Laboratory Technician)

The resources are available through multiple formats, including easily accessible brochures placed throughout the hospital and regular updates sent via email, as reported: *"We have brochures everywhere. Especially essential guidelines such as patient waste, body fluids. In addition to these papers and information, they send by email information with all the new standards."* (Site.3, Laboratory Specialist 1)

However, one participant expressed concern about a lack of information available to them on guidelines and policies: *"I don't know if there are any guidelines or policies for laboratory-associated infections available in the laboratory."* (Site.1, Laboratory Specialist 2)

Moreover, another participant reported that guidelines related to laboratory-associated infections were not available for Laboratory Technicans: "*No, not available. Only general precautionary guidelines are available."* (Site.2, Laboratory Specialist/Supervisor of Technicians)

Overall, staff at the selected hospitals are aware of the risk of laboratory-associated infections and the importance of the availability of IPC guidelines. However, limited access to information and resources poses barriers to the successful implementation of IPC guidelines.

6.1.2 Valuing the benefits of IPC guidelines

Implementing IPC guidelines in any healthcare facility is considered essential and valuable for staff, patients and organisation.

Understanding the aims and purposes of IPC guidelines

There were multiple meanings associated with the aim and purpose of IPC guidelines among the participants reflect the varied perspectives of participants on IPC guidelines. Some emphasised their evidence-based nature and reliance on authoritative sources like the WHO and: "*It is evidence-based precautions, it helps us a lot to prevent and control healthcare-associated infections. I know the sources of it are always the World Health Organisation or Centers for Disease Control and Prevention."* (Site.1, Infection Control Practitioner 1)

Some focused on specific safety practices and reporting protocols such as prohibiting eating in laboratories, wearing PPE, and reporting incidents like needle stick injuries "*Precautions are, for example, forbidden to eat inside the laboratory, wearing gloves and PPE. If there is, for example, a needle stick injury, we go to infection control and inform them."*(Site.2, Laboratory Technician/Quality Officer)

While others acknowledged a general understanding of the guidelines, including knowledge of infection sources and actions to take with specific samples, but admits to lacking detailed knowledge *"I know, in general, for example, what the sources of infection are, what action to take, and how to deal with a specific type of sample. This is in general, but I don't know the details, to be honest."*(Site.3, Laboratory Specialist 2)

Despite the multiple interpretations of IPC guidelines, the theme suggests that across all sites the participants do value the benefits of implementing the guidelines in clinical practice.

Improving safety and quality

There was evidence that some participants, regardless of occupational group, fully understand the significance and value of IPC guidelines. They collectively agreed that the guidelines protect employees from infection and provide a safe environment for staff and patients. As commented: *"Infection control precautions mainly mean the safety of the patient and the health practitioner; they are concerned with limiting the spread of infection among patients and* *between Health Practitioners and even visitors and auditors of the health facility in order to provide healthcare, and with high quality for the safety of the patient and the health practitioner as well."* (Site.2, Infection Control Practitioner)

Since healthcare workers are viewed as the first line of defense, prioritising self-protection through IPC protocols allows them to safeguard their own health while also contributing to the overall safety and well-being of their colleagues and the wider community, ultimately leading to a healthier society*"For sure, reduce the spread of infection. Especially since we are considered the first line of defence. Protecting ourselves is important for the protection of the people around us, and society in general is based on it."* (Site.3, Laboratory Specialist 2)

In spite of occupational group differences, the participants appeared to understand the importance of IPC guidelines, and agreed on their value for protecting patients and staff.

Increasing awareness and adherence

Many participants frequently commented that implementing IPC guidelines is appropriate for their jobs, and the importance of doing so is linked to the nature of their work particularly because their work involves handling samples with various types of infections, such as Brucella, as reported: *"Yes, for example, we have some of our samples with Brucella, which is an airborne bacteria. We are working on the samples inside the safety cabinet. Of course, we wear all the preventive equipment."* (Site.1, Laboratory Specialist 2)

In addition, most of participants acknowledged that the implementation of IPC guidelines is essential to combat healthcare-associated infections and to prevent and respond to outbreaks. As commented: *"During my previous work, I often neglected guidelines like changing gloves after each patient, thinking it unnecessary. Later, I realized the importance of hygiene and began cleaning the chair after each use, becoming more cautious about infection control and its role in preventing outbreaks."* (Site.3, Laboratory Specialist 1)

Some participants expressed the view that the guidelines increased their vigilance when handling any form of sample, with one participant commenting: *"The guidelines are very useful for us. They made us more careful while dealing with any type of sample inside the laboratory."* (Site.1, Laboratory Specialist 2)

For some participants, the COVID-19 pandemic significantly influenced their adherence to infection prevention and control measures. Initially, they followed the guidelines, but their awareness was not as strict. The pandemic heightened their awareness of infection risks, resulting in a dramatic increase in sterilisation practices both inside and outside the laboratory, reflecting a stronger commitment to maintaining a safe environment, as commented: *"I was committed to the guidelines before COVID, but different from my commitment after COVID. After the COVID pandemic, my sterilisation increased dramatically inside and outside the laboratory."* (Site.1, Laboratory Specialist 2)

The awareness of infection transmission risks and the importance of careful practices in everyday laboratory activities were alco increased after COVID-19 pandemic *"At first, we were not aware of how much the infection could be transmitted by anything as simple as touching the phone, touching the keyboard, or touching the biohazard bag. But after the COVID pandemic, I understood the risk available within the laboratory and the importance of following the safety guidelines."* (Site.3, Laboratory Specialist 1)

In this context, some participants felt that effective prevention and control of infection was an integral part of their clinical routines and everyday practice and noncompliance triggers a feeling of guilt or negligence, as expressed: *"It has become a routine to wear gloves and a mask, and if I don't wear them, I will feel that I am doing something wrong."* (Site.1, Laboratory Specialist 1)

The application of IPC guidelines not only affected the work but also the lifestyle of one participant. This change reflects an increased awareness of infection risks, as reported: *"My perspective on things changed. Initially, I was careless, as was the case with the coronavirus. We frequently used cash, but after the pandemic, I switched to using a Visa card or other contactless methods. These practices have improved significantly, and the level of awareness people have gained is commendable."* (Site.1, Infection Control Practitioner 2)

Overall, the theme demonstrates that the participants understand and are aware of the value of implementing IPC guidelines. This coherence in understanding has increased their adherence to the guidelines in both their work environment and personal lives. Moreover, IPC guidelines have changed the participants' perspectives on laboratory-associated infections, especially since the COVID-19 pandemic.

6.1.3 Accreditation achievement

This study's participants acknowledged that implementing IPC guidelines is important for globally recognised qualifications such as the Joint Commission International (JCIA), the College of American Pathologists (CAP), and the Saudi Central Board for accreditation of Healthcare Institutions (CBAHI). As reported: *"It is a necessary part of the certificates that exist globally."* (Site.1, Laboratory Specialist/Supervisor)

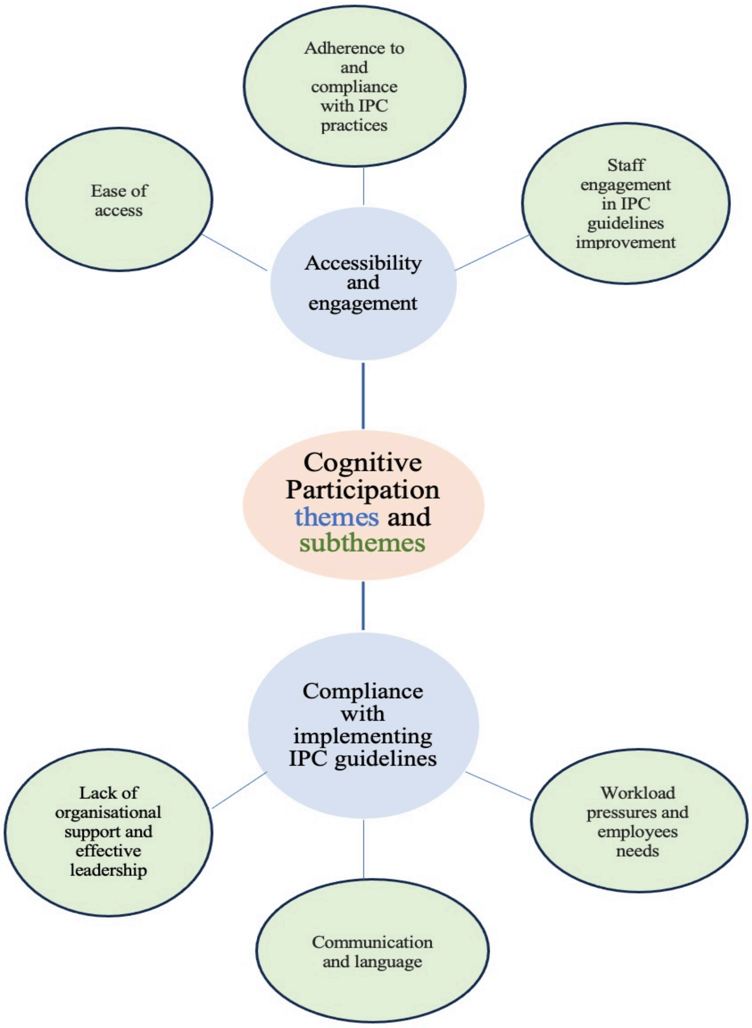
However, some participants claimed that their hospital adheres to IPC regulations and guidelines only in order to achieve the accreditation certificate, ignoring the important purpose of implementing the guidelines as an essential part of delivering high-quality and safe healthcare services. This neglect explained the efforts the hospital staff made when they were expecting a visit from accreditation bodies, as noted: *"I think the purpose of following it in this hospital could only be to obtain accreditation, because, as I said previously, infection control is active only at the time of official visits; as for normal times, there is no follow-up.*" (Site.2, Laboratory Specialist/Supervisor)

Overall, the theme shows that some participants appreciate the need to implement IPC guidelines in order to achieve accreditation. However, others observed that their hospital only follows the requirements to achieve accreditation, not for the purposes for which they are actually intended.

6.2 Cognitive Participation

In normalisation process theory, cognitive participation refers to how relationships with other staff influence implementation of IPC guidelines. Two themes and six subthemes were identified under this construct (Figure 6.2).

Figure 6.2: Themes and subthemes of cognitive participation construct



6.2.1 Accessibility and engagement (enrolment)

The primary factors encouraging compliance with IPC guidelines is their availability and ease of access.

Ease of access

All staff in the laboratory can easily access infection control guidelines and relevant information online as commented: *"Anyone employed can access our guidelines online at any time. They simply need to click on the internet to be directed to the organized manuals, where they can select the infection control guidelines."* (Site.1, Infection Control Practitioner 3)

Staff can also access IPC guidelines through the hospital's electronic system, and supplies such as gloves and masks are available, ensuring that resources are readily accessible, as reported *"Staff can access any policy, guidance, or relevant information through the hospital's electronic system, and supplies are available in abundance."* (Site.3, Laboratory Specialist 3).

However, one participant expressed the view that although access to the guidelines was straightforward, there was a lack of broader organisational support related to infrastructure investments necessary to improve infection prevention and control measures. They highlighted that essential resources, such as proper ventilation systems and safety cabinets for handling hazardous materials like dyes and formaldehyde, were missing, which left staff vulnerable to harmful fumes and compromised their safety in the Histopathology Department, as commented: *"Gloves and masks are available along with instructions. There are critical resource shortages in the Histopathology Department with the presence of many dyes, alcohol, and formaldehyde, such as proper ventilation and safety cabinets for TB samples, which have been long requested. When these concerns are raised, infection control often deflects responsibility, citing financial constraints and administrative indifference. As a result, many employees suffer from harmful fumes due to the lack of support from various departments, including Quality Management and Infection Control."* (Site.2, Laboratory Technician/Quality Officer)

Overall, this theme shows that access to IPC guidelines is straightforward across all hospital sites. However, a lack of organisational support is seen as a barrier to the successful implementation of infection prevention and control measures.

Adherence to and compliance with IPC practices

Despite all the participants acknowledging that accessibility to guidelines and availability of resources is an important factor in compliance, engagement with IPC guidelines varied from hospital to hospital. In particular, for most interviewees, there seems to be a lack of awareness in relation to the guidelines themselves. Some staff, particularly older employees, were reported to wear inappropriate dress, highlighting inconsistent commitment to safety protocols and the need for stronger enforcement. As reported: *"Some employees come to work wearing sandals*[4] *or the traditional Saudi dress*[5]*, and there is no consistent commitment to safety standards. While some employees are very careful, others are not. For instance, I now appreciate the importance of infection control, but I don't apply it strictly to myself because I don't want to become obsessed with it. Among our employees, there is group commitment, but often older staff members feel no obligation to follow dress codes or procedures, although some younger employees behave similarly."* (Site.2, Laboratory Specialist/Supervisor)

Personal attitudes significantly influence adherence to safety practices, with some staff being highly committed, others demonstrating average compliance, and a few showing negligence. This highlights the importance of administrative supervision in reducing negligence, as noted: *"Undoubtedly, not all employees are committed to infection control procedures, meaning that there will be someone who is very committed, someone who is average, and someone who is a bit negligent. But with ours and the administration, there will be less negligent, and in the last it is all related to their personalities."* (Site.3, Infection Control Director)

A Laboratory Specialist from KFSH stated that he engaged more with IPC guidelines only when he receives notification that the IPC Department is planning to visit the laboratory for an observation, similar to what the Infection Department do when they are expecting a visit from the accreditation bodies: *"I work like what the infection control staff do for getting accreditation. If the time comes for visits from them, I give my staff instructions, i.e., for*

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[4] Wearing sandals in the laboratory is considered inappropriate and does not comply with IPC standards, which require closed-toe shoes. Sandals offer inadequate protection against spills, splashes, or accidents involving biological agents or sharp objects.

[5] Staff working in the laboratory wearing traditional Saudi dress, which is often long and flowing, may risk exposure to chemicals and biological agents. This type of dress may not offer the same level of protection as laboratory coats.

example, about dealing with samples and what is required in terms of clothing, and dealing with spell kit and infection that may happen in the department, etc." (Site.2, Laboratory Specialist/Supervisor)

Moreover, two participants highlighted the issue of gender difference in compliance, with males generally being less compliant than females. For instance, males working in laboratory management are usually wearing traditional Saudi dress instead of laboratory coats and often eat and drink inside the laboratory, despite having a designated area for this purpose. One participant from KFSH noted that: *"As for the laboratory management, I can see that many of the staff working there are not obligated to wear the laboratory coat, they only wear traditional Saudi dress, although they sometimes entering the sample processing area. In addition, all men drink and eat inside the laboratory. Although they have a special room for eating and drinking, they are not obligated to sit there when eating and drinking."* (Site.2, Laboratory Technician/Quality Officer)

The second participant highlights a perception that females are more committed to following safety guidelines than males, who are seen as more relaxed and prone to risky behaviors, such as not wearing gloves when handling samples, as reported: *"I noticed that females are stricter and better in following the guidelines than male whatever their job e.g., a specialist, technician or so on. Males always take things lightly and easily. For example, it is possible for them to hold samples without wearing gloves."* (Site.3, Laboratory Specialist 1)

Overall, the theme here reveals different levels of adherence to and compliance with infection prevention and control practices across the hospital sites among staff and between gender, something connected to individual staff members' personalities and behaviours.

Staff engagement in IPC guidelines improvement

An opportunity for each staff member to offer feedback to improve IPC guidelines could assist organisations in their attempts to successfully implement the guidelines. Most participants suggested that all hospital employees, regardless of position, have the ability to provide comments and recommendations to shape improvements to IPC guidelines. One commented: *" I hadn't had the chance to deal with the Infection Control Department before, but we have no problem at all with submitting feedback or suggestions, whether to the Laboratory*

Department or to the Infection Control Department. For sure they will respond to our suggestions." (Site.1, Laboratory Specialist 2)

However, a participant from KFSH suggested that laboratory management teams did not respond to comments or feedback, highlighting a common issue where decisions are filtered through management that may undervalue specific needs. Additionally, budget constraints from departments like infection control further limit the ability to address important issues, as commented: *"I have not tried to make the request because I lack the power to do so. I can refer them to the laboratory Director, but management may deem the request unnecessary. Secondly, departments like infection control or safety explain that they are linked to a budget, linked, for example, to a company that supplies this thing, leaving no available funds for this issue. Unfortunately, I feel powerless, and I doubt anyone will respond."* (Site.2, Laboratory Technician/Quality Officer)

Moreover, the participants suggested that local hospitals have some flexibility to modify IPC guidelines to meet their local needs, and they are annually updated based on the MoH guidelines. As reported: *"The guidelines reach us from the MoH and the Infection Control Coordinator here update it and makes the required modifications based on our needs. It is updated annually, or according to whether there are new additions or modifications."* (Site.1 Infection Control Practitioner 2).

However, any modifications made to the guidelines by the hospital should fulfil the infection control principles and be done carefully with an awareness of the potential effects on patient and environment safety. As said: *"From each section, the head nurse comes to us, discussing with us the existing irregularities and solutions to them instead of the solutions we have already mentioned. If it is in line with infection control policies and will not harm the patient and the work environment, then there is no problem with that."* (Site.3, Infection Control Director)

In general, the theme here showes that all the participants have the capacity for cognitive participation to provide feedback that enhances the application of IPC guidelines, that local hospitals have the ability to adapt the guidelines based on their needs, and that any adaptation should comply with public health principles.

6.2.2 Compliance with implementing IPC guidelines

The main reasons behind the varied degrees of engagement with IPC guidelines were related to workload pressures and communication challenges among Laboratory Technicians.

Workload pressures and employees needs

Some participants acknowledged that workload pressures could pose barriers to compliance: *"Sometimes, due to the workload or being in a rush, it can be forgotten and I think this is involuntary, unintentional."* (Site.1, Laboratory Specialist 2).

A participant from a different hospital identified the number of tasks performed during work as a barrier. The frequent need to wear and remove gloves for each new sample can be perceived as overwhelming by staff, resulting in some choosing not to use appropriate protective equipment: *"The number of tasks to perform, every three or four minutes we get a sample for the emergency room, so there is a need to wear or remove gloves every time, and some of the staff say 'I don't want to do that', so they work without wearing gloves."* (Site.2, Laboratory Technician)

Another challenge staff reporting encountering with implementing IPC guidelines is the availability of a room or a place for rest, eating, and drinking during breaks. As the laboratory prepared for sample processing, this enforces staff to eat in the offices. As commented: "*We do not have a place for the employees. We are in the laboratory. Our places are all practical: storage places, the refrigerator, the media, and the supply. Sometimes they have to enter one of the offices to eat."* (Site.1, Laboratory Specialist/Supervisor)

A participant from HNH conveys annoyance over the prohibition on drinking water while working, emphasising that it disrupts their ability to perform effectively. While acknowledging the rationale behind restricting food consumption in the laboratory, the argument is about that access to water should be considered essential, especially in a demanding environment like the laboratory where staff may not have designated break rooms : "*For example, I am not allowed to drink water at all in the laboratory. This affects me and disrupts my work. In my opinion, preventing eating food is possible and correct. However, drinking water, which is supposed to be allowed, for example, especially in workplaces, is an essential necessity, especially since* *we are in a laboratory and there is no rest room for staff, so I have to drink in the laboratory."* (Site.3, Laboratory Specialist 1)

Another participant claimed that the male staff room is not fully equipped and that the arrangements for male staff lack consideration for comfort and functionality, in contrast to female staff, who have a larger room. Additionally, their requests for improved facilities have not been addressed: "*We have a staff room, but it was not fully equipped for us. It was not prepared for us because we have two sexes, males and females*[6]*. I mean, for females, they put them in a large room. We asked for such and such a room, but so far, our request has not been met."* (Site.2, Laboratory Technician)

For some participants, the poor quality of different resources, such as gloves and masks, and the risk of allergic reactions when using the available types of gloves for some employees, were the greatest obstacles to following IPC guidelines. It seems to be difficult to ask suppliers for an alternative, as mentioned: *"We requested a good type of gloves, but the hospital provided the powdered ones, which cause allergies. The resource department can't specify glove types because the ministry supplies them, so we have no choice but to use the available gloves. My sensitivity makes wearing gloves uncomfortable, and hand lotion hasn't helped."* (Site.2, Laboratory Technician)

The theme generally showes that workload pressures, frequency of tasks, and meeting employees' needs such as access to restrooms and quality of resources all have an impact on staff compliance with IPC guidelines.

Communication and language

The interviews revealed that a number of participants felt that IPC guidelines sometimes obstruct communication with others and disturb staff in the workplace. For example, using masks disrupts their conversation with each other in the workplace: "*The mask also sometimes hinders our communication with each other because our work includes the fact that I work in*

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[6] Cultural norms in Saudi Arabia require females to wear hijabs and veils. These norms make it inappropriate for males and females to share a break room because females would be unable to remove their veils while eating or drinking if male staff are present. As a result, maintaining separate break rooms for males and females is necessary to respect these cultural practices and ensure that all staff can take breaks comfortably.

one place and my colleague is in another place. So, if I need to communicate with him, I have to put the mask down or remove it." (Site.2, Laboratory Technician)

Moreover, one of the challenges faced by female staff was regarding personal comfort and safety during the COVID-19 pandemic. While the staff acknowledge that wearing a mask was necessary during the pandemic for their own protection and the safety of their families, the discomfort of wearing a mask under a veil, highlighting the practical difficulties of combining safety measures with cultural clothes: "*There is nothing other than wearing a mask under the veil. which is very uncomfortable. During the COVID pandemic, I was forced to wear it to protect myself and my family."* (Site.3, Laboratory Specialist 1)

Some participants reported that language is sometimes considered a challenge to complying with implementing IPC guidelines, especially for Infection Control Practitioners when supervising or educating other staff. An Infection Control Coordinator reported difficulties in communicating with the laboratory cleaners: "*For example, the cleaners, most of whom are Nepalese. Initially, we did not understand each other, so we had to ask one of the old employees to translate the words between us, and so on until they learned the language and we were able to communicate easily."* (Site.3, Nurse/ Infection Control Coordinator)

Overall, the theme demonstrates that applying IPC guidelines sometimes interferes with participants' ability to communicate with one another at work and causes discomfort, which may potentially impact compliance with the guidelines

Lack of organisational support and effective leadership

The participants repeatedly mentioned their obligation to implement IPC guidelines, citing infection control awareness as their primary motivation. However, the perception of insufficient organisational support appeared to be impeding implementation. It was suggested that greater organisational support and effective leadership would lead to greater responsibility and acceptance of IPC guidelines. One participant highlights significant concerns regarding the enforcement of workplace policies and the effectiveness of the current system in KFSH including application of penalties. The flexibility and lack of strictness in the system can create an environment where standards are not taken seriously, potentially jeopardizing safety and Service quality. As commented: "*Penalties exist, but they are not enforced. For example, I* *would like to require employees to wear official clothing and adhere to precautions, but due to the weaknesses in the system, I cannot enforce this. There is nothing I can rely on or any means of punishment. I believe the entire system has flaws, particularly regarding reward and punishment, procedures, and a lack of accountability for employees who do not comply. Unfortunately, our system is very flexible and lacks strict enforcement"* (Site.2, Laboratory Specialist/Supervisor)

Another staff member from the same hospital highlighted the role of the laboratory culture and work environment in poor commitment to IPC guidelines among staff, indicating that a stricter environment from the start could have led to better compliance: "*The commitment to IPC guidelines in our hospital is very poor. I believe this lack of commitment is related to the 'culture of the laboratory' or 'work environment.' If the environment had been strict from the beginning, things would be different."* (Site.2, Laboratory Technician/Quality Officer)

In addition, the lack of organisational support reflected also a lack of awareness among some staff working inside the laboratory such as laboratory management staff and staff from other departments who visit the laboratory such as doctors without applying the safety guidelines. As one participant from KAMC commented: "*Sometimes the laboratory management staff may enter the laboratory and they have a coffee in their hands, and some doctors who come from abroad to do teaching work or other things carry a can of water with them."* (Site.1, Laboratory Specialist/Supervisor)

A different participant from HNH raised concerns regarding leadership behavior and its impact on the culture of infection prevention and control (IPC) within the laboratory. The manager's habitual entrance with a cup of coffee not only undermines the seriousness of safety protocols but also sets a poor example for the staff. This raises questions about whether the IPC team supervises the entire laboratory or only the sample processing area: "*One of our managers has never participated. He always walks into the laboratory with a cup of coffee, which raises many questions in our minds as staff. Maybe this is because the IPC team is focusing more on the blood sampling area and the sample processing area in the laboratory! I don't know!"* (Site.3, Laboratory Specialist 1)

One staff claimed that, lack of awareness may lead to insufficient resources for implementing the guidelines, as staff responsible for resource allocation are often unaware of the danger's laboratory staff face. The belief that wearing gloves is sufficient for protection reflects a misunderstanding of essential safety measures. Additionally, concerns about critical resource shortages are often dismissed due to this lack of awareness regarding the risks involved. As said: "*I believe the issue stems from a lack of awareness; many people are unaware of our laboratory operations and the risks involved. Some staff responsible for resource allocation think that wearing gloves is sufficient. As an employee in the Quality Department, I try to communicate these problems, but responses from officials often dismiss our concerns as trivial or outside their competence. Basic supplies, like N95 masks for the histopathology department, are unavailable due to funding issues, putting the staff working there at high risk.*" (Site.2, Laboratory Technician/Quality Officer)

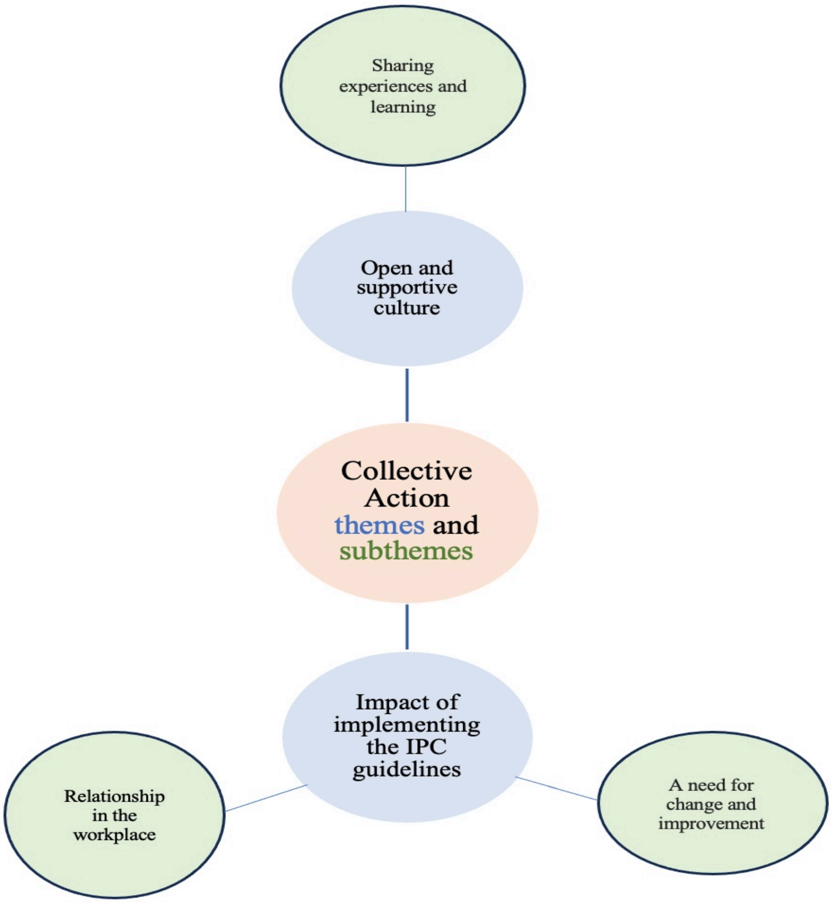
Training and shadowing for new employees were seen as potential opportunities to raise awareness of and compliance with IPC practice, but some challenges were foreseen with this. The behaviors and attitudes of experienced staff directly influence the compliance and safety practices of new staff. When the employees demonstrate adherence to guidelines, they foster a culture of diligence and responsibility. Conversely, when they ignore guidelines, it sets an example that can jeopardize safety standards and undermine the effectiveness of training: "*When a new employee starts work, their training largely depends on the behavior of the employee accompanying them. If the accompanying employee is diligent and follows the instructions, the new employee is likely to adopt the same careful approach over time. However, if the accompanying employee disregards the instructions, the new employee may eventually follow suit and neglect the guidelines, as they learn from that example.*" (Site.2, Laboratory Technician)

In general, the theme here showes that the participants' compliance is impacted by a lack of organisational support and effective leadership, a lack of awareness among some staff, a lack of resources (resulting from the ignorance of the responsible staff), and an absence of effective training for new employees.

6.3 Collective Action

In normalisation process theory, collective action refers to the work undertaken by organisation and staff to implement IPC guidelines. Two themes and three subthemes were identified under this construct (Figure 6.3).

Figure 6.3: Themes and subthemes of collective action construct



6.3.1 Open and supportive culture

The discussion among staff members regarding their experiences with IPC guidelines serves as a platform for sharing knowledge, exchanging insights, and gaining a variety of perspectives on IPC practices. Additionally, it offers opportunities for collaborative learning and continuous IPC implementation enhancement.

Sharing experiences and learning

All participants acknowledged that discussion among staff about experiences using IPC guidelines always take place, and that staff members have varying experiences and knowledge of the guidelines. For example, an Infection Control Director from HNH commented on that the hospital conducts weekly meetings to share insights about challenges encountered in implementing the guidelines, discuss recent incidents, and report on best practices, and for ensuring that everyone remains well-informed about the latest updates in infection control: *"In this hospital, we have multiple branches, each with its own head of the Infection Control Department and one director overseeing all branches. We meet weekly to share experiences and report any issues that arise, ensuring that everyone is informed and knows how to handle similar situations."* (Site.3, Infection Control Director)

Overall, the theme here reveals that discussions between staff regarding their experiences with IPC guidelines provide opportunities for shared learning.

6.3.2 Impact of implementing the IPC guidelines

The way staff members interact and cooperate in their daily work seems to be affected by how well they follow and comply with the IPC guidelines. This influence can be either positive or negative. In addition, some staff have personal preferences with regards to the guidelines. However, it is not clear whether these personal preferences are based on health and safety considerations.

Relationship in the workplace

When asked about the effects of IPC guidelines on their collaboration with others, the majority of participants believed that implementing these guidelines not only helps them work more effectively with their colleagues but also reduces personal bias: *"The Guidelines are always helpful in working with others since the role of both parties is very clear. Following the guidelines will remove any personal bias."* (Site.2, Infection Control Coordinator)

However, a minority contended that following IPC guidelines has a direct negative impact on relationships between staff members at work. For instance, some participants were reluctant to work with colleagues who do not follow the guidelines: "*I avoid working with staff who do not follow the guidelines correctly. It is impossible for me to grab something without gloves. Sometimes it is an obstacle for me to communicate with people because of that."* (Site.1, Laboratory Specialist 2)

Another participant reported: *"I prioritise cleanliness and ensure our workspace is clean before starting. If my coworker neglects cleanliness, I either avoid working with them or encourage them to maintain better hygiene."* (Site.2, Laboratory Technician)

Occasionally, the guidelines have indirect effects on personal relationships between staff members. For example, a participant from HNH reported that her relationship with a colleague was negatively impacted by their noncompliance, leading her to notify the manager: *"If a coworker is non-compliant and his workspace is dirty, I warn him. If he ignores my warning, I report it to the laboratory manager, which can strain my communication with that staff member."* (Site.3, Laboratory Specialist 1)

Similarly, an Infection Control Practitioner at KFSH described the situation during the COVID-19 pandemic and the unfavorable effects of strict compliance with IPC guidelines on Infection Control Practitioners. It suggests how bias and fear can arise in high-stress environments, leading to adverse reactions among staff. The idea that practitioners feared rejection or bias if they suspected infection reflects the emotional impact of the pandemic, which can significantly impact teamwork and collaboration: "*For practitioners, there are instructions that guide them to work in a safe manner. During COVID, there was a bias used against them. Regarding strictness in infection control instructions, for example, some people had the opposite reaction if they thought they had been infected, so they feared that they were being rejected or feared that someone was biased against them. This affected a lot of health practitioners and their relationships with each other."* (Site.2, Infection Control Practitioner)

This theme indicates that while many staff members view the implementation of IPC guidelines as essential to their daily work, some feel it could impede their effectiveness and affect their relationships, thereby challenging the collective action needed for successful infection control.

A need for change and improvement

Two participants suggested that some guidelines require modification in order to make compliance with them easier. Drinking water in the laboratory was seen as one example of this by a participant from HNH: *"Simply allowing us to drink water in the laboratory while we work would be better."* (Site.3, Laboratory Specialist 1)

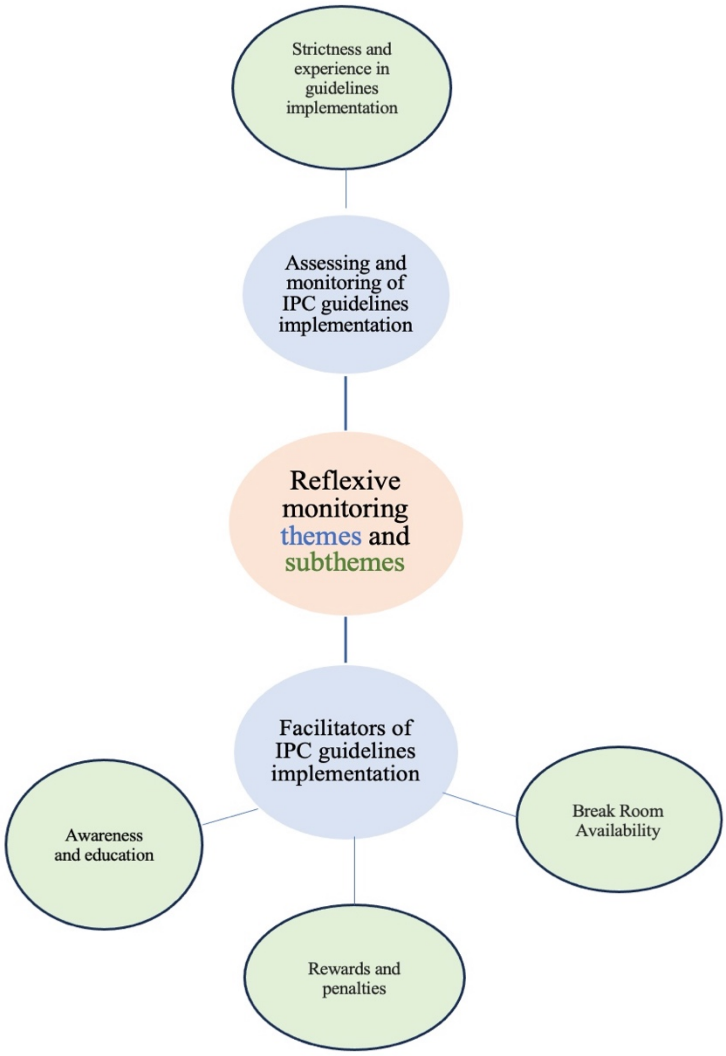
The second example was about claiming more strictness in uniform policy. While the uniform policy may not be directly tied to infection control, the participant believes that improved adherence to proper uniforms could enhance overall professionalism and potentially contribute to a safer, more consistent working environment: "*We have a uniform policy, but it isn't strictly enforced and isn't specifically related to infection control. In some areas, uniform adherence is important, yet anyone can wear whatever they want here. Personally, I believe we should improve adherence to proper uniforms in our hospital."* (Site.1, Nurse/ Infection Control Practitioner 3)

Overall, the theme reveales some personal preferences regarding the guidelines, policy such as allowing drinking water and wearing a uniform in the workplace. Changing the first and improving adherence to the second policy would facilitate compliance with guidelines.

6.4 Reflexive monitoring

In normalisation process theory, reflexive monitoring refers to formal and informal appraisal of the benefits of IPC guidelines and what else is needed to make it effective. Two themes and four subthemes were identified under this construct (Figure 6.4).

Figure 6.4: Themes and subthemes of Reflexive monitoring construct



6.4.1 Assessing and monitoring of IPC guidelines implementation

In order to successfully implement and maintain IPC guidelines, work monitoring is crucial. The primary comments raised by several participants was the strictness of the guidelines and reliance on work experience for safeguarding against risk.

Strictness and experience in guideline implementation

While all staff acknowledged the benefits of implementing the IPC guidelines, some felt that the guidelines were strict. For instance, although some male staff wear masks (which is currently mandatory) only when the IPC team supervise them, viewing the mask requirement as an example of excessive strictness.: "*For example, some men feel that masks hinder them, although they only wear them when someone is supervising, even though it's still mandatory in our hospital.*" (Site.2, Laboratory Technician/Quality Officer)

Other participants often view the guidelines regarding the ban on eating and drinking in the laboratory as overly strict, leading to a lenient attitude toward compliance. This perception is promoted by the belief that being away from samples mitigates risk. Implementing daily monitoring could foster a more conscientious approach among staff: *"Employees may feel the guidelines are strict, especially regarding eating and drinking. They are lenient in this area, assuming the samples are far from them. While they comply with other guidelines, eating and drinking need daily monitoring."* (Site.1, Laboratory Specialist/Supervisor)

In addition to concerns about strictness, some staff members believed that work experience alone was sufficient for protection against infections. For instance, one staff member shared his personal experience of working without gloves, relying on his confidence and familiarity with the environment, which led him to underestimate the risks he encountered: "*Some people believe experience alone is enough for protection, which is a mistake. I once worked without gloves, thinking the situation was safe and that the dangers were exaggerated.*" (Site.2, Laboratory Technician)

Overall, the theme here showes that not all participants see the value of following IPC guidelines. Some rely on their own expertise to avoid getting a laboratory-associated infection, which reflects a gap in reflexive monitoring of compliance with these guidelines.

6.4.2 Facilitators of IPC guidelines implementation

Continuous awareness and education, the availability of incentives and rewards, and adequate organisational support may all serve to facilitate and encourage staff to implement and comply with IPC guidelines.

Awareness and education

When the participants were asked what might motivate staff members to comply more with IPC guidelines, the majority responded that continuous education, opportunities for training and enhanced awareness would improve staff compliance. For example, one staff highlighted the positive impact of awareness-raising activities on staff participation. Including competitions and offering incentives in such activities would therefore enhances staff engagement with the guidelines: *"It is very useful when they organise awareness-raising weeks with training sessions, competitions, and gifts, as this encourages and excites employees. As a result, there is greater honesty and engagement from the staff afterward."* (Site.1, Laboratory Specialist/Supervisor)

Additionally, another participant suggested a preference for more frequent, short, and simple awareness programmes rather than long, intensive orientations. By breaking down the information into manageable parts, staff can gradually absorb and understand the material over time, promoting better retention and acceptance: "*It's better for awareness courses to be simple and held periodically. I mean, instead of doing a big orientation for new staff, maybe just an hour to an hour and a half with limited information. Employees can then absorb the material gradually over time, allowing for better understanding and acceptance*." (Site.1, Laboratory Specialist 1)

Furthermore, one interviewee reported that communicating the benefits of IPC guidelines in a friendly manner by using more engaging and less intimidating methods such as visuals or videos would be effective. Focusing on reducing fear and making guidelines more approachable would create a positive work environment where staff feel supported rather than monitored, which would improve their compliance: "*The best way to communicate infection control guidelines, in my opinion, is through a more friendly approach, such as pictures, designs, videos, or text messages. Instead of constantly supervising or 'terrifying' staff, using* *friendlier methods could make the guidelines more approachable and encourage staff to apply them without fear."* (Site.2, Infection Control Practitioner)

Moreover, some participants perceived that by implementing permanent reminders and providing awareness during IPC team tours, staff can be consistently reminded of the guidelines and their importance. *"Permanent reminders and awareness during IPC team tours would help them engage better."* (Site.3, Laboratory Specialist/Supervisor of Technicians)

One staff member mentioned the importance of including infection control training during employee orientation, such as using a questionnaire. Standardising this strategy across all hospitals would enhance staff compliance and awareness of IPC "*With every contract written for employees, it is necessary to be accompanied by a questionnaire regarding infection control to remind them of the types of masks they must wear, and all instructions regarding waste, and deal with splash. If they happen in every hospital, it would be good."* (Site.1, Laboratory Specialist/Supervisor)

Another participant had a particularly noteworthy opinion, suggesting that it would be preferable to increase staff awareness and engagement with IPC guidelines via self-compliance rather than making it mandatory by including compliance in annual assessment: "*Including compliance with the guidelines in the annual assessment makes it mandatory. I prefer internal motivation over external pressure and aim to promote voluntary self-compliance among employees. While obligation is easy, it doesn't build trust"* (Site.2, Laboratory Specialist/Supervisor of Technicians)

Overall, the theme showes that continuous education, opportunities for training, awareness, and reminders about the significance of the guidelines would be helpful in motivating the staff to effectively implement and comply with IPC guidelines.

Rewards and penalties

Most of the participants suggested that providing motivational incentives during educational programmes such as "Employee of the Month" recognition, licenses from a laboratory manager, or a day off, can also motivate employees to engage with the implementation of IPC guidelines: *"For example, motivational incentives like 'Employee of the Month' recognition,* *licenses granted by the laboratory manager, or even a day off can encourage honesty. For example, by some companies, the chief technician might offer rewards like trips, allowing employees free travel"* (Site.2, Laboratory Technician/Quality Officer)

An Infection Control Director highlighted her efforts in improving staff compliance through a combination of competitions and rewards, such as certificates, small gifts, and financial incentives. Fnancial rewards, in particular, are highly effective in motivating foreign employees, like Filipinos and Indians, by increasing their commitment.: *"I've implemented a practice with my team and employees that I find quite effective. Every now and then, we hold an infection control test competition, consisting of questions or exams, and I reward them with certificates or small gifts. Additionally, financial rewards, especially for foreign nationalities like Filipinos and Indians, make them very happy and more committed. They understand that the more they commit, the more likely they are to receive a reward. "* (Site.3, Infection Control Director)

Moreover, ss the annual evaluation is important for staff, some participants suggested that including compliance with IPC guidelines as part of the annual evaluation of each staff member and linking compliance to their performance reviews can serve as a strong motivator and would enhance engagement and use of the guidelines, as commented: "*Certainly, if following the instructions is included in the annual evaluation, compliance will significantly increase, as evaluations are important to employees. I believe that linking compliance to the evaluation will lead to considerable changes"* (Site.2, Laboratory Technician)

Overall, the results here showes that motivators, incentives and awards are seen as the best ways to increase employee compliance with the guidelines.

Break room availability

Some participants, particularly those at KFSH and HNH, emphasised that all laboratory employees should have designated areas for relaxation, eating, and drinking to enhance engagement with IPC guidelines and reduce unacceptable behaviors. For instance, one participant highlighted his practice of drinking tea in the laboratory, which raises concerns about potential hygiene issues due to the lack of designated rest areas in his department: "*In our department, we do not have a room to rest in, so I am forced to finish my work and drink* *my tea in the middle "clean area" of the laboratory. There isn't a designated space nearby, so I hope they provide a suitable room for us, so we don't have to eat and drink in the laboratory."* (Site.2, Laboratory Technician)

Agreeing, a participant from HNH highlighted the same issue of lacking a staff room which not only disrupts staff ability to take necessary breaks but also affects adherence to infection control guidelines : "*We, as a laboratory, lack a staff room, forcing me to leave the lab to find a place to eat, drink, or pray. This is impractical, and without such a space, compliance with the guidelines becomes more challenging"* (Site.3, Laboratory Specialist 2)

Generally, this theme demonstrates that the majority of the participants feel that providing an appropriate staff area could reduce improper behaviours in the laboratory and facilitate implementation of IPC guidelines.

In summary, this chapter has identified a number of key factors affecting the successful implementation of IPC guidelines, including staff awareness of LAIs, clear roles and responsibilities, valuing the benefits of IPC guidelines, organisational support and effective leadership, among others. It has also highlighted the factors that may negatively affect the (successful) implementation of guidelines, such as a lack of a wider organisational support related to infrastructure investments and resources allocation, workload pressures, frequency of tasks, employees needs like access to restrooms, poor quality of resources, and language issues. By using NPT theory, the chapter has provided a clear picture of the implementation of IPC guidelines at three selected hospitals from the point of view of their staff and highlighted some differences in the implementation processes at these hospitals.

Chapter 7 Discussion

This mixed-methods study consisted of two separate, but inter-related, components. Each of which addressed the aim and objectives of the study. The study was quantitatively focused on assessing the knowledge, attitudes and practices of IPC guidelines, and qualitatively explored the implementation of the IPC/biosafety guidelines from the laboratory staff viewpoint.

This chapter will present a summary of the main findings from the quantitative and qualitative components separately. Then, the results of both components will be integrated and the discussion will then focus on the points of agreement and areas of difference between the qualitative and quantitative findings. The strengths and weaknesses of the study in relation to other studies will be presented, followed by consideration of the implications of the study and, finally, some recommendations for future work.

7.1 Summary of main quantitative findings

A total of 110 participants completed the questionnaire designed to assess the knowledge, attitudes and practices of the IPC guidelines.

Knowledge of IPC guidelines

The mean knowledge score for KAMC participants was higher than for the other participants (9.81). The findings from the multivariable analysis revealed that participants working at KFSH had on average a lower IPC knowledge score compared to other hospitals. Moreover, those participants who specialising in health management had an average lower knowledge score compared to other specialisations.

Knowledge of PEP

The results suggested that male participants had lower knowledge of PEP scores than their female peers. Similar to knowledge scores, participants working at KFSH also had an average lower knowledge of PEP score compared to participants from KAMC based on simple regression. None of the variables showed a significant association with the knowledge of PEP score in multivariable analysis.

Attitude towards IPC guidelines

The median attitude score for Indian and Jordanian participants were higher than those of other nationalities (54 and 54, respectively), and the participants working at HNH had a higher median attitude score than the other participants (53.5). Based on multivariable analysis, there was no significant association between attitude scores and gender. Surprisingly, and in contrast to other IPC knowledge, the KFSH participants and HNH participants had average higher attitude scores than KAMC participants based on simple regression.

Practice of IPC guidelines

The findings for IPC practice suggested that, participants who had training on IPC guidelines had the highest median practice scores (52), as result well-matched with the results of the simple linear regression. Furthermore, in contrast to the attitudes towards the IPC findings, male participants had an average lower practice score compared to females. Participants specialising in health management had an average lower practice score compared to other specialties based on simple regression. These findings showed that there was no significant association between practice scores with gender and specialty in multivariable analysis only nationality was significant

Participants' perception of IPC implementation

There was a weak positive correlation between perceptions of IPC implementation and age and years of experience, with participants who had received training on IPC guidelines reporting the highest mean scores (46.26). Notably, there was a statistically significant difference between occupation groups; infection control specialists had the highest perception scores. Moreover, KAMC participants had the highest perception scores (48.03) of all participants. This finding was well matched with the multivariable analysis findings, which showed that participants working at KFSH had an average lower score compared to other hospitals.

Knowledge scores with attitude and practice scores

The correlation between knowledge scores and attitude scores was weak. However, a moderate positive correlation existed between knowledge scores and practice scores ($r = 0.32$, $p = 0.003$).

7.1.1 Interpretations and contributions to existing knowledge

Regarding training, the findings revealed that 83.64% of the study's participants had received training in IPC guidelines. One previous study in the KSA reported similar findings (84.5%) (162), while another study reported a lower result (68%) (93).

In relation to the immunisation status of the study's participants, 86.36% received immunisation when they joined their workplace, such as three doses of the HBV vaccine. In an Indian study, a lower percentage - only 8.5% - of participants reported having received immunisation (95). The high percentage observed in this study highlights the crucial role of pre-employment clinics at hospitals for ensuring that all laboratory staff are immunised to maintain a safe and healthy work environment. This reinforces staff commitment to adhere to best practices and maintain high safety standards.

The findings here revealed that 71% of the participants answered the knowledge questions correctly. A similar knowledge study conducted reported slightly lower results (67.6%) (162), while yet another study conducted in a different region in the KSA reported higher results (85%) (93). The fact that the mean knowledge score of KAMC participants was higher than for the other participants can be explained by their positive responses to the implementation questions in the qualitative study interviews. According to the results, there were no differences in the knowledge scores based on the main source of information (Colleagues, training courses, etc.). No studies on laboratory staff reported the same findings; however, one study concerning knowledge of IPC guidelines among undergraduate health professional students reported that those students who used four sources of information for gaining knowledge of IPC had a higher mean knowledge score compared to those who used only one source (163). Regarding the association between knowledge scores and the participants' specialisations, significant associations were reported in this study, with participants in health management having lower knowledge score compared to other specialisations. This finding may be due to participants in health management roles not having received sufficient education and training in IPC guidelines. Such a finding would be concerning, as laboratory management has the overall responsibility to ensure the safety of all staff working in their departments. If laboratory management themselves do not demonstrate the required level of knowledge in this area, it poses a potential risk for overall safety management in the laboratory. No previous studies on laboratory staff reported the similar finding.

The study showed that only 11.82% of the participants had an injury while working in the laboratory. Such low percentage inconsistent with the percentage reported in two Nigerian studies (53.23%- 52.7%) (49,81), respectively. However, among those who have been injured, only 5.45% took PEP following the injury. A prior Indian study focused on needle injuries specifically revealed higher injury rate and higher PEP usage in which 53.23% of the participants had been injured by needles and only 28.78% took PEP thereafter (95). The reason behind this low percentage of PEP use may be due to a lack of awareness of its importance among staff (164), fear of being stigmatised and discriminated against and a failure to understand the importance of reporting exposures (165).

With respect to the participants' knowledge of PEP, the results showed that approximately 67% answered the PEP questions correctly. This finding is supported by a prior study conducted in Ethiopia (68.8%) (86). However, the results of the Ethiopian study were for all HCWs, not specifically for laboratory staff. With regard to male participants, the current research does not supports previous evidence demonstrating an association between males and good knowledge of PEP scores (166). This study suggested no significant association between knowledge of PEP scores and availability of competence assessment, something which no prior studies have been found to support. However, the strong positive association reported at KFSH between knowledge of PEP and competence assessment may be an indication of the hospital's commitments to safety culture and ensuring that staff have adequate knowledge of PEP through robust competence assessment mechanisms.

In this study, a quarter of participants disagreed with that the staff cannot eat, drink in the laboratory. Other than that, most of participants in this study agreed with that staff cannot eat and drink in the laboratory. Eating and drinking in the laboratory may increase the possibility of food or drink to absorb vapours of chemicals or other contaminants which may cause accidental or unintentional ingestion of potentially hazardous (radiological, biological, and/or chemical) substance. (167,168). This finding could be explained by the lack of training on IPC guidelines and low experience (93). It may be also due to unavailability of staff relaxation areas, as was reported in the qualitative study. With regard to significant associations between attitude scores and nationalities of the participants reported in this study, no previous research provided similar findings. The finding that Indian and Jordanian participants reported higher median attitude score than those of other nationalities could be explained by the small number of Indian and Jordanian participants compared to other nationalities in this study. The study findings regarding KAMC, which reported high knowledge scores and lower attitude scores compared to other hospitals, suggested a potential inconsistency between knowledge and attitudes at that institution, while having a high score does not necessarily guarantee positive attitudes. There is a need to evaluate whether the training programs provided to hospital staff focus solely on knowledge acquisition but also on cultivating positive attitudes. With regards to that no association between attitude scores and gender revealed in this study, an earlier study conducted in the KSA suggested the same finding (162).

Sixty-five percent of the participants always practice IPC guidelines, a similar number reported in two Ethiopian studies (85,86). The results here suggested an association between the practice of IPC guidelines and training, with those participants who had received training in guidelines having the highest practice scores. This finding is supported by similar studies in KAS (162), Yemen (101), Tanzania (102) and Ethiopia (87), and in a systematic review (169). However, the results of these prior studies were for all HCWs, with only the Yemeni study focusing on laboratory staff. Clearly, receiving training in IPC guidelines is associated with improved understanding and practice of those guidelines. In relation to that, female participants reported higher practice scores than males, a finding in agreement with the findings the Yemeni study (101), but in contrast to the Ethiopian study (170). No available evidence supported the current study's findings for a significant association between practice scores and nationality and speciality.

With regard to participants' perceptions of the implementation of the IPC guidelines, this study found that most participants agreed that the guidelines are important for their work and that participating in the implementation of IPC guidelines is a legitimate part of their role. No previous study reported similar finding. Although no available evidence supported the finding of significant associations between high scores of perceptions of IPC implementation and age and years of experience in this study, this could be justified by the fact that older staff with more years of experience may have had a better understanding of the situation regarding the implementation of guidelines in the workplace. In addition, these staff members may have experienced the evolution of the guidelines over the years. Exposure to developments and changes in guidelines may have contributed to a more positive perception of their implementation. Consistent with a previous study (64), the current study identified significant differences across occupation groups in terms of perception scores, with the infection control specialists having the highest perception of implementation scores and the laboratory specialists recording the lowest scores. However, previous studies focused on all HCWs and not specifically laboratory staff. The reason behind the association identified in the current study could be explained by the nature of the work of infection control specialists, who are responsible for supervising and improving the implementation of guidelines.

The findings of this study revealed a weak, non-significant correlation between knowledge scores and attitude scores. This was inconsistent with the findings of a prior study conducted in the KSA (92). However, a moderate positive correlation was reported in this study between the knowledge scores and practice scores, such positive correlation was reported in previous studies (85,102,171). This finding could be explained by the fact that having enough knowledge and up-to-date information regarding the guidelines could increase staff confidence in practicing and complying with the guidelines (88). No previous research was found which supported the finding that knowledge scores were positively correlated with perceptions of IPC guideline implementation scores.

7.2 Summary of main qualitative findings

A thematic approach was applied to analyse the data deductively, mapping the findings to the four constructs of the Normalization Process Theory (NPT). Using these NPT constructs, several themes regarding the implementation of IPC/safety guidelines were identified. A concise summary of the main themes under each construct will be provided in this section.

The data for each sub-theme was aligned with the corresponding sub-constructs of the NPT, except for the sub-constructs of systemisation, skill set workability. In this study, systemisation refers to "Will laboratory staff be able to judge the effectiveness of the IPC guidelines?", and including data under this sub-construct would have led to repetition, as similar points were already covered in other sub-constructs, such as internalisation and contextual integration. The same applies to skill set workability which refers to "Do those implementing the IPC guidelines have the correct skills and training for the job?". A similar point was already presented under communal appraisal as a barrier to the implementation of IPC guidelines. Therefore, to avoid redundancy and ensure clarity, no data were assigned to this sub-construct.

1. Coherence

Awareness, risk perception and IPC practice related to LAIs

In general, the interviews reveal that hospital laboratory injuries were uncommon, with neither of the COVID-19 cases being related to laboratory work.

In addition, the findings demonstrated that, despite some concerns related to the limited engagement with the Infection Control Department at the various hospitals, laboratory-based staff members understand their own and others' roles in controlling LAIs and implementing IPC guidelines.

Staff at the selected hospitals are aware of the risk of LAIs and the importance of the availability of IPC guidelines. However, limited access to information and resources poses barriers to the successful implementation of IPC guidelines.

Valuing the benefits of IPC guidelines

The findings suggested that across all sites the participants do value the benefits of implementing the guidelines in clinical practice.

The participants collectively understand and are aware of the value of implementing IPC guidelines. Such awareness increased their adherence to the guidelines in their work environment, in addition to their personal lives. Moreover, IPC guidelines have changed the participants' perspectives on LAIs, especially since the COVID-19 pandemic.

In addition, some participants appreciate the need to implement IPC guidelines in order to achieve accreditation. However, others observed that their hospital only follows the requirements to achieve accreditation, not for the purposes for which they are actually intended.

2. Cognitive Participation

Accessibility and engagement (enrollment)

Access to IPC guidelines is straightforward across all hospital sites. However, a lack of organisational support related to infrastructure investments required to improve successful implementation of the guidelines (such as lack of appropriate ventilation systems and safety cabinets for TB samples) is seen as a barrier at KFSH.

Furthermore, the results showed different levels of adherence to and compliance with IPC practices across the hospital sites. Some staff engage with the IPC guidelines only when they expect a visit from the IPC department to the laboratory. Moreover, at KFSH and HNH there is a gender difference in compliance, with men generally being less compliant than women. This reflects the fact that engagement with guidelines is connected to staff members' personalities and behaviour, and surrounded culture.

The findings also demonstrated that all the participants have the capacity to provide feedback for enhancing the application of the IPC guidelines, that local hospitals have the ability to adapt the guidelines based on their needs and that any adaptation should be evidence-based, justified, and comply with public health principles.

Compliance with implementing IPC guidelines

The main challenges to the varied degrees of engagement with IPC guidelines were heavy workload and numerous tasks, in addition to the non-availability of a room or a place to rest, eat, and drink during the working day. Additionally, the poor quality of different resources, such as gloves and masks, and the risk of allergic reactions when using the available types of gloves, were the greatest obstacles to following the IPC guidelines at KFSH.

Infection control staff at HNH reported language as a challenge to complying with implementing the IPC guidelines, especially when supervising or educating other staff from different nationalities.

Furthermore, the participants' compliance was impacted by effective leadership, a lack of awareness among some staff and a lack of resources (resulting from the ignorance of the responsible staff), and an absence of effective – if any at all - training for new employees.

3. Collective Action

Open and supportive culture

The data revealed that discussions between staff regarding their experiences in using the IPC guidelines often take place. Such discussion serves as a platform for sharing knowledge, exchanging insights, and gaining a variety of perspectives on IPC practices. Additionally, it has been observed that staff members among and between hospitals have varying experiences and approaches in adhering to IPC guidelines.

Impact of implementing the IPC guidelines

Despite the fact that many staff members see implementing IPC guidelines as an integral part of their daily work, some participants believed that following the IPC guidelines has a direct negative impact on relationships between staff members in the workplace, with some employees avoiding working with colleagues who do not follow the guidelines. This is in addition to the unfavourable effects of strict compliance with the IPC on healthcare practitioners during the COVID-19 pandemic, as described by an infection control practitioner at KFSH (see Chapter 6, P 197).

According to the findings, some personal preferences regarding the guidelines were noted, policy such as allowing drinking water and wearing a uniform in the workplace. Changing the first one and improving awareness of the second would facilitate compliance with the guidelines, it was suggested.

4. **Reflexive monitoring**

Assessing and monitoring of IPC guidelines implementation

The most common comments raised by the participants concerned the strictness of the guidelines implementation (such as strictness in obligatory wearing of the mask while working and prohibiting eating and drinking in the laboratory), and some staff in KFSH rely on their work experience for protection against infections.

Facilitators of IPC guidelines implementation

The research suggested that continuous awareness, opportunities for training and awareness, and reminders of staff about the importance of the guidelines would be helpful in motivating employees to effectively implement them.

Furthermore, employees could also be motivated to engage with the guidelines by providing entertainment and incentives during educational programmes, using attractive ways to deliver the guidelines, as well as including compliance with the guidelines in annual evaluations.

The majority of the participants feel that providing an appropriate staff area could reduce improper behaviours in the laboratory such as drinking water and facilitate implementation of IPC guidelines.

7.2.1 Interpretations and contributions to existing knowledge

The findings of this study suggested that the participants understood their own role and that of others in implementing the IPC guidelines. No prior studies focused on the implementation of IPC guidelines among laboratory staff reported similar findings. However, prior research on nurses at South Africa has suggested the same degree of knowledge regarding roles and responsibilities (172). While comparing the findings of this study with those of a study involving a different group would be a limitation, the limited availability of studies with similar groups of participants could justify such a comparison. With regards to the participants comments, they claimed that the role of the staff responsible for managing LAIs and implementation of IPC guidelines in the laboratory is not effective. This was seen in the interviews' transcripts of KFSH participants. This finding supports the results of the nurses study (172). It might be explained by a lack of knowledge of and training in the IPC guidelines among those staff responsible for their implementation. In relation to the finding that, at KFSH there was no formal engagement between the laboratory and the infection control department suggesting there exists a lack of official collaboration and interaction between the two departments, something which may also indicate that there is a perceived gap in how the infection control guidelines are communicated and coordinated within the laboratory.

Like the present research, one prior study suggested that staff were aware of the risk of LAIs and the importance of the availability of guidelines to prevent any infection (173), although it was conducted across all HCWs.

The finding that participants across all hospitals were aware of the value of implementing the IPC guidelines to protect employees infections and provide a safe environment for staff and patients was inconsistent with a qualitative study conducted among nurses in which the guidelines were often overlooked by staff because they were perceived as conflicting with the delivery of acute care to patients (174). With regards to effect of COVID-19 pandemic, the COVID-19 pandemic positively influenced the adherence to IPC measures for some participants included in this study. However, no previous studies on laboratory staff reported similar finding. This may be an indication of the staff awareness of the importance of IPC guidelines in protecting against infections such as COVID-19. The participants in this study viewed infection prevention and control as a routine part of their daily practice, which aligns with the concept of habit in implementation. According to habit theory, actions that are regularly performed in predictable settings become automatic over time (175,176). When laboratory staff integrate IPC measures into their daily routines, these behaviours can become habitual, triggered by internal or contextual signs. Therefore, adherence to IPC practices may become a seamless aspect of their workflow, requiring less conscious effort and facilitating consistent implementation in laboratory settings and the habitual integration of IPC into everyday routines enhances its effectiveness and reliability.

This study also suggested that implementing the IPC guidelines was also important for achieving accreditation, a finding which supports that of a Saudi study suggesting that the application of hospital accreditation encourages patient and staff safety and that quality measures improve with time (177), and also with the findings of a systematic review which concluded that accreditation programmes increase staff and patient satisfaction and improve safety, processes, and efficiency (178). However, data in this study also revealed that one hospital followed the guidelines for achieving accreditation only and ignoring the main purpose of implementing the guidelines. This may result in that the hospital management may concentrate only on fulfilling the minimum requirements listed in the certification rules instead of actual improvements in quality and safety for staff and patients. In addition, allocating resources, such as time, funds, and staff efforts, to activities only dedicated to fulfilling accreditation requirements, possibly at the cost of more strategic quality improvement programs that aligned with organisation objectives. Moreover, this may have an adverse effect on staff who believe that accreditation efforts are superficial or not aligned with the practical aspects of patient care and may experience disillusionment resulting in reduced motivation, engagement, and job satisfaction, which may also affect their compliance with the guidelines.

In relation to accessibility to the guidelines, all the participants across all the hospitals stated that they enjoy easy access. This access is provided either through an online document uploaded to each participant's account or through a hard copy of the guidelines available in the laboratory. This finding concurs with the work from a prior qualitative study of HCWs in which most participants reported that the guidelines are easily accessible for employees and are available in digital format (179). This highlights the organisation's responsibility to facilitate implementation of the guidelines by making them easily accessible to staff. However, despite the ease of access to the guidelines, a lack of important resources such as ventilation systems and safety cabinets for TB was reported by some participants. Agreeing with the present study, a lack of adequate ventilation was also reported as common barrier to achieving IPC measures by HCWs in two other studies (180,181). Such a lack of required resources may be explained by the lack of awareness of staff responsibe for supplies, as highlighted in this study. Previous research in Mongolia reported the same issue, namely that resource allocation decisions are often made by those who have a non-medical background, resulting in that they tend to cut infection control resources and the infection control receive low priority (100). This may be due to the carelessness of the supply staff or ignorance and/or unawareness of the high risks available and the nature of the work in a laboratory setting. According to the researcher's knowledge, the MoH responsible for overseeing healthcare services in KSA and conducts routine inspections of all healthcare facilities, encompassing various aspects of their operations, including infrastructure, equipment, infection control practices, staff qualifications, and patient care. The previous two findings (lack of required resources and lack of awareness among staff responsibe for supplies) have raised questions to the MoH about the reasons behind the lack of the important resources cited by the participants.

The findings in this study revealed that staff adhere and comply with IPC rules differently. This difference in engagement was reported in a study aimed at understanding the implementation process of infection prevention and control guidelines in Ireland (174). This issue could be related to some individual factors such as staff knowledge, attitudes and beliefs of the importance of implementing the guidelines (180). Behavioral theory could provide useful insight into how individual and organisational factors influence compliance with IPC guidelines. There are many frameworks and models that have been employed to explore health professionals' intentions and behaviors in relation to healthcare interventions. One of these is the Theory of Planned Behavior (TPB) which aims to explain how healthcare professionals' intentions to follow IPC guidelines are shaped by three components: their attitudes toward these practices, subjective norms (the perceived pressure pressure from others to do or not do the behaviour), and perceived behavioral control (the perceived simplicity or complexity of performing the behaviour, based on previous experiences and expected challenges) (182). For example, a previous study on nurses was aimed to predict and explain nurses' adherence to Universal Precautions (UPs), suggested that perceived barriers such as training and perception of social expectation and motivation were two of the factors that affect the nurses' decision to adhere to UPs (183). Another study on physicians assessed the relationship between practitioners' behavioral intentions to comply and their actual guideline compliance using TPB, also suggest that perceived barriers (such as accessibility of guideline, practice habits understanding of the guideline, and confidence that the physician can use the guideline) to guideline utilisation may influence physicians' compliance to guidelines (184).

With regard to gender differences in compliance, this qualitative study found male staff to be less compliant with the guidelines than females. Socialisation may be an explanation for such gender differences, with females being more motivated to engage in discussions about health and safety procedures, something which shapes their attitudes (185). Within the KSA content, strict sociocultural and/or religious practices may play an important role in such differences. The KSA's conservative society restricts social contact between males and females, something which may not facilitate inter-gender discussion of health and safety information (186,187). In addition to socialisation, cultural and societal norms may have influenced the males' compliance. Their willingness to comply with IPC guidelines may be affected by cultural perceptions or beliefs about masculinity or health-seeking behavior. According to traditional gender roles and expectations in the KSA, men should be strong, independent, and stoic (185). For example, in the context of IPC guidelines, which entail wearing PPE and using hand hygiene, male employees may consider adherence to these guidelines as weakness or as somehow indicative of 'reliance on others'. Rather than seeing PPE as essential tools for preventing infection, they may view it as symbols of vulnerability. Education and training opportunities also play a role in employee compliance. It is possible that female employees may have more access to educational and training programs and resources related to IPC, which will therefore lead to higher levels of knowledge and compliance. Gender inequality in leadership roles may also contribute to differences in compliance, as indicated in Table 6.1. Most supervisory roles, such as specialist and technician supervisors, as well as the laboratory manager position, were predominantly held by males. For instance, the male laboratory manager was observed frequently entering the lab with a cup of coffee (Site 3, Laboratory Specialist 1). Additionally, the laboratory supervisor, who reported handling tasks like infection control to prepare for accreditation visits only (Site 2, Laboratory Specialist/Supervisor), was also male. According to Alhassan and Al Doghan, 2022, the labor force participation of Saudi women is still among the lowest globally, and they continue to be underrepresented in leadership roles (188). Involvement of female in leadership activity has numerous benefits. For example, female leaders often advocate in interpersonal skills like inspiring others, motivating employees, and prioritizing communication. These strengths contribute a unique diversity of experiences and perspectives to the workplace (189). Moreover, a study by De Paola et al., 2022 found that, female leadership has a positive and significant impact on team performance, particularly in cooperative environments. This effect is largely due to the stronger performance of female team members. Gender differences in leadership are shown to be effective (190).

The findings in this study suggested all the participants have the capacity to provide feedback for enhancing the application of the IPC guideline. A previous study utilised NPT to explore the meaning of IPC ownership among healthcare workers and to evaluate the impact of an action plan aimed at encouraging IPC ownership in the UK from the perspectives of doctors, nurses, and managers (191). Its findings are consistent with those of this study, where the importance of attending IPC-focused meetings as part of collective action was frequently emphasized. For these meetings to be effective, they needed to include a multidisciplinary group, have strong participation, and follow targeted agendas to establish clear objectives (191).

Regarding how workloads were reported as a main challenge to compliance in this study, one previous systematic review generally agreed that high workloads were a predictor of HCWs noncompliance with the guidelines (169). According to the results of systematic review on the implementation of clinical practice guidelines (CPGs) among nurses using NPT, the staff of Ploeg et al., (2007) described workloads as a challenge to successful implementation of the guidelines as part of Reflexive Monitoring (192,193). The Theoretical Domains Framework (TDF) is an example of behavioral theory frameworks that have been utilised to explore health professionals' intentions and behaviors in relation to healthcare interventions. This framework aims to identify the factors influencing behaviour by categorising them into several domains, such as knowledge, skills, beliefs about capabilities, social influences, and environmental context (194,195). For example, a previous study that aimed to identify key attitudes, barriers, and facilitators to hand hygiene compliance in long-term care homes – an understudied healthcare setting by mapping data onto the domains of the TDF reported workloads as one of the barriers to hand hygiene (194). Workloads may reflect limitations on the medical laboratories' resources, such as a lack of staff, a lack of time for training and implementing IPC procedures into practice and leadership support. By addressing this barrier and proposing practical solutions, medical laboratories would enhance compliance with the guidelines. Another challenge to compliance was non-availability of a staff break room for eating and drinking; however, no available studies reported similar findings and this may be because these studies have been conducted in countries that would have staff break rooms. The availability of such a staff area would better facilitate their compliance. The finding that poor quality of different resources was a challenge to compliance supports the findings of a previous qualitative research of HCWs (180). It was found that an adequate quantity and quality of PPE were key considerations for staff to be able to prevent contamination (196). In line with two previous studies (180,197), discomfort of using PPE was seen as a hinderance to compliance with the guidelines. Organising fit tests could help minimise this problem (180). No available evidence supported our finding for language being a barrier to communicating IPC guidelines between infection control practitioners and other staff who speak different language.

Lack of organisational leadership and support did impact compliance with the guidelines. This finding supports a similar study (198). According to Zimba at al., "*It is known that a positive proactive leadership, support, and presence of senior leaders, team commitment, and clear boundaries of roles and responsibilities are prerequisites for effective action to control of infections in health institutions*" (169, p.19). A prior study aimed to elucidate experiences and factors of importance for the implementation of CPGs among nurses in hospital care identified several factors that influence the use and compliance with CPGs. The authority of the person in charge and the support from management were seen as crucial to the implementation process, affecting both management and the experts involved. Compliance was notably improved when the manager actively participated in the working team (199). In addition, according to the systematic review on implementation of hospital-based CPGs, the nurses on Graham et al. (2004) study reported that the manager and educator play a key role in engaging and motivating the team to adopt and adhere to the CPGs guidelines. They enhance both Cognitive Participation (by fostering commitment) and Collective Action (by coordinating practical efforts), ultimately improving compliance with the guidelines (192,200). Moreover, as in a previous study, the participants of the current study mentioned the influence of workplace culture on compliance with the guidelines. Whether or not the staff in a particular workplace adhere to IPC guidelines, HCWs feel like they are 'pulling together' as a result of this culture (180). This study found that, in one of the study settings, there was no training for new employees, while prior research has suggested that training was one of the factors prompting HCWs to comply with IPC guidelines (169). Regarding the finding that discussions between staff regarding their experiences with IPC guidelines often take place, no available evidence supported this finding.

One finding in this study suggested that most participants felt that there was a strictness in implementing the guidelines, specifically in mentioning the compulsory wearing of masks in the laboratory throughout the workday. This was inconsistent with the finding of a previous study in which the participants explained that the guidelines merely work ‘on paper’ and that not much was done in practice to oblige strict adherence to them (198). One possible explanation for this is that the hospitals in the current study are strictly implementing the IPC guidelines, and this was something which some staff members disliked. Regarding the finding that some staff members at KFSH rely on their work experience for protection against infections, another study - of Tanzanian HCWs - found that number of years of work experience was a predictor of high compliance with IPC guidelines. Training, mentorship, and active supervision of IPC at work may thus have a significant effect on how work experience reinforces IPC guidelines on hygiene (201). However, the reason behind this finding in the current study was that those staff with more years of experience tended to comply less than other staff because they felt confident at work and in dealing with different samples due to their experience, which had an adverse effect on new and junior employees, who were viewing those with more experience as role models.

In order to facilitate implementation of IPC guidelines, hospital staff suggested that continuous awareness and education were major factors. Such findings were consistent with the findings from previous studies in which education and training were factors prompting HCWs to comply with IPC measures (169,180). In addition, suggesting including incentives into educational programmes might be supported by the idea that incentives are important factors for continuous improvement (202,203).

7.3 General discussion (integration of quantitative and qualitative findings)

After discussing the results of the qualitative and quantitative studies of this research separately, this section will combine and integrate the results.

7.3.1 Comparison of qualitative and quantitative studies

Although the qualitative and quantitative elements of this research used two different methodologies to assess knowledge of, attitudes to, practices of, and implementation of the IPC guidelines among laboratory staff at three hospitals, there was some overlap in the study findings.

Several areas of agreement were found between the qualitative and quantitative components of this research study. Firstly, participants working at KAMC who had the highest knowledge scores expressed more positive attitudes as to the value and benefit of implementing of the IPC guidelines in the interviews. This may be attributable to the fact that they all can access to the guidelines easily and at any time (e.g. through an online document) and the resources required to successfully implement the guidelines are all available, in addition to the continuous organisational support and leadership. In contrast, those participants working at KFSH expressed some issues regarding the implementation process in the interviews, including: there was no formal engagement of the infection control department with the laboratory; the hospital followed the guidelines for achieving accreditation only; there was low engagement and some staff relied on their own experience; there was no staff area for eating and drinking; there was a lack of organisational support and a lack of resources as a consequence of unawareness of the responsible staff; and, finally, there was an absence of training for new employees. These points are reflected in their lower knowledge scores compared to other hospitals.

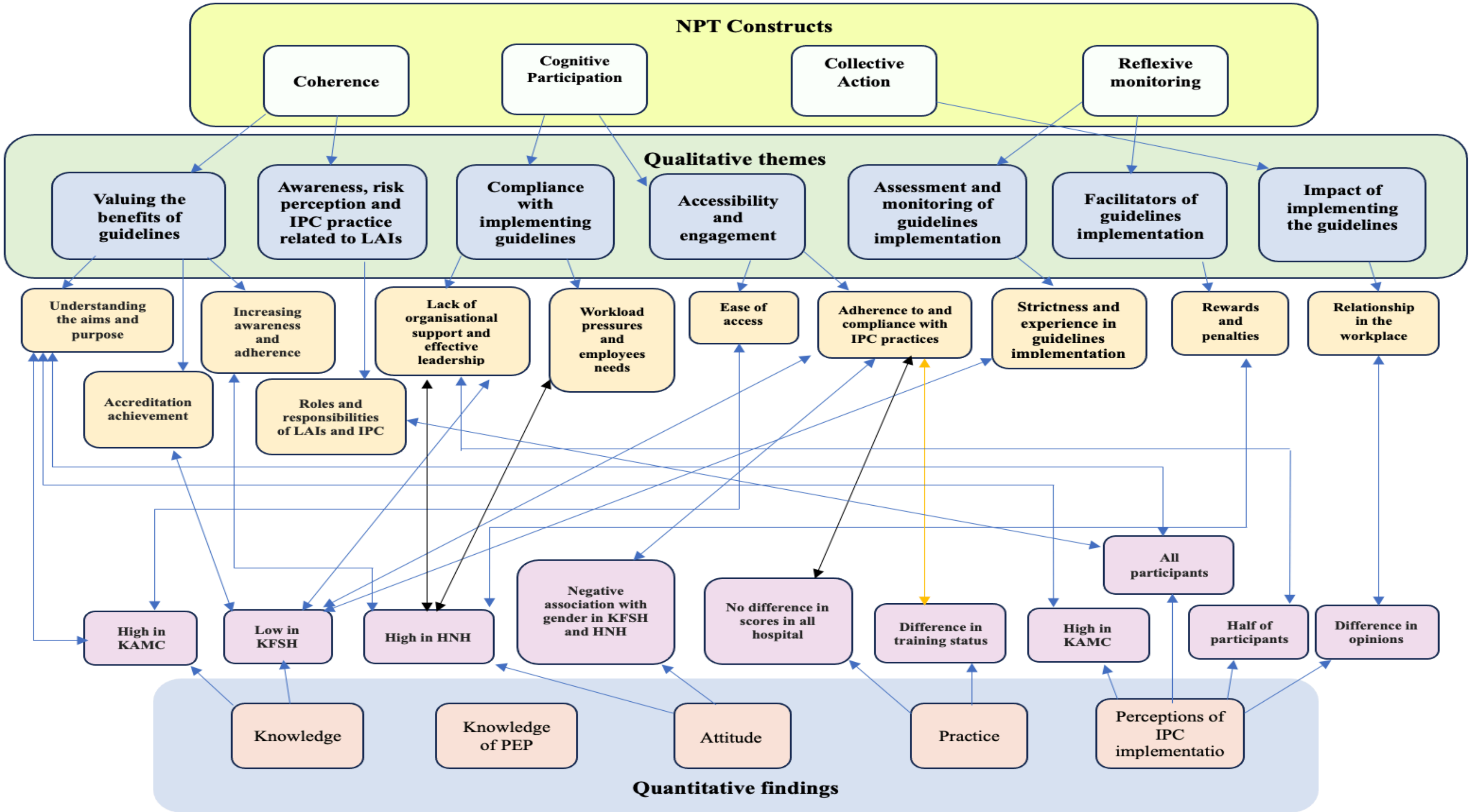
The highest attitude scores of HNH participants compared to the other participants were compatible with high awareness of a risk of LAIs, especially after COVID-19, and efforts made by the infection control director regarding motivation and rewards (as reported in the Chapter 6, p.196). In addition, the quantitative study suggested that there were negative associations between gender and IPC attitude scores at KFSH and at HNH. At these hospitals, male participants tend to have lower IPC attitude scores than female participants, an association particularly strong at KFSH. In line with a previous study (185), these findings, and the findings from the interviews with two participants from each of these hospitals, concur, suggesting a gender gap in compliance and attitudes towards the guidelines, with males generally being less compliant than females.

There were two broad areas of agreement regarding perceptions of IPC implementation between the quantitative and qualitative findings, including: all staff have the same understanding of the purpose of the guidelines and there are key people who advance the IPC guidelines forward and inspire others to participate; and IPC guidelines have potential value for their work and the guidelines are a legitimate part of their role. The fact that only half of participants in this study survey reported that sufficient training is provided and they have sufficient resources, necessary equipment and management support to enable staff to implement the guidelines, can be explained by the previous issues reported by this study participants working at KFSH, such as absence of training for new employees, lack of important resources (such as ventilation system and cabinet for TB samples) and lack of organisational support. The same differences in opinion regarding how the IPC guidelines disrupt working relationships were reported by the quantitative and qualitative components. In addition, a positive attitude expressed by the participants working at KAMC in the interviews regarding the implementation process of the guidelines reinforced the findings from the quantitative study, as those participants had higher perception scores than other participants.

The quantitative and qualitative studies also diverged in some respects. The highest attitude scores of HNH participants in the quantitative study contradicted the findings from the interviews with laboratory specialists, who reported that the staff drink water in the laboratory because of 'heavy workloads' and there being no specially dedicated rooms available for breaks. According to the laboratory specialist, "[The manager] *always walks into the laboratory with a cup of coffee*" (Site.3, Laboratory Specialist 1).

Moreover, although the qualitative research highlighted a variety of compliance and adherence on the use of the guidelines among staff across all hospitals, the quantitative findings suggested there was no statistically significant association between the practice of IPC scores according to gender, nationality, level of education, location of practice, occupation, specialty or position. However, there was a statistically significant difference in training status, with those who had received training in IPC guidelines having the highest median scores. This may be the reason behind variety of compliance and use among staff. Figure 7.1 provides visual representation of the integration of the qualitative and quantitative dimensions of the research.

Figure 7.1: Integration of qualitative and quantitative research



*Blue arrows represent agreement between quantitative and qualitative findings.
*Black arrows represent disagreement between quantitative and qualitative findings.
*Yellow arrow suggests that one finding may be a reason for the other.

7.4 Research strengths and limitations

7.4.1 Quantitative study

Strengths

The quantitative dimension to this study had many advantages. As the first of its type in the KSA (to the best of the researcher's knowledge), this comparative study included three hospitals, related to two different providers (MoH and MNG-HA), to assess knowledge, attitudes and practice related to the implementation of IPC guidelines among laboratory staff and infection control specialists who may be representative of the Saudi population, while taking into account the origins of the participants from different regions of the KSA and from around the world. In doing so, it has explored a much under-researched topic.

In order to ensure that the results of the regression analysis used in this review were reliable, the assumptions for regression analysis were checked and the required modifications and tests were taken for the assumptions that were not met. In addition, epidemiology methods such as confounding, guided by DAGs, and interaction testing were used to ensure meaningful and accurate interpretation of the study findings.

Limitations

As with all research, this study had a number of limitations. One of the major limitations was that the cross-sectional nature of the study limited its ability to create definitive cause-and-effect relationships between the outcome variables and the explanatory variables.

The small sample size (n=110) obtained could be explained by the study's focus on staff working in specific departments (laboratory and infection control) at the selected hospitals and the busy nature of their work. Moreover, since the staff at the three hospitals share similar characteristics, roles and responsibilities, a smaller sample size may still capture representative perspectives within the study context.

Thirdly, the study utilised self-reported data, which are intentionally or unintentionally susceptible to bias due to either ignorance or a lack of awareness of the study (204). Self-reports of previous injuries may also have been inaccurate and the information may have been subject to recall bias. Furthermore, self-reports of attitudes and practices of IPC guidelines may have limited the study as the participants might have exaggerated their compliance with the guidelines, which in turn may have appeared less unfavorable than it really is. It has been claimed that observations might be a more effective way to assess compliance as a recommended 'gold standard' for compliance assessment (205). Although direct observation was initially considered in this study, in order to respect the privacy and professionalism of the laboratory staff, to minimise the potential disruption of the workflow in the laboratory, and to limit the potential for 'reactivity' (whereby staff may have altered their behaviour when aware they are being observed), direct observation was considered inappropriate as a research method. To gain reliable data, the participants were reminded of the importance of accurate and honest reporting.

Another limitation in this study was the possibility of bias due to missing data; however, this issue was assessed and addressed in detail in the quantitative chapter (see Chapter 5).

7.4.2 Qualitative study

Strengths

To the best of the researcher's knowledge, this is the first qualitative study to assess implementation of IPC guidelines in three hospitals related to three different organisations in order to draw a clear picture of the implementation process and to explore the differences in the way the guidelines are implemented. This study applied NPT to explain how IPC guidelines are implemented and embedded in practice. Using NPT was helpful in enabling the researcher to focus on observable actions and to explain the dynamics that drive IPC guideline implementation.

Limitations

One of the potential limitations of this study's qualitative research was the small sample size - only 18 participants. Nevertheless, the data saturation point was reached and no new information were added from interviewing more participants. For example, participants repeatedly mentioned continuous education and training as facilitators for compliance with the guidelines. Due to the use of purposive sampling, only those participants recommended by key stakeholders (and who were willing to take part) were interviewed. This may have lead to a potential for selection bias, as these participants might not have been the best individuals to engage with regarding IPC guideline implementation. Nonetheless, since participants from a variety of professional backgrounds, age groups and experience were included, it can be assumed that the sample was fairly representative of the study population.

Secondly, in order to ensure the validity of the identified themes and sub-themes in this study, an expert (GM) reviewed the codes iteratively and verified the findings during analysis. However, this does not exclude the possibility that the study results may have been influenced by the personal biases and views of the researcher.

7.5 Significance of the study

This study makes some important contributions in the field.

Firstly, as the first mixed-method study of its kind in the KSA, integrating quantitative and qualitative data provided a more comprehensive understanding of the subject matter, enhancing our understanding of the implementation of and compliance with IPC guidelines.

Secondly, in the healthcare system, laboratory staff play a crucial role. Their work impacts diagnostics, infection surveillance, and patient care decisions. However, their compliance with IPC guidelines has not been sufficiently explored. This study addresses this significant knowledge gap and emphasises the importance of laboratory staff in implementing IPC guidelines. For example: adherence to protocols: laboratory staff adherence to guidelines such as wearing PPE, ensures the safety of not only themselves but also others in the laboratory and their families. Training and education: laboratory staff are important in continuous education and training of new staff or students about IPC guidelines, they support the maintenance of best practices by ensuring that all laboratory staff are aware of and follow to the necessary safety measures.

Thirdly, although the study focused on three KSA hospitals, its findings may have broader implications. This research can thus be used as a reference model for future IPC assessments and interventions, not only in the KSA but also in other countries with similar healthcare systems. This include for example: countries with a mix of public and private healthcare providers or large government-funded healthcare institutions, countries where religious and cultural norms, particularly those related to gender, or other social practices, influence healthcare delivery and staff interactions, and countries that face similar challenges in IPC program, or other developing countries where healthcare systems may be evolving.

Next, using the findings of this study, policies, procedures, and training programmes for IPC guidelines in KSA can be developed and refined. In addition, policymakers, healthcare executives, and IPC practitioners can use the information produced by this study for better resource allocation and strategies to enhance IPC implementation and compliance within laboratories.

Finally, this study's systematic review is the first systematic exploration of the knowledge, attitudes and practices of laboratory staff regarding IPC guidelines in laboratories. As such, it sets the stage for future research and exploration in the field of IPC among laboratory staff. In addition, it provides a baseline against which future studies can be compared.

7.6 Generalisability

KAMC and KFSH are two of the largest military and medical hospitals in the KSA, thus, the findings can be generalised to other military and medical hospitals in the country and other countries with a similar healthcare system. Moreover, some of the findings such as levels on knowledge, attitude and practice can not be fully generalisable globally due to several reason including: cultural values and norms in KSA my influenced the generalisability of the findings. Social and cultural factors such as strict communication practices between males and females within the laboratory may have influenced the males' compliance with the guidelines. In addition, organisational factors such as the non-availability of break rooms and poor quality of available gloves and how organisations tend to ignore the staff needs, which may result in unacceptable behaviours such as drinking water and working without gloves. Finally, within the KSA context, language was considered as a barrier to communication and compliance with the guidelines, this aspect might be unique and local to the KSA and cannot be generalised.

Chapter 8 Recommendations and Conclusions

This chapter will present implications of the main findings and offer recommendations for policymakers and future research, before offering some concluding remarks.

8.1 Implications of the study

Health policy makers in the KSA can draw on the findings of this study to prepare laboratory staff, allied health professionals and infection control specialists to provide effective hospital services by placing employee safety as the top priority. Additionally, the findings of this study are expected to be valuable to the KSA's GDIPC and infection control departments at the three selected hospitals (copies of this study will be made available to them). These agencies should use these findings to evaluate the need for infection control and implement an active IPC programme for reducing the risks associated with LAIs and improving the quality of service. These findings would also be useful to support the policy makers' objectives of 2030 vision (p.15).

This study has revealed a number of differences between hospitals in terms of the knowledge, attitude and practice levels regarding IPC guidelines. Such differences confirming the need for standardisation across hospitals and continuous education and training, presuming that contextually and linguistically appropriate educational interventions and materials are crucial to increase staff knowledge and awareness of the risk of LAIs and the importance of the guidelines and increase the chance of them being practiced and complied with. New employees should be included in early needs education and training as part of their induction before they start their jobs.

The qualitative research element of this study explored the implementation process from the viewpoint of laboratory staff at the three selected hospitals. It has indicated that hospitals need to comply with policy and guidelines from the MoH and other government agencies (such as CBAHI). In addition, proper routine inspections by the MoH are required for hospitals to address any concerns within healthcare facilities, including infrastructure and equipment requirements. The findings of this research are potentially useful for policy makers in, for example, addressing awareness of compliance barriers. In order to facilitate improved implementation of and compliance with IPC guidelines, the study participants provided tangible examples about increasing awareness, including education and training, organisation support and engagement, availability of required, high-quality resources (such as gloves of several types to meet the staff needs), and providing entertainment and incentives. Moreover, the findings of this study proposed that multiple factors should be targeted in strategies for encouraging IPC implementation and compliance, such as staff attitudes, organisational support and effective management and leadership. Accordingly, in order to improve compliance with guidelines, infection control practitioners need to be proactive, creative, and devise user-friendly methods in their education efforts. The participants' suggestions should be considered in the development of future interventions, including those aimed at changing behaviour.

The need for a comprehensive action plan from the MoH and the GDIPC to facilitate the implementation of the IPC program specifically within hospitals' laboratories, should be regarded as critical for ensuring the uptake of IPC safety guidelines.

8.2 Recommendations

8.2.1 Recommendations for education

Knowledge, attitudes and practices differed from hospital to hospital. Hospitals that reported lower levels of knowledge, knowledge of PEP, attitude, practice and perception of IPC implementation than others, together with the MoH, are recommended to develop educational campaigns to increase awareness and compliance with the IPC guidelines. This should be seen as continuing scientific education and training and a means of enhancing pre-employment awareness for laboratory staff.

Moreover, an assessment of new staff awareness and practice of the guidelines before conducting laboratory work, in addition to an annual assessment of all current staff, should be mandatory in order to supervise practice and manage compliance with the guidelines. Assessment or competence assessment is an essential part of laboratory process, and used to enhance the laboratory's efficiency by identifying areas that need staff education and/or training, consequently encouraging best practices and maintaining staff and patient safety.

Further it could enable laboratories to provide documentation of the laboratory quality to management, staff, inspectors, and consumers (206).

8.2.2 Recommendations for infection prevention and control

Additional PEP training is required to prevent the incidence of infections due to needle stick or other injuries while working with samples. It is imperative that all laboratory staff and allied health professionals receive comprehensive training in infection control methods and strictly adhere to established IPC guidelines, which encompass the use of PPE.

Although it was reported that the resources are provided by the MoH to all of the hospitals, adequate protective materials with high quality and in accordance with staff needs should also be provided for healthcare facilities. In addition, it is important to take into account the proper design of general ventilation systems in order to prevent the spread of infections during work on airborne infections. Staff who work with chemicals such as dyes and waxes that are commonly available in the histopathology sections should be provided with the appropriate chemicals control measures to limit exposure.

A thorough evaluation must be conducted at the highest level of authority with regard to hospitals' prevention and control strategy. This evaluation should include factors such as affordability, budgetary implications, anticipated consequences, and cost-effectiveness.

8.2.3 Recommendations related to gender

Development of gender-sensitive training programs and educational materials is required for acknowledging and addressing both males' and females' unique preferences, needs, and challenges.

Enhancement of gender diversity in leadership within healthcare organisations and ensuring that both males and females are included in leadership roles related to development and improvement of IPC guidelines is required in order to ensure that diverse perspectives are represented and valued.

Cross-gender mentoring and networking programs should be designed and implemented for staff members of all genders to allow them to share knowledge, develop skills and, more generally, collaborate productively.

8.3 Future research

Given the findings presented above, the following suggestions for further study are made.

In order to gain a better understanding of what happens in real world practice, future studies using documentary analysis and observational data are necessary. For example, observe laboratory workers performing various tasks to assess their consistent and proper usage of PPE such as gloves and masks and dispose of waste materials would provide a more accurate picture of practices than relying on questionnaires or interviews. Analyse documents such as incident reports, standard operating procedures (SOPs), and training materials to identify potential compliance gaps.

The qualitative research in this study suggested the existence of a number of individual and organisational barriers to compliance with IPC guidelines, which varied from hospital to hospital. Further studies of the compliance issues at these – and other – public and private hospitals is necessary in order to provide a detailed picture of how to address them.

Study with larger sample sizes and including more than one hospital from the same ministries (e.g., MoH or MNGHA) is required in order to assess how the ministry supervise and manage the implementation of IPC guidelines and to determine the reasons behind differences in implementation between hospitals under the same provider (if available).

Further research applying behavioral change theories to develop effective, theory-informed strategies for enhancing the implementation of IPC guidelines is needed. Particularly, theories such as the TPB, Social Cognitive Theory (SCT), or the COM-B model (Capability, Opportunity, Motivation-Behavior) could provide structured approaches to address the implementation gaps identified in this study (207–209). Using the COM-B model, for example, future interventions can focus on assessment and enhancement the Capability**,** Opportunity, and Motivation of laboratory staff in implementing IPC practices (208). Improve Capability by increasing staff knowledge and practical skills through specialised training; enhance

Opportunity by establishing an environment that supports compliance with IPC guidelines, such as facilitating access to resources or reducing competing workload pressures; boost Motivation by addressing attitudes and beliefs about the importance and effectiveness of IPC guidelines through behavioral reinforcement strategies such as certificates of excellence, monetary bonuses, and public recognition.

Several strategies have been suggested under facilitators of IPC guidelines implementation theme (p.194) to improve knowledge, attitudes and practices of IPC guidelines among laboratory staff. Therefore, well designed studies may be useful in assessing the effectiveness of these interventions.

Further international studies are needed to analyse and evaluate approaches to laboratory management across different countries by comparing and contrasting laboratory management practices, policies, and outcomes. This should particularly include countries like the UK, which have standardized and strict policies and procedures for laboratory health and safety, as well as KSA.

8.4 Conclusion

The overall study findings have revealed that although the majority of this study's participants had high scores on knowledge, attitudes and practices, there were differences between hospitals, confirming the need for standardisation among hospitals and continuous education and training of laboratory staff on the importance of the implementation and practice of IPC guidelines. Moreover, the interview findings suggested that staff were also aware of the risk of LAIs and the value of implementing guidelines to minimise occupational risk. However, factors such as a lack of organisational support and a lack of resources affect the implementation process. Overall, this research highlights the importance of ensuring that the existing IPC guidelines are effectively implemented, monitored and maintained and recommended that a comprehensive action plan to facilitate the implementation of the IPC programme from the MoH and the GDIPC is crucial across all hospitals to ensure the serious and sustained uptake of IPC safety guidelines.

References

1. Monitoring the building blocks of Health System: A handbook of indicators and their measurement strategies [Internet]. World Health Organization. 2010 [cited 2023 Aug 31]. Available from: https://iris.who.int/handle/10665/258734
2. Plsek PE, Greenhalgh T. The challenge of complexity in health care. BMJ [Internet]. 2001 Sep 15 [cited 2023 Aug 31];323(7313):625–8. Available from: https://www.bmj.com/content/323/7313/625
3. Boslaugh SE. Health care systems around the world: a comparative guide. SAGE Publications, Inc. USA: SAGE Publications, Inc; 2013.
4. Occupationally-Acquired Infections in Healthcare Settings. Infection Control. [Internet]. Centers for Disease Control and Prevention. 2023 [cited 2023 Nov 7]. Available from: https://www.cdc.gov/infectioncontrol/oai-hcp.html
5. Occupational infections [Internet]. World Health Organization. 2023 [cited 2023 Nov 7]. Available from: https://www.who.int/tools/occupational-hazards-in-health-sector/occupational-infections
6. Prüss-Üstün A, Rapiti E, Hutin Y. Estimation of the global burden of disease attributable to contaminated sharps injuries among health-care workers. Am J Ind Med [Internet]. 2005 Dec [cited 2023 Nov 7];48(6):482–90. Available from: https://pubmed.ncbi.nlm.nih.gov/16299710/
7. Aw TC, Blair I. Occupational infections. Infect Dis [Internet]. 2010 Jan 1 [cited 2023 Nov 7];1:715. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7152341/
8. Revelas A. Healthcare – associated infections: A public health problem. Niger Med J [Internet]. 2012 [cited 2023 Aug 31];53(2):59. Available from: /pmc/articles/PMC3530249/
9. Laboratories. Health risks in laboratories. Health and Safety Executive [Internet]. [cited 2024 Mar 12]. Available from: https://www.hse.gov.uk/biosafety/laboratories.htm
10. Global report on infection prevention and control [Internet]. World Health Organization. 2022 [cited 2023 Aug 31]. Available from: https://www.who.int/publications/i/item/9789240051164

11. Weinstein RA, Singh K. Laboratory-Acquired Infections. Clin Infect Dis [Internet]. 2009 Jul 7 [cited 2023 Nov 7];49(1):142. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7107998/
12. Peng H, Bilal M, Iqbal HMN. Improved biosafety and biosecurity measures and/or strategies to tackle laboratory-acquired infections and related risks. International Journal of Environmental Research and Public Health [Internet]. 2018 Nov 29 [cited 2023 Aug 31];15(12):2697. Available from: https://www.mdpi.com/1660-4601/15/12/2697/htm
13. Wedum AG. History & Epidemiology of Laboratory-Acquired Infections (in Relation to the Cancer Research Program). Journal of the American Biological Safety Association [Internet]. 1997 Mar [cited 2024 Sep 13];2(1):12–29. Available from: www.liebertpub.com
14. Petts D, Wren MWD, Nation BR, Guthrie G, Kyle B PL, Mortlock S, et al. A short history of occupational diseases: 1.Laboratory acquired infections. Ulster Med J . 2021;90(1).
15. Wurtz N, Papa A, Hukic M, Caro A Di, Leparc-Goffart I, Leroy E, et al. Survey of laboratory-acquired infections around the world in biosafety level 3 and 4 laboratories. European Journal of Clinical Microbiology & Infectious Diseases [Internet]. 2016 May 27 [cited 2023 Sep 5];35(8):1247. Available from: /pmc/articles/PMC7088173/
16. Wedum AG. Prevention of Laboratory-Acquired Infections. Can J Med Technol [Internet]. 1956 [cited 2023 Sep 6];18(3):169–82. Available from: https://onlinelibrary.wiley.com/doi/full/10.1128/9781555817381.ch12
17. Hageman JC, Hazim C, Wilson K, Malpiedi P, Gupta N, Bennett S, et al. Infection Prevention and Control for Ebola in Health Care Settings — West Africa and United States. MMWR Suppl. 2017 Jul 8;65(3):50–6.
18. Infection prevention and control [Internet]. World Health Organization. 2024 [cited 2023 Aug 31]. Available from: https://www.who.int/health-topics/infection-prevention-and-control#tab=tab_1
19. Laboratory Employees. Environment, Health and Safety [Internet]. Cornell University. [cited 2024 Sep 16]. Available from: https://ehs.cornell.edu/research-safety/chemical-safety/laboratory-safety-manual/chapter-1-introduction/12-laboratory-4
20. Forney JR. The Joint Commission. 2021 [cited 2023 Aug 31]. Infection Control in the Clinical Laboratory Environment. Available from: https://www.jointcommission.org/-/media/tjc/documents/accred-and-cert/lab-and-pbm/lab-infec-control-whitepaper-final-_sep-22.pdf

21. Lelieveld HLM, Boon B, Bennett A, Brunius G, Cantley M, Chmiel A, et al. Safe biotechnology. Classification of microorganisms on the basis of hazard. Appl Microbiol Biotechnol [Internet]. 1996 [cited 2024 Mar 12];45(6):723–9. Available from: https://link.springer.com/article/10.1007/s002530050754
22. Laboratory biosafety manual third edition. World Health Organization. 2004. p. 1–178.
23. Kimman TG, Smit E, Klein MR. Evidence-based biosafety: A review of the principles and effectiveness of microbiological containment measures. Clin Microbiol Rev [Internet]. 2008 Jul [cited 2023 Aug 31];21(3):403–25. Available from: https://journals.asm.org/doi/10.1128/cmr.00014-08
24. Shinnick TM, Gilpin C. A Risk Assessment-based Approach to Defining Minimum Biosafety Precautions for Tuberculosis Laboratories in Resource-limited Settings. Applied Biosafety. 2012 Mar;17(1):6–10.
25. Containment Levels. Safety Services - UCL – University College London [Internet]. 2023 [cited 2023 Nov 8]. Available from: https://www.ucl.ac.uk/safety-services/policies/2023/jan/containment-levels
26. Biosafety in Microbiological and Biomedical Laboratories (BMBL) 6th Edition. CDC Laboratory Portal. Centers for Disease Control and Prevention [Internet]. 2023 [cited 2024 Mar 12]. Available from: https://www.cdc.gov/labs/BMBL.html
27. Safe working and the prevention of infection in clinical laboratories and similar facilities. [Internet]. Health and Safety Executive; 2003 [cited 2023 Sep 12]. Available from: https://www.hse.gov.uk/pubns/clinical-laboratories.pdf
28. Health and safety in the laboratory. The Open University [Internet]. [cited 2023 Nov 8]; Available from: https://learn5.open.ac.uk/pluginfile.php/2256/mod_resource/content/1/S288 Health and safety guide live.pdf
29. Standard Operating Procedures - Environment, Health and Safety [Internet]. UNC-University of North Carolina. [cited 2023 Sep 12]. Available from: https://ehs.unc.edu/topics/standard-operating-procedures/
30. Health Surveillance - View our Range of Services - Healthscreen UK [Internet]. [cited 2023 Sep 12]. Available from: https://www.healthscreenuk.co.uk/health-surveillance/
31. Health Surveillance. Occupational Health [Internet]. University of Cambridge. [cited 2023 Sep 12]. Available from: https://www.oh.admin.cam.ac.uk/services/health-surveillance

32. Standard Precautions. [Internet]. Centers for Disease Control and Prevention. 2018 [cited 2024 Apr 3]. Available from: https://www.cdc.gov/oralhealth/infectioncontrol/summary-infection-prevention-practices/standard-precautions.html#print
33. Najeeb N, Taneepanichsakul S. Knowledge, Attitude, and Practice of Doctors and Nurses in Tertiary and Secondary Health Care Setting of Maldives. J Health Res [Internet]. 2008 [cited 2024 Mar 10];22(Suppl.):45–8. Available from: https://he01.tci-thaijo.org/index.php/jhealthres/article/view/156297
34. Infection prevention and control: resource for adult social care. Department of Health and social care [Internet]. 2024 [cited 2023 Aug 31]. Available from: https://www.gov.uk/government/publications/infection-prevention-and-control-in-adult-social-care-settings/infection-prevention-and-control-resource-for-adult-social-care
35. Handwashing. Environmental Health & Safety. [Internet]. Michigan State University. [cited 2024 Sep 16]. Available from: https://ehs.msu.edu/lab-clinic/lab-inspect/hk-handwashing.html
36. Rational use of personal protective equipment for coronavirus disease (COVID-19): interim guidance-2-Recommendations for optimizing the availability of PPE. World Health Organization [Internet]. 2020 [cited 2023 Aug 31]; Available from: https://iris.who.int/bitstream/handle/10665/338033/WHO-2019-nCoV-IPC_PPE_use-2020.4-eng.pdf?sequence=1
37. Preventing Healthcare-associated Infections. HAI. CDC [Internet]. Centers for Disease Control and Prevention. 2015 [cited 2023 Aug 31]. Available from: https://www.cdc.gov/hai/prevent/prevention.html
38. What is Implementation?. Implementation [Internet]. [cited 2023 Sep 28]. Available from: https://implementation.effectiveservices.org/overview/what-is-implementation
39. Barrett SM. Implementation studies: Time for a revival? Personal reflections on 20 years of implementation studies. Public Adm. 2004;82(2):249–62.
40. Part II: How to Successfully Implement Each Core Component of an IPC Programme. Interim Practical Manual supporting national implementation of the WHO Guidelines on Core Components of Infection Prevention and Control Programmes. [Internet]. World Health Organization. 2017 [cited 2023 Sep 29]. Available from: http://apps.who.int/bookorders.

41. Grol R, Wensing M. What drives change? Barriers to and incentives for achieving evidence-based practice. Med J Aust [Internet]. 2004 Mar 15 [cited 2023 Sep 29];180(S6). Available from: https://pubmed.ncbi.nlm.nih.gov/15012583/
42. Akagbo SE, Nortey P, Ackumey MM. Knowledge of standard precautions and barriers to compliance among healthcare workers in the Lower Manya Krobo District, Ghana. BMC Res Notes [Internet]. 2017 Aug 30 [cited 2023 Nov 8];10(1):432. Available from: /pmc/articles/PMC5577785/
43. Alhumaid S, Al Mutair A, Al Alawi Z, Alsuliman M, Ahmed GY, Rabaan AA, et al. Knowledge of infection prevention and control among healthcare workers and factors influencing compliance: a systematic review. Antimicrob Resist Infect Control [Internet]. 2021 Dec 1 [cited 2023 Nov 8];10(1):1–32. Available from: https://aricjournal.biomedcentral.com/articles/10.1186/s13756-021-00957-0
44. Andersen JH, Møller A, Due TD. Making sense of and working with COVID-19 related guidelines and information in Danish general practice–A qualitative study. PLoS One [Internet]. 2023 Feb 1 [cited 2023 Sep 29];18(2):e0281579. Available from: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0281579
45. Health and Social Care Act 2008: code of practice on the prevention and control of infections and related guidance. Department of Health and Social care [Internet]. 2022 [cited 2024 Mar 10]. Available from: https://www.gov.uk/government/publications/the-health-and-social-care-act-2008-code-of-practice-on-the-prevention-and-control-of-infections-and-related-guidance/health-and-social-care-act-2008-code-of-practice-on-the-prevention-and-control-of-infections-and-related-guidance
46. Australian Guidelines for the Prevention and Control of Infection in Healthcare. Australian Commission on Safety and Quality in Health Care [Internet]. 2019 [cited 2024 Sep 12]. Available from: https://www.safetyandquality.gov.au/publications-and-resources/resource-library/australian-guidelines-prevention-and-control-infection-healthcare
47. Tannous E, El-Saed A, Ameer K, Khalaf A, Mohammad S, Molaeb B, et al. Infection prevention and control staffing and programs in Middle Eastern Countries. The Journal of Infection in Developing Countries [Internet]. 2022 May 30 [cited 2023 Nov 9];16(05):889–96. Available from: https://jidc.org/index.php/journal/article/view/15504
48. Infection Control Guidelines in Clinical Laboratory. General Directorate of Infection Prevention and Control in Healthcare Facilities. Ministry of Health. 2021 [cited 2023

Nov 15]; Available from: https://jed-s3.bluvalt.com/psj1-ifn-s3-ifn01/files/03/Guidelines/Infection-Control-Guidelines-in-Clinical-Laboratory.pdf

49. Izegbu M, Amole O, Ajayi G. Attitudes, perception and practice of workers in laboratories in the two colleges of Medicine and their teaching hospitals in Lagos State, Nigeria as regards universal precaution measures. Biomedical Research-tokyo [Internet]. 2006 [cited 2024 Mar 10]; Available from: https://www.researchgate.net/publication/237321967_Attitudes_perception_and_practice_of_workers_in_laboratories_in_the_two_Colleges_of_Medicine_and_their_teaching_hospitals_in_Lagos_State_Nigeria_as_regards_universal_precaution_measures
50. Almalki M, Fitzgerald G, Clark M. Health care system in Saudi Arabia: an overview. East Mediterr Health J [Internet]. 2011 [cited 2023 Sep 21];17(10):784–93. Available from: https://pubmed.ncbi.nlm.nih.gov/22256414/
51. Gallagher EB. Modernization and health reform in Saudi Arabia, Chapter 4.Health care reform around the world. In: Twaddle AC, ed. 2002. 181–197 p.
52. Alslamah T, Abalkhail A. The National Strategies for and Challenges in Infection Prevention and Control of the Healthcare System in the Kingdom of Saudi Arabia (Review Study). Vaccines (Basel) [Internet]. 2022 Aug 1 [cited 2023 Sep 20];10(8). Available from: /pmc/articles/PMC9416472/
53. Ministry of Health [Internet]. 2024 [cited 2023 Nov 13]. Health Regions in Saudi Arabia. Available from: https://samrindia.org/health-regions-in-saudi-arabia
54. Albagawi B. Examining barriers and facilitators to effective nurse-patient communication within a Saudi Arabic cultural context. 2014 [cited 2024 Mar 10]; Available from: https://www.researchgate.net/publication/262918757_Examining_Barriers_and_Facilitators_to_Effective_Nurse-Patient_Communication_Within_a_Saudi_Arabic_Cultural_Context
55. Assiri AM, Choudhry AJ, Alsaleh SS, Alanazi KH, Alsaleh SS. Evaluation of Infection Prevention and Control Programmes (IPC), and Assessment Tools for IPC-Programmes at MOH-Health Facilities in Saudi Arabia. Open J Nurs [Internet]. 2014 [cited 2023 Sep 26];04(07):483–92. Available from: https://www.scirp.org/journal/paperinformation?paperid=46633
56. Alkabba A, Hussein G, Albar A, Bahnassy A, Qadi M. The major medical ethical challenges facing the public and healthcare providers in Saudi Arabia. J Family

Community Med [Internet]. 2012 Apr 1 [cited 2023 Sep 27];19(1):1. Available from: /pmc/articles/PMC3326764/

57. Saudi Arabia: hospital number by region. Statista [Internet]. [cited 2023 Nov 13]. Available from: https://www.statista.com/statistics/608528/number-of-hospitals-in-saudi-arabia-by-region/

58. Saudi Arabia Laboratories for Saudi Arabia Testing, Inspection and Certification [Internet]. [cited 2023 Nov 14]. Available from: https://www.contractlaboratory.com/directory/laboratories/by-location.cfm?Saudi-Arabia-Laboratories&i=SA

59. Laboratory Department - King Fahd Specialist Hospital in Buraidah [Internet]. 2024 [cited 2023 Nov 15]. Available from: https://www.kfshb.med.sa

60. CBAHI at a glance. CBAHI [Internet]. [cited 2023 Nov 14]. Available from: https://portal.cbahi.gov.sa/english/about-us/cbahi-at-a-glance

61. Apostolopoulos V, Chavda V, Alshahrani NZ, Mehta R, Satapathy P, Rodriguez-Morales AJ, et al. MERS outbreak in Riyadh: A current concern in Saudi Arabia. Infez Med [Internet]. 2024 [cited 2024 Sep 10];32(2):264. Available from: /pmc/articles/PMC11142407/

62. Almazroa MA, Memish ZA, Alwadey AM. Pandemic influenza A (H1N1) in Saudi Arabia: description of the first one hundred cases. Ann Saudi Med [Internet]. 2010 Jan 1 [cited 2024 Sep 10];30(1):11. Available from: /pmc/articles/PMC2850176/

63. Monne I, Fusaro A, Al-Blowi MH, Ismail MM, Khan OA, Dauphin G, et al. Co-circulation of two sublineages of HPAI H5N1 virus in the Kingdom of Saudi Arabia with unique molecular signatures suggesting separate introductions into the commercial poultry and falconry sectors. J Gen Virol [Internet]. 2008 [cited 2024 Sep 10];89(Pt 11):2691. Available from: /pmc/articles/PMC2886959/

64. Rabaan AA, Alhani HM, Bazzi AM, Al-Ahmed SH. Questionnaire-based analysis of infection prevention and control in healthcare facilities in Saudi Arabia in regards to Middle East Respiratory Syndrome. J Infect Public Health [Internet]. 2017 Sep 1 [cited 2023 Sep 26];10(5):548. Available from: /pmc/articles/PMC7102716/

65. Sheerah HA, Almuzaini Y, Khan A. Public Health Challenges in Saudi Arabia during the COVID-19 Pandemic: A Literature Review. Healthcare [Internet]. 2023 Jun 1 [cited 2024 Sep 10];11(12). Available from: /pmc/articles/PMC10298102/

66. Memish ZA, Mah MW. Brucellosis in laboratory workers at a Saudi Arabian hospital. Am J Infect Control [Internet]. 2001 [cited 2023 Sep 21];29(1):48–52. Available from: https://pubmed.ncbi.nlm.nih.gov/11172318/
67. Hassan MI, Diab AE. Detection of latent tuberculosis infection among laboratory personnel at a University Hospital in Eastern Saudi Arabia using an interferon gamma release assay. J Infect Public Health. 2014 Jul 1;7(4):289–95.
68. Gulf Cooperation Council (GCC). [cited 2023 Sep 29]; Available from: www.dgft.gov.in
69. Alasiri AA, Mohammed V. Healthcare Transformation in Saudi Arabia: An Overview Since the Launch of Vision 2030. Health Serv Insights [Internet]. 2022 [cited 2024 Feb 14];15. Available from: /pmc/articles/PMC9445529/
70. About MNGHA. Ministry of National Guard Health Affairs [Internet]. 2023 [cited 2023 Sep 28]. Available from: https://ngha.med.sa/English/AboutNGHA/Pages/default.aspx
71. Policies and Procedures. Ministry of National Guard Health Affairs [Internet]. 2020 [cited 2023 Sep 28]. Available from: https://www.ngha.med.sa/English/Pages/VPoliciesE.aspx
72. Abalkhail A, Al Imam MH, Elmosaad YM, Jaber MF, Al Hosis K, Alhumaydhi FA, et al. Knowledge, Attitude and Practice of Standard Infection Control Precautions among Health-Care Workers in a University Hospital in Qassim, Saudi Arabia: A Cross-Sectional Survey. Int J Environ Res Public Health [Internet]. 2021 Nov 1 [cited 2023 Nov 13];18(22). Available from: /pmc/articles/PMC8624606/
73. Aldhamy H, Maniatopoulos G, McCune VL, Mansi I, Althaqafy M, Pearce MS. Knowledge, attitude and practice of infection prevention and control precautions among laboratory staff: a mixed-methods systematic review. Antimicrob Resist Infect Control [Internet]. 2023 Dec 1 [cited 2024 Mar 27];12(1):1–14. Available from: https://aricjournal.biomedcentral.com/articles/10.1186/s13756-023-01257-5
74. Aldhamy H, Majid Althaqafy, Gregory Maniatopoulos, Mark Pearce, Victoria L. McCune, Ilaf Mansi. Knowledge, attitude and practice of infection prevention and control precautions among hospital laboratory staff: a mixed-methods systematic review. PROSPERO 2023 CRD42023188876 [Internet]. 2023 May 5 [cited 2024 Mar 5]; Available from: https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42023188876
75. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ

[Internet]. 2021 Mar 29 [cited 2024 Jan 24];372. Available from: https://www.bmj.com/content/372/bmj.n71
76. JBI Critical Appraisal Tools. JBI [Internet]. [cited 2024 Jan 24]. Available from: https://jbi.global/critical-appraisal-tools
77. Popay J, Roberts H, Sowden A, Petticrew M, Arai L, Rodgers M, et al. Guidance on the Conduct of Narrative Synthesis in Systematic Reviews A Product from the ESRC Methods Programme Peninsula Medical School, Universities of Exeter and Plymouth. 2006;
78. Ibeziako SN, Ibekwe RC. Knowledge and practice of universal precaution in a tertiary health facility. Niger J Med. 2006;15(3):250–4.
79. Sadoh WE, Fawole AO, Sadoh AE, Oladimeji AO, Sotiloye OS. Practice of universal precautions among healthcare workers. J Natl Med Assoc [Internet]. 2006 May [cited 2024 Mar 10];98(5):722. Available from: /pmc/articles/PMC2569287/?report=abstract
80. Fadeyi A, Fowotade A, Abiodun MO, Jimoh AK, Nwabuisi C, Desalu OO. Awareness and practice of safety precautions among healthcare workers in the laboratories of two public health facilities in Nigeria. Niger Postgrad Med J. 2011 Jun;18(2):141–6.
81. Isara A, Ofili A. Prevalence of occupational accidents/Injuries among health care workers in a federal medical centre in southern Nigeria. West Afr J Med [Internet]. 2012 [cited 2024 Mar 10]; Available from: https://www.researchgate.net/publication/232745758_Prevalence_of_Occupational_AccidentsInjuries_among_Health_Care_Workers_in_a_Federal_Medical_Centre_in_Southern_Nigeria
82. Mohammed Bello F, Public Health in, Penny Anne C, Abdullahi Musa K, Bello Fufore M. Health Workers' Knowledge, Attitude and Practice towards Hepatitis B Infection in Northern Nigeria. Int J Caring Sci [Internet]. [cited 2024 Jan 24];9:3–939. Available from: www.internationaljournalofcaringsciences.org
83. Ndu AC, Arinze-Onyia SU. Standard precaution knowledge and adherence: Do Doctors differ from Medical Laboratory Scientists? Malawi Medical Journal [Internet]. 2017 Dec 1 [cited 2024 Jan 24];29(4):294. Available from: /pmc/articles/PMC6019545/
84. Alemie GA. Exploration of healthcare workers' perceptions on occupational risk of HIV transmission at the University of Gondar Hospital, Northwest Ethiopia. BMC Res Notes [Internet]. 2012 Dec 29 [cited 2024 Jan 24];5(1):1–4. Available from: https://link.springer.com/articles/10.1186/1756-0500-5-704

85. Deress T, Hassen F, Adane K, Tsegaye A. Assessment of Knowledge, Attitude, and Practice about Biomedical Waste Management and Associated Factors among the Healthcare Professionals at Debre Markos Town Healthcare Facilities, Northwest Ethiopia. J Environ Public Health [Internet]. 2018 [cited 2023 Dec 7];2018. Available from: /pmc/articles/PMC6189693/
86. Sahiledengle B, Gebresilassie A, Getahun T, Hiko D. Infection Prevention Practices and Associated Factors among Healthcare Workers in Governmental Healthcare Facilities in Addis Ababa. Ethiop J Health Sci [Internet]. 2018 Mar 1 [cited 2023 Dec 6];28(2):177. Available from: /pmc/articles/PMC6016341/
87. Desta M, Ayenew T, Sitotaw N, Tegegne N, Dires M, Getie M. Knowledge, practice and associated factors of infection prevention among healthcare workers in Debre Markos referral hospital, Northwest Ethiopia. BMC Health Serv Res [Internet]. 2018 Jun 18 [cited 2023 Nov 30];18(1). Available from: https://pubmed.ncbi.nlm.nih.gov/29914477/
88. Nasim S, Shahid A, Mustufa MA, Kazmi SU, Siddiqui TR, Mohiuddin S, et al. Practices and awareness regarding biosafety measures among laboratory technicians working in clinical laboratories in Karachi, Pakistan. Applied Biosafety. 2010 Dec;15(4):172–9.
89. Nasim S, Shahid A, Ayaz Mustufa M, Arain GM, Ali G, Taseer I ul H, et al. Biosafety perspective of clinical laboratory workers: a profile of Pakistan. The Journal of Infection in Developing Countries [Internet]. 2012 Aug 21 [cited 2024 Jan 24];6(08):611–9. Available from: https://jidc.org/index.php/journal/article/view/2236
90. Qazi AR, Siddiqui FA, Faridi S, Nadeem U, Umer NI, Mohsini ZS, et al. Comparison of awareness about precautions for needle stick injuries: a survey among health care workers at a tertiary care center in Pakistan. Patient Saf Surg [Internet]. 2016 Sep 7 [cited 2024 Jan 24];10(1). Available from: /pmc/articles/PMC5015332/
91. Alam M, Bbs M. Knowledge, attitude and practices among health care workers on needle-stick injuries. Annals o f Saudi Medicine. 2001;22(5-6).
92. Khan MU, Shah S, Ahmad A, Fatokun O. Knowledge and attitude of healthcare workers about middle east respiratory syndrome in multispecialty hospitals of Qassim, Saudi Arabia. BMC Public Health [Internet]. 2014 Dec 16 [cited 2023 Dec 8];14(1):1–7. Available from: https://bmcpublichealth.biomedcentral.com/articles/10.1186/1471-2458-14-1281
93. Khabour OF, Al Ali KH, Aljuhani JN, Alrashedi MA, Alharbe FH, Sanyowr A. Assessment of biosafety measures in clinical laboratories of Al-Madinah city, Saudi

Arabia. J Infect Dev Ctries [Internet]. 2018 Sep 1 [cited 2023 Nov 30];12(9):755–61. Available from: https://pubmed.ncbi.nlm.nih.gov/31999634/

94. Binsaleh NK, Bazaid AS, Aldarhami A, Sherwani S, Althomali OW. Awareness and Practice of COVID-19 Precautionary Measures Among Healthcare Professionals in Saudi Arabia. J Multidiscip Healthc [Internet]. 2021 [cited 2024 Jan 24];14:1553–60. Available from: https://pubmed.ncbi.nlm.nih.gov/34188482/

95. Zaveri J, Karia J. Knowledge, attitudes and practice of laboratory technicians regarding universal work precautions. National Journal of Medical Research [Internet]. 2012 [cited 2024 Mar 10];2:4995. Available from: https://njmr.in/index.php/file/article/view/734

96. Wader J, Kumar V, Mutalik A V. Knowledge, Attitude, Practice of Biosafety Precautions amongst Laboratory Technicians in a Teaching Hospital. Int J Health Sci Res [Internet]. 2013 [cited 2024 Jan 24]; Available from: https://www.researchgate.net/publication/285838061_Knowledge_attitude_practice_of_biosafety_precautions_amongst_laboratory_technicians_in_a_teaching_hospital

97. Vaughn TE, McCoy KD, Beekmann SE, Woolson RF, Torner JC, Doebbeling BN. Factors promoting consistent adherence to safe needle precautions among hospital workers. Infect Control Hosp Epidemiol [Internet]. 2004 Jul [cited 2024 Jan 24];25(7):548–55. Available from: https://pubmed.ncbi.nlm.nih.gov/15301026/

98. Benzekri N, Goldman E, Lewis F, Johnson CC, Reynolds SM, Reynolds MG, et al. Laboratory worker knowledge, attitudes and practices towards smallpox vaccine. Occup Med (Chic Ill) [Internet]. 2010 Jan 1 [cited 2024 Jan 24];60(1):75–7. Available from: https://dx-doi-org.libproxy.ncl.ac.uk/10.1093/occmed/kqp120

99. Davidson G, Gillies P. Safe working practices and HIV infection: knowledge, attitudes, perception of risk, and policy in hospital. Quality in Health Care. 1993;2:21–6.

100. Ider BE, Adams J, Morton A, Whitby M, Clements A. Perceptions of healthcare professionals regarding the main challenges and barriers to effective hospital infection control in Mongolia: a qualitative study. BMC Infect Dis [Internet]. 2012 Jul 31 [cited 2023 Dec 12];12(1):1–10. Available from: https://bmcinfectdis.biomedcentral.com/articles/10.1186/1471-2334-12-170

101. Al-Abhar N, Al-Gunaid E, Moghram G, Al-Hababi AA, Al Serouri A, Khader YS. Knowledge and Practice of Biosafety Among Laboratory Staff Working in Clinical Laboratories in Yemen. Applied Biosafety [Internet]. 2017 Dec 1 [cited 2024 Jan 24];22(4):168–71. Available from: www.liebertpub.com

102. Chalya G, Mbunda F, Chalya PL. Knowledge, practice and factors associated with poor compliance with universal precautions among healthcare workers at Bugando Medical Centre, Mwanza, Tanzania. Tanzan J Health Res [Internet]. 2016 [cited 2024 Mar 10];18(3). Available from: https://www.semanticscholar.org/paper/Knowledge%2C-practice-and-factors-associated-with-at-Chalya-Chalya/3920055c2ee7ece0b9e72df2b993c04944649f74
103. Fayaz SH, Higuchi M, Hirosawa T, Sarker MAB, Djabbarova Z, Hamajima N. Knowledge and practice of universal precautions among health care workers in four national hospitals in Kabul, Afghanistan. The Journal of Infection in Developing Countries [Internet]. 2014 Apr 15 [cited 2024 Jan 24];8(04):535–42. Available from: https://jidc.org/index.php/journal/article/view/4143
104. Kahhaleh JG, Jurjus AR. Adherence to universal precautions among laboratory personnel in Lebanon. EMHJ - Eastern Mediterranean Health Journal [Internet]. 2005 [cited 2024 Mar 10];929–42. Available from: https://www.researchgate.net/publication/7020953_Adherence_to_universal_precautions_among_laboratory_personnel_in_Lebanon
105. Jin YH, Huang Q, Wang YY, Zeng XT, Luo LS, Pan ZY, et al. Perceived infection transmission routes, infection control practices, psychosocial changes, and management of COVID-19 infected healthcare workers in a tertiary acute care hospital in Wuhan: A cross-sectional survey. Mil Med Res [Internet]. 2020 May 11 [cited 2024 Jan 24];7(1):1–13. Available from: https://link.springer.com/articles/10.1186/s40779-020-00254-8
106. Ngwa CH, Ngoh EA, Cumber SN. Assessment of the knowledge, attitude and practice of health care workers in Fako Division on post exposure prophylaxis to blood borne viruses: a hospital based cross-sectional study. Pan Afr Med J [Internet]. 2018 [cited 2024 Jan 24];31. Available from: /pmc/articles/PMC6462352/
107. Buxton JA, Henry B, Waheed Bsc A, Crabtree A, Mph BA. Prion disease risk perception in Canadian medical laboratories. Can J Infect Dis Med Microbiol. 2012;23(2).
108. Nkonge Njagi A, Mayabi Oloo A, Kithinji J, Magambo Kithinji J. Knowledge, attitude and practice of health-care waste management and associated health risks in the two teaching and referral hospitals in Kenya. J Community Health. 2012 Dec;37(6):1172–7.
109. Woith W, Volchenkov G, Larson J. Barriers and Facilitators Affecting Tuberculosis Infection Control Practices of Russian Health Care Workers. Int J Tuberc Lung Dis [Internet]. 2012 Aug 1 [cited 2024 Jan 24];16(8):1092. Available from: /pmc/articles/PMC3685429/

110. Ahammed T, Zaman S, Hassan MJ, Nigar S. Evaluation of biosafety assessment among laboratory staff in selected hospitals and diagnostic centers at Jashore district in Bangladesh. Asian Journal of Microbiology, Biotechnology & Environmental Sciences. 2023;25(02):190–205.
111. Sadoh WE, Sadoh AE, Sotiloye OS. Practice of Universal Precautions among Healthcare Workers. 2006 [cited 2024 Jan 24]; Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2569287/pdf/jnma00192-0062.pdf
112. Abdullahi LH, Kagina BM, Cassidy T, Adebayo EF, Wiysonge CS, Hussey GD. Knowledge, attitudes and practices on adolescent vaccination among adolescents, parents and teachers in Africa: A systematic review. Vaccine. 2016 Jul 25;34(34):3950–60.
113. Yazie TD, Sharew GB, Abebe W. Knowledge, attitude, and practice of healthcare professionals regarding infection prevention at Gondar University referral hospital, northwest Ethiopia: a cross-sectional study. BMC Res Notes [Internet]. 2019 Sep 9 [cited 2024 Jan 24];12(1):563. Available from: /pmc/articles/PMC6734428/
114. Mossburg S, Agore A, Nkimbeng M, Commodore-Mensah Y. Occupational Hazards among Healthcare Workers in Africa: A Systematic Review. Ann Glob Health [Internet]. 2019 [cited 2024 Jan 25];85(1). Available from: https://annalsofglobalhealth.org/articles/10.5334/aogh.2434
115. Potter AW, Gonzalez JA, Xu X. Ebola Response: Modeling the Risk of Heat Stress from Personal Protective Clothing. PLoS One [Internet]. 2015 Nov 1 [cited 2024 Jan 25];10(11):e0143461. Available from: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0143461
116. Johnson RB, Onwuegbuzie AJ. Toward a Definition of Mixed Methods Research. J Mix Methods Res. 2007;1(2):112–33.
117. Zohrabi M. Mixed method research: Instruments, validity, reliability and reporting findings. Theory and Practice in Language Studies. 2013;3(2):254–62.
118. Sharique A, Saeeda W, Sumaiya I, Sudarshana G, Anshika S, Zarina F. Qualitative V/s. quantitative research- A summarized review. Journal of Evidence Based Medicine and Healthcare. 2019;6(43):2828–32.
119. Normalization Process Theory | Normalization Process Theory [Internet]. [cited 2024 Jan 29]. Available from: https://normalization-process-theory.northumbria.ac.uk/
120. Authority Portal - Home Page [Internet]. [cited 2024 Jan 29]. Available from: https://portal.saudicensus.sa/portal/public/1/15/101460?type=TABLE

121. King Abdulaziz Medical City - Jeddah - IHR Canada [Internet]. [cited 2024 Jan 29]. Available from: https://ihrcanada.com/hospitals/king-abdulaziz-medical-city-in-jeddah-saudi-arabia/
122. King Fahd Specialist Hospital in Buraidah [Internet]. [cited 2024 Jan 29]. Available from: https://www.kfshb.med.sa/
123. Hayat National Hospitals. Riyadh - Asir - Jazan - Al-Qassim - Medina [Internet]. [cited 2024 Jan 29]. Available from: https://hayathospitals.com/
124. File:Saudi Arabia map.png - Wikipedia [Internet]. [cited 2024 Sep 16]. Available from: https://en.m.wikipedia.org/wiki/File:Saudi_Arabia_map.png
125. Public Health Career Spotlights. [Internet]. Centers for Disease Control and Prevention. 2023 [cited 2024 Jan 29]. Available from: https://www.cdc.gov/scienceambassador/nerdacademy/careers.html
126. Convenience Sampling (Accidental Sampling): Definition, Method & Examples. Simply psychology [Internet]. 2023 [cited 2024 Jan 29]. Available from: https://www.simplypsychology.org/convenience-sampling.html
127. Arinze-Onyia SU, Ndu AC, Aguwa EN, Modebe I, Nwamoh UN. Knowledge and Practice of Standard Precautions by Health-Care Workers in a Tertiary Health Institution in Enugu, Nigeria. Niger J Clin Pract [Internet]. 2018 Feb 1 [cited 2024 Jan 29];21(2):149–55. Available from: https://pubmed.ncbi.nlm.nih.gov/29465047/
128. Finch TL, Girling M, May CR, Mair FS, Murray E, Treweek S, et al. Improving the normalization of complex interventions: part 2 - validation of the NoMAD instrument for assessing implementation work based on normalization process theory (NPT). BMC Med Res Methodol [Internet]. 2018 Nov 15 [cited 2024 Jan 29];18(1). Available from: https://pubmed.ncbi.nlm.nih.gov/30442094/
129. McKnight PE, Najab J. Mann-Whitney U Test. The Corsini Encyclopedia of Psychology [Internet]. 2010 Jan 30 [cited 2024 Sep 16];1–1. Available from: https://onlinelibrary.wiley.com/doi/full/10.1002/9780470479216.corpsy0524
130. The Kruskal–Wallis Test | Technology Networks [Internet]. [cited 2024 Jan 29]. Available from: https://www.technologynetworks.com/informatics/articles/the-kruskal-wallis-test-370025
131. The t-Test | Introduction to Statistics | JMP [Internet]. [cited 2024 Jan 29]. Available from: https://www.jmp.com/en_gb/statistics-knowledge-portal/t-test.html
132. Analysis of Variance (ANOVA) Explanation, Formula, and Applications [Internet]. [cited 2024 Jan 29]. Available from: https://www.investopedia.com/terms/a/anova.asp

133. Greenland S, Pearl J, Robins JM. Epidemiology. 1999 [cited 2024 Jan 29]. p. 37–48 Causal Diagrams for Epidemiologic Research. Available from: https://journals.lww.com/epidem/abstract/1999/01000/causal_diagrams_for_epidemiologic_research.8.aspx
134. Saunders B, Sim J, Kingstone T, Baker S, Waterfield J, Bartlam B, et al. Saturation in qualitative research: exploring its conceptualization and operationalization. Qual Quant [Internet]. 2018 Jul 1 [cited 2024 Sep 11];52(4):1893. Available from: /pmc/articles/PMC5993836/
135. Coyne IT. Sampling in qualitative research. Purposeful and theoretical sampling; merging or clear boundaries? J Adv Nurs [Internet]. 1997 Sep 1 [cited 2024 Jan 29];26(3):623–30. Available from: https://onlinelibrary.wiley.com/doi/full/10.1046/j.1365-2648.1997.t01-25-00999.x
136. Palinkas LA, Horwitz SM, Green CA, Wisdom JP, Duan N, Hoagwood K. Purposeful sampling for qualitative data collection and analysis in mixed method implementation research. Adm Policy Ment Health [Internet]. 2015 Sep 22 [cited 2024 Oct 2];42(5):533. Available from: /pmc/articles/PMC4012002/
137. Nilsen P. Making sense of implementation theories, models and frameworks. Implementation Science [Internet]. 2015 Apr 21 [cited 2024 Sep 17];10(1):1–13. Available from: https://implementationscience.biomedcentral.com/articles/10.1186/s13012-015-0242-0
138. Damschroder LJ, Aron DC, Keith RE, Kirsh SR, Alexander JA, Lowery JC. Fostering implementation of health services research findings into practice: a consolidated framework for advancing implementation science. Implement Sci [Internet]. 2009 [cited 2024 Sep 17];4(1). Available from: https://pubmed.ncbi.nlm.nih.gov/19664226/
139. Schroeder D, Luig T, Finch TL, Beesoon S, Campbell-Scherer DL. Understanding implementation context and social processes through integrating Normalization Process Theory (NPT) and the Consolidated Framework for Implementation Research (CFIR). Implement Sci Commun [Internet]. 2022 Dec 1 [cited 2024 Sep 17];3(1):1–16. Available from: https://implementationsciencecomms.biomedcentral.com/articles/10.1186/s43058-022-00264-8
140. Holtrop JS, Estabrooks PA, Gaglio B, Harden SM, Kessler RS, King DK, et al. Understanding and applying the RE-AIM framework: Clarifications and resources. J

Clin Transl Sci [Internet]. 2021 [cited 2024 Sep 17];5(1). Available from: /pmc/articles/PMC8327549/

141. May CR, Cummings A, Girling M, Bracher M, Mair FS, May CM, et al. Using Normalization Process Theory in feasibility studies and process evaluations of complex healthcare interventions: a systematic review. Implementation Science 2018 13:1 [Internet]. 2018 Jun 7 [cited 2024 Sep 17];13(1):1–27. Available from: https://link.springer.com/articles/10.1186/s13012-018-0758-1

142. Hooker L, Taft A. Using theory to design, implement and evaluate sustained nurse domestic violence screening and supportive care. http://dx.doi.org/101177/1744987116649633 [Internet]. 2016 Jun 15 [cited 2024 Jan 29];21(5–6):432–42. Available from: https://journals.sagepub.com/doi/10.1177/1744987116649633

143. Huddlestone L, Turner J, Eborall H, Hudson N, Davies M, Martin G. Application of normalisation process theory in understanding implementation processes in primary care settings in the UK: a systematic review. BMC Fam Pract [Internet]. 2020 Mar 16 [cited 2024 Sep 17];21(1). Available from: /pmc/articles/PMC7075013/

144. Normalization Process Theory. NPT Core Constructs [Internet]. [cited 2024 Jan 29]. Available from: https://normalization-process-theory.northumbria.ac.uk/what-is-npt/npt-core-constructs/

145. Tazzyman A, Ferguson J, Hillier C, Boyd A, Tredinnick-Rowe J, Archer J, et al. The implementation of medical revalidation: An assessment using normalisation process theory. BMC Health Serv Res [Internet]. 2017 Nov 21 [cited 2024 Oct 1];17(1):1–14. Available from: https://link.springer.com/article/10.1186/s12913-017-2710-5

146. Herbert J. Rubin, Irene S. Rubin. Thousand Oaks, CA: Sage Publications Ltd. 2011. Qualitative Interviewing: The Art of Hearing Data. 3rd ed.

147. Automatically convert audio and video to text: Fast, Accurate, & Affordable | Sonix [Internet]. [cited 2024 Jan 29]. Available from: https://sonix.ai/

148. Murray E, Treweek S, Pope C, MacFarlane A, Ballini L, Dowrick C, et al. Normalisation process theory: A framework for developing, evaluating and implementing complex interventions. BMC Med [Internet]. 2010 Oct 20 [cited 2024 Jan 29];8(1):1–11. Available from: https://bmcmedicine.biomedcentral.com/articles/10.1186/1741-7015-8-63

149. Carl May, Tracy Finch, Luciana Ballini, Anne MacFarlane, Elizabeth Murray, France Mair, et al. A toolkit for complex interventions and health technologies using

normalization process theory. PPT [Internet]. 2011 [cited 2024 Jan 29]. Available from: https://www.slideshare.net/Normalizationprocess/a-toolkit-for-complex-interventions-and-health-technologies-using-normalization-process-theory

150. Fetters MD, Curry LA, Creswell JW. Achieving Integration in Mixed Methods Designs—Principles and Practices. Health Serv Res [Internet]. 2013 Dec 1 [cited 2024 Mar 6];48(6pt2):2134–56. Available from: https://onlinelibrary.wiley.com/doi/full/10.1111/1475-6773.12117

151. Sevilla-Liu A. The theoretical basis of a functional-descriptive approach to qualitative research in CBS: With a focus on narrative analysis and practice. J Contextual Behav Sci. 2023 Oct 1;30:210–6.

152. Steels R. Untold Stories: Parents' Experiences of Young People Reintegrating from Alternative Provision to Mainstream Education. 2022;

153. Katie Moon, Deborah Blackman. A guide to ontology, epistemology, and philosophical perspectives for interdisciplinary researchers. Integration and Implementation Insights [Internet]. 2017 [cited 2024 Jan 29]. Available from: https://i2insights.org/2017/05/02/philosophy-for-interdisciplinarity/

154. Clarke V, Braun V. Successful Qualitative Research: A practical guide for beginners. QMiP bulletin [Internet]. 2013 [cited 2024 Mar 11];1(18):39–41. Available from: https://www.researchgate.net/publication/256089360_Successful_Qualitative_Research_A_Practical_Guide_for_Beginners

155. Berth Danermark, Mats Ekström, Jan Ch. Karlsson. Explaining Society: Critical Realism in the Social Sciences. 2nd ed. Routledge. 2019.

156. Scott D. Critical realism and empirical research methods in education. Journal of Philosophy of Education. 2005 Nov;39(4):633–46.

157. Carla Willig. Introducing Qualitative Research in Psychology (Third ed). McGraw-Hill Education. 2013.

158. Bill Gillham. Case Study Research Methods. 2nd ed. Bloomsbury Publishing. 2000.

159. Finefter-Rosenbluh I. Incorporating perspective taking in reflexivity: A method to enhance insider qualitative research processes. Int J Qual Methods [Internet]. 2017 Dec 1 [cited 2024 Sep 11];16(1). Available from: https://us.sagepub.com/en-us/nam/open-access-at-sage

160. Olmos-Vega FM, Stalmeijer RE, Varpio L, Kahlke R. A practical guide to reflexivity in qualitative research: AMEE Guide No. 149. Med Teach [Internet]. 2023 [cited 2024 Jan

29];45(3):241–51. Available from: https://www.tandfonline.com/doi/abs/10.1080/0142159X.2022.2057287

161. Richards H, Emslie C. The “doctor” or the “girl from the University”? Considering the influence of professional roles on qualitative interviewing. Fam Pract [Internet]. 2000 [cited 2024 Apr 3];17(1):71–5. Available from: https://pubmed.ncbi.nlm.nih.gov/10673494/

162. Abalkhail A, Al Imam MH, Elmosaad YM, Jaber MF, Al Hosis K, Alhumaydhi FA, et al. Knowledge, Attitude and Practice of Standard Infection Control Precautions among Health-Care Workers in a University Hospital in Qassim, Saudi Arabia: A Cross-Sectional Survey. Int J Environ Res Public Health [Internet]. 2021 Nov 1 [cited 2023 Dec 6];18(22). Available from: /pmc/articles/PMC8624606/

163. Nalunkuma R, Nkalubo J, Abila DB. Knowledge on Infection Prevention and Control and associated factors among undergraduate health professional students at Makerere University College of Health Sciences, Uganda. PLoS One [Internet]. 2021 Aug 1 [cited 2023 Dec 6];16(8):e0255984. Available from: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0255984

164. Sadoh WE, Sadoh AE, Sotiloye OS. Practice of Universal Precautions among Healthcare Workers. 2006;

165. Tarimo EA, Mashoto KO. A Qualitative Study of Perceived Risk of Occupational Exposure to HIV and Use of Post Exposure Prophylaxis Services Among Health-Care Workers in Tanzania. East Afr Health Res J [Internet]. 2019 [cited 2024 Feb 6];3(2):96. Available from: /pmc/articles/PMC8279300/

166. Adebimpe WO. Knowledge and practice of health care workers towards post exposure prophylaxis in the era of low and stable HIV prevalence in Southwestern Nigeria. Bulletin of Faculty of Pharmacy, Cairo University. 2018 Jun 1;56(1):104–8.

167. Prohibition of Food & Drink in ODU Laboratories. Old Dominion University. [cited 2024 Feb 6]; Available from: https://www.odu.edu/sites/default/files/documents/eating-drinking-labs.pdf

168. Eating, Drinking, and Applying Cosmetics in the Lab. Environment, Health and Safety [Internet]. [cited 2024 Feb 6]. Available from: https://ehs.cornell.edu/research-safety/chemical-safety/laboratory-safety-manual/chapter-4-administrative-controls/46

169. Alhumaid S, Al Mutair A, Al Alawi Z, Alsuliman M, Ahmed GY, Rabaan AA, et al. Knowledge of infection prevention and control among healthcare workers and factors influencing compliance: a systematic review. Antimicrob Resist Infect Control

[Internet]. 2021 Dec 1 [cited 2023 Dec 6];10(1). Available from: /pmc/articles/PMC8173512/
170. Kassa W, Mindaye T. Assessment of Knowledge, Attitude and Practice Towards Occupational Health and Safety Among Medical Laboratory Personnel In Selected Governmental Teaching Hospitals Of Ethiopia. 2015 [cited 2023 Dec 7]; Available from: http://etd.aau.edu.et/handle/123456789/6033
171. Kuzu N, Özer F, Aydemir S, Yalcin AN, Zencir M. Compliance with hand hygiene and glove use in a university-affiliated hospital. Infect Control Hosp Epidemiol [Internet]. 2005 Mar [cited 2023 Dec 11];26(3):312–5. Available from: https://pubmed.ncbi.nlm.nih.gov/15796286/
172. Magadze TA, Nkhwashu TE, Moloko SM, Chetty D. The impediments of implementing infection prevention control in public hospitals: Nurses' perspectives. Health SA Gesondheid [Internet]. 2022 [cited 2023 Dec 8];27. Available from: /pmc/articles/PMC9724072/
173. Alemie GA. Exploration of healthcare workers' perceptions on occupational risk of HIV transmission at the University of Gondar Hospital, Northwest Ethiopia. BMC Res Notes [Internet]. 2012 Dec 29 [cited 2023 Dec 8];5(1):1–4. Available from: https://link.springer.com/articles/10.1186/1756-0500-5-704
174. Agreli H, Barry F, Burton A, Creedon S, Drennan J, Gould D, et al. Ethnographic study using Normalization Process Theory to understand the implementation process of infection prevention and control guidelines in Ireland. [cited 2023 Dec 11]; Available from: http://bmjopen.bmj.com/
175. Potthoff S, Kwasnicka D, Avery L, Finch T, Gardner B, Hankonen N, et al. Changing healthcare professionals' non-reflective processes to improve the quality of care. Soc Sci Med. 2022 Apr 1;298:114840.
176. Potthoff S, Rasul O, Sniehotta FF, Marques M, Beyer F, Thomson R, et al. The relationship between habit and healthcare professional behaviour in clinical practice: a systematic review and meta-analysis. Health Psychol Rev [Internet]. 2019 Jan 2 [cited 2024 Sep 18];13(1):73–90. Available from: https://www.tandfonline.com/doi/abs/10.1080/17437199.2018.1547119
177. Abduljawad AA. Impact of Accreditation on Improvement of Hospital's Infection Control Programs Quality and Safety in Saudi Arabian Hospitals. Journal of Research in Medical and Dental Science | [Internet]. 2022 [cited 2023 Dec 19];10(9):14–9. Available from: www.jrmds.in

178. Hussein M, Pavlova M, Ghalwash M, Groot W. The impact of hospital accreditation on the quality of healthcare: a systematic literature review. BMC Health Serv Res [Internet]. 2021 Dec 1 [cited 2023 Dec 19];21(1). Available from: https://pubmed.ncbi.nlm.nih.gov/34610823/
179. Houben F, van Hensbergen M, Den Heijer CDJ, Dukers-Muijrers NHTM, Hoebe CJPA. Barriers and facilitators to infection prevention and control in Dutch residential care facilities for people with intellectual and developmental disabilities: A theory-informed qualitative study. PLoS One [Internet]. 2021 Oct 1 [cited 2023 Dec 11];16(10). Available from: /pmc/articles/PMC8555856/
180. Houghton C, Meskell P, Delaney H, Smalle M, Glenton C, Booth A, et al. Barriers and facilitators to healthcare workers' adherence with infection prevention and control (IPC) guidelines for respiratory infectious diseases: A rapid qualitative evidence synthesis. Cochrane Database of Systematic Reviews. 2020;4:1–55.
181. Buregyeya E, Nuwaha F, Verver S, Criel B, Colebunders R, Wanyenze R, et al. Implementation of tuberculosis infection control in health facilities in Mukono and Wakiso districts, Uganda. BMC Infect Dis [Internet]. 2013 Aug 1 [cited 2023 Dec 11];13(1):1–9. Available from: https://bmcinfectdis.biomedcentral.com/articles/10.1186/1471-2334-13-360
182. Ajzen I. The theory of planned behavior: Frequently asked questions. Hum Behav Emerg Technol [Internet]. 2020 Oct 1 [cited 2024 Sep 18];2(4):314–24. Available from: https://onlinelibrary.wiley.com/doi/full/10.1002/hbe2.195
183. Godin G, Naccache H, Morel S, Ébacher MF. Determinants of nurses' adherence to Universal Precautions for venipunctures. Am J Infect Control. 2000 Oct 1;28(5):359–64.
184. Maue SK, Segal R, Kimberlin CL, Lipowski EE. Predicting physician guideline compliance: an assessment of motivators and perceived barriers. Am J Manag Care. 2004;10(6):383–91.
185. Ward D. Gender differences in compliance with infection control precautions. British Journal of Infection Control. 2004 Feb;5(1):17–9.
186. Baqi S, Albalbeesi A, Iftikhar S, Baig-Ansari N, Alanazi M, Alanazi A. Perceptions of gender equality, work environment, support and social issues for women doctors at a university hospital in Riyadh, Kingdom of Saudi Arabia. PLoS One [Internet]. 2017 Oct 1 [cited 2024 Jan 31];12(10). Available from: /pmc/articles/PMC5658081/

187. Habib S, Khan MA, Hamadneh NN. Gender Sensitivity in Accessing Healthcare Services: Evidence from Saudi Arabia. Sustainability 2022, Vol 14, Page 14690 [Internet]. 2022 Nov 8 [cited 2024 Jan 31];14(22):14690. Available from: https://www.mdpi.com/2071-1050/14/22/14690/htm
188. Alhassan S, Al Doghan MA. Gender Differences in Leadership: Role of Gender Diversity, Leadership Style, Cultural Influence and Leadership Behavior. . Croatian International Relations Review. 2022;28(90):332–47.
189. Franczak J, Margolis J. Women and great places to work: Gender diversity in leadership and how to get there. Organ Dyn. 2022 Oct 1;51(4):100913.
190. De Paola M, Gioia F, Scoppa V. Female leadership: Effectiveness and perception. J Econ Behav Organ. 2022 Sep 1;201:134–62.
191. Gould DJ, Hale R, Waters E, Allen D. Promoting health workers' ownership of infection prevention and control: using Normalization Process Theory as an interpretive framework. Journal of Hospital Infection. 2016 Dec 1;94(4):373–80.
192. May C, Sibley A, Hunt K. The nursing work of hospital-based clinical practice guideline implementation: An explanatory systematic review using Normalisation Process Theory. Int J Nurs Stud. 2014 Feb 1;51(2):289–99.
193. Ploeg J, Davies B, Edwards N, Gifford W, Miller PE. Factors Influencing Best-Practice Guideline Implementation: Lessons Learned from Administrators, Nursing Staff, and Project Leaders. Worldviews Evid Based Nurs [Internet]. 2007 Dec 1 [cited 2024 Sep 24];4(4):210–9. Available from: https://onlinelibrary.wiley.com/doi/full/10.1111/j.1741-6787.2007.00106.x
194. Smith JD, Corace KM, MacDonald TK, Fabrigar LR, Saedi A, Chaplin A, et al. Application of the Theoretical Domains Framework to identify factors that influence hand hygiene compliance in long-term care. J Hosp Infect [Internet]. 2019 Apr 1 [cited 2024 Sep 24];101(4):393–8. Available from: https://pubmed.ncbi.nlm.nih.gov/30594611/
195. Greene C, Wilson J. The use of behaviour change theory for infection prevention and control practices in healthcare settings: A scoping review. J Infect Prev [Internet]. 2022 May 1 [cited 2024 Sep 24];23(3):108–17. Available from: https://journals.sagepub.com/doi/full/10.1177/17571774211066779
196. Chapman HJ, Veras-Estévez BA, Pomeranz JL, Pérez-Then EN, Marcelino B, Lauzardo M. Perceived Barriers to Adherence to Tuberculosis Infection Control Measures among Health Care Workers in the Dominican Republic. MEDICC Rev. 2017;19(1):16–22.

197. Kang JH, Kim EJ, Choi JH, Hong HK, Han SH, Choi IS, et al. Difficulties in using personal protective equipment: Training experiences with the 2015 outbreak of Middle East respiratory syndrome in Korea. Am J Infect Control [Internet]. 2018 Feb 1 [cited 2023 Dec 12];46(2):235–7. Available from: https://pubmed.ncbi.nlm.nih.gov/29050907/
198. Zimba MM, Dorothy CO, Mulubwa C, Ngoma-Hazemba A. Infection Prevention and Control practices; an exploratory qualitative study of experiences of health care providers and support staff at the University Teaching Hospital, Lusaka, Zambia. [cited 2023 Dec 12]; Available from: https://doi.org/10.1101/2022.03.23.22269760
199. Bahtsevani C, Willman A, Stoltz P, Östman M. Experiences of the implementation of clinical practice guidelines - interviews with nurse managers and nurses in hospital care. Scand J Caring Sci. 2010 Sep;24(3):514–22.
200. Graham ID, Logan J, Davies B, Nimrod C. Changing the Use of Electronic Fetal Monitoring and Labor Support: A Case Study of Barriers and Facilitators. Birth [Internet]. 2004 Dec 1 [cited 2024 Sep 24];31(4):293–301. Available from: https://onlinelibrary.wiley.com/doi/full/10.1111/j.0730-7659.2004.00322.x
201. Bahegwa RP, Hussein AK, Kishimba R, Hokororo J, German C, Ngowi R, et al. Factors affecting compliance with infection prevention and control standard precautions among healthcare workers in Songwe region, Tanzania. Infection Prevention in Practice [Internet]. 2022 Dec 1 [cited 2023 Dec 19];4(4):100236. Available from: /pmc/articles/PMC9424571/
202. Bartzokas CA, Slade PD. Motivation to comply with infection control procedures. J Hosp Infect [Internet]. 1991 [cited 2023 Dec 19];18 Suppl A(SUPPL. A):508–14. Available from: https://pubmed.ncbi.nlm.nih.gov/1679824/
203. Wang L, Zhang D, Liu J, Tang Y, Zhou Q, Lai X, et al. The mediating role of incentives in association between leadership attention and self-perceived continuous improvement in infection prevention and control among medical staff: A cross-sectional survey. Front Public Health. 2023 Feb 9;11:984847.
204. Rosenman R, Tennekoon V, Hill LG. Measuring bias in self-reported data. Int J Behav Healthc Res. 2011;2(4):320.
205. Bredin D, O'Doherty D, Hannigan A, Kingston L. Hand hygiene compliance by direct observation in physicians and nurses: a systematic review and meta-analysis. Journal of Hospital Infection. 2022 Dec 1;130:20–33.

206. Nemenqani DM, Tekian A, Park YS. Competency assessment in laboratory medicine: Standardization and utility for technical staff assessment and recertification in Saudi Arabia. Med Teach. 2017 Mar 16;39:S63–74.
207. University of Wisconsin-Madison [Internet]. 2009 [cited 2024 Sep 24]. Changing Public Behavior. Behavior Change Theories and Techniques. Available from: https://fyi.extension.wisc.edu/wateroutreach/files/2016/04/CPB-Behavior-Change-TheoriesTechniques8.pdf
208. Michie S, van Stralen MM, West R. The behaviour change wheel: A new method for characterising and designing behaviour change interventions. Implementation Science [Internet]. 2011 Apr 23 [cited 2024 Sep 24];6(1):1–12. Available from: https://implementationscience.biomedcentral.com/articles/10.1186/1748-5908-6-42
209. Greene C, Wilson J. The use of behaviour change theory for infection prevention and control practices in healthcare settings: A scoping review. J Infect Prev [Internet]. 2022 May 1 [cited 2024 Sep 24];23(3):108–17. Available from: https://journals.sagepub.com/doi/full/10.1177/17571774211066779

Appendices

Appendix A: JBI Critical Appraisal Checklist for Cross-sectional Studies

	Yes	No	Unclear	Not applicable
1. Were the criteria for inclusion in the sample clearly defined?	☐	☐	☐	☐
2. Were the study subjects and the setting described in detail?	☐	☐	☐	☐
3. Was the exposure measured in a valid and reliable way?	☐	☐	☐	☐
4. Were objective, standard criteria used for measurement of the condition?	☐	☐	☐	☐
5. Were confounding factors identified?	☐	☐	☐	☐
6. Were strategies to deal with confounding factors stated?	☐	☐	☐	☐
7. Were the outcomes measured in a valid and reliable way?	☐	☐	☐	☐
8. Was appropriate statistical analysis used?	☐	☐	☐	☐

Overall appraisal: Include ☐ Exclude ☐ Seek further info ☐

Appendix B: JBI Critical Appraisal Checklist for Qualitative Research

	Yes	No	Unclear	Not applicable
1. Is there congruity between the stated philosophical perspective and the research methodology?	☐	☐	☐	☐
2. Is there congruity between the research methodology and the research question or objectives?	☐	☐	☐	☐
3. Is there congruity between the research methodology and the methods used to collect data?	☐	☐	☐	☐
4. Is there congruity between the research methodology and the representation and analysis of data?	☐	☐	☐	☐
5. Is there congruity between the research methodology and the interpretation of results?	☐	☐	☐	☐
6. Is there a statement locating the researcher culturally or theoretically?	☐	☐	☐	☐
7. Is the influence of the researcher on the research, and vice- versa, addressed?	☐	☐	☐	☐
8. Are participants, and their voices, adequately represented?	☐	☐	☐	☐
9. Is the research ethical according to current criteria or, for recent studies, and is there evidence of ethical approval by an appropriate body?	☐	☐	☐	☐
10. Do the conclusions drawn in the research report flow from the analysis, or interpretation, of the data?	☐	☐	☐	☐

Overall appraisal: Include ☐ Exclude ☐ Seek further info ☐

Appendix C The questionnaires-English version

Questionnaires:

This survey is designed to help better understand the implementation, knowledge, attitude and practice ofinfection prevention and control (IPC) guidelines among laboratory staff in Saudi Arabian hospitals.

For this survey, please answer all the statements from the perspective of this role. Depending on your role or responsibilities in the IPC guidelines, some statements may be more relevant than others.

1- Sociodemographic characteristics:

1. Gender: ☐ Male ☐ Female

2. Age: ☐ Years

3. Nationality:

☐ Saudi ☐ Arab- Non-Saudi, please specify: ☐

☐ Filipino ☐ Indian ☐ Pakistani

☐ Bangladesh ☐ South African ☐ European

☐ North American ☐ Other, please specify: ☐

4. Highest level of education:

☐ Elementary ☐ Intermediate ☐ Secondary ☐ Diploma

☐ Bachelor ☐ Master ☐ PhD

☐ Other, please specify: ☐

5. Years of experience in healthcare institutions: ☐ Year/Years

6. Current location of Practice:

☐ King Abdulaziz Medical City- Jeddah

☐ King Fahad Specialists Hospital- Qassim

☐ Hayat National Hospital- Qassim

7. Occupation:

☐ Laboratory specialist ☐ Laboratory technician ☐ Admin

☐ Infection control specialist ☐ Nurse ☐ Phlebotomist

☐ Other, please specify: ______

8. Specialty: please specify: ______

9. Position or skill level: please specify: ______

10. Have you received training on IPC guidelines and laboratory safety?

☐ Yes ☐ No

If yes, are they:

☐ On the job training ☐ formal mandatory training ☐ Both

What type of training you have attended?

☐ National training ☐ Generic local induction health and safety training

Any specific training:

☐ biological hazard groups ☐ personal protective equipment

☐ risk assessment training ☐ sharps training

☐ decontamination training ☐ spillage training

☐ Post exposure prophylaxis. ☐ Other, please specify: ______

Is there any process of competence assessment for health and safety in your laboratory?

☐ Yes ☐ No

If yes, is this reviewed and re-assessed annually?

☐ Yes ☐ No

11. When you joined your workplace did your employer undertake a pre-employment health assessment which reviewed your previous immunization records?

☐ Yes ☐ No

Have you been offered vaccination(s) as part of your workplace occupational health policy?

☐ Yes ☐ No

If you have been offered workplace occupational health vaccination(s), did you take the vaccinations?

☐ Yes ☐ No

Please specify which vaccines you have received as part of occupational health vaccination (tick all that apply)

☐ Completed three doses of Hepatitis B vaccine. ☐ Influenza vaccine.

☐ Two doses of MMR vaccine. ☐ Meningococcal vaccine. ☐ Rabies vaccine.

☐ Tetanus, diphtheria (Td). ☐ Hepatitis A vaccine.

☐ Tetanus-Diphtheria Acellular Pertussis (Tdap). ☐ Typhoid vaccine.

☐ BCG vaccine (TB). ☐ Varicella vaccine. ☐ Polio vaccine.

☐ Cholera vaccine.

12. Have you been exposed to any injury while working in the laboratory?

☐ Yes ☐ No

If yes, through which of the following you have been exposed?

☐ To a needle stick. ☐ To a sharp instrument ☐ Other, please specify: ______

To what of the following have you been exposed?

☐ To blood. ☐ To other body fluids.

☐ To body tissues. ☐ To body secretions.

Did you take post-exposure prophylaxis following the exposure?

☐ Yes ☐ No

2- Participants' awareness and knowledge of the infection prevention and control (IPC) guidelines:

1. Do you think you have information about infection prevention and control guidelines such as clear policies, guidelines and standard operating procedures?

☐ Yes, enough ☐ Yes, but not enough ☐

2. If you have some knowledge about the IPC guidelines, what is the source of this information? (you can choose more than one answer) otherwise move to question 3 on this page:

☐ TV/Radio ☐ Newspaper/Magazine ☐ Internet ☐ Colleagues

☐ Education ☐ Families ☐ Hospital/laboratory standard operating procedures

☐ Hospital/laboratory policies ☐ Occupational training courses

☐ National guidelines, please specify: ________

☐ International guidelines, please specify: ________

☐ Other, please specify: ________

3. IPC guidelines should apply to situations that might lead to contact with blood.

☐ True ☐ False ☐ I don't know

4. IPC guidelines are not necessary for situations that might lead to contact with saliva.

☐ True ☐ False ☐ I don't know

5. IPC guidelines are not applied to patients with HIV and hepatitis only.

☐ True ☐ False ☐ I don't know

6. IPC guidelines should not apply to situations that might lead to contact with urine or feces.

☐ True ☐ False ☐ I don't know

7. IPC guidelines should be applied to all persons regardless of their infectious status.

☐ True ☐ False ☐ I don't know

8. For decontamination of equipment and devices, washing with the usual detergent is enough.

☐ True ☐ False ☐ I don't know

9. Blood spills should be cleaned up promptly with the hospital-approved disinfectant.

☐ True ☐ False ☐ I don't know

10. A face mask should be worn for all procedures where blood and body fluids may splash.

☐ True ☐ False ☐ I don't know

11. Gloves should be worn for all procedures that may involve contact with blood and body fluids.

☐ True ☐ False ☐ I don't know

12. Eye protection should be worn for all procedures where blood and body fluids may splash.

☐ True ☐ False ☐ I don't know

13. Hands should always be washed after gloves are removed.

☐ True ☐ False ☐ I don't know

14. Used needles and sharp instruments should be disposed of separately from other waste.

☐ True ☐ False ☐ I don't know

15. Used needles should not be recapped.

☐ True ☐ False ☐ I don't know

16. First aid measure that should be applied immediately following needle stick injury is:

☐ Wash thoroughly with soap and water ☐ Bandage appropriately

☐ I don't know

17. Mucocutaneous and non-intact skin exposures should be irrigated with water or appropriate eyewash.

☐ True ☐ False ☐ I don't know

18. After applying the first aid, the line manager or supervisor should be informed.

☐ True ☐ False ☐ I don't know

3- Participants' attitude to the IPC guidelines:

1. The IPC guidelines are useful in protecting against hazards in the workplace.

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐ I don't know

2. Healthcare workers must be aware of all the IPC guidelines applicable to their work.

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐ I don't know

3. Staff should take immunisation against HBV.

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐ I don't know

4. Do you think staff cannot eat and drink and use a mobile phone in the laboratory?

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐ I don't know

5. Do you think staff cannot store food and water in the refrigerator for body fluids, drugs, chemicals or other specimens?

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐ I don't know

6. Do you think staff cannot apply cosmetics and smoke in the laboratory?

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐ I don't know

7. Do you think staff should wear protective equipment to limit touching their face/nose/ear during work?

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐ I don't know

8. Do you think staff cannot pipet with their mouth?

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐ I don't know

9. Do you believe that employers should always provide training on IPC guidelines?

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐ I don't know

10. Do you believe that proper disinfection of all materials such as bench surfaces, spill procedures or autoclaving of waste is an essential measure for prevention and protection from disease transmission in the laboratory?

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐ I don't know

11. Do you believe it is essential to take post-exposure prophylaxis after exposure to HIV or HBV infections?

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐ I don't know

4- Participants' practice of the IPC guidelines:

1. I dispose of all blood-contaminated items into the bag or bucket designated for disposal.

☐ Always ☐ Often ☐ Sometimes ☐ Never ☐ Not relevant to my role

2. I wear gloves when I am exposed to body fluids or blood products.

☐ Always ☐ Often ☐ Sometimes ☐ Never ☐ Not relevant to my role

3. I cover my wound(s) or lesion(s) that might come in contact with patients' blood and other body fluids with plaster or bandage before coming to work.

☐ Always ☐ Often ☐ Sometimes ☐ Never ☐ Not relevant to my role

4. I wash my hands immediately after the removal of disposable gloves.

☐ Always ☐ Often ☐ Sometimes ☐ Never ☐ Not relevant to my role

5. I change gloves when they are damaged.

☐ Always ☐ Often ☐ Sometimes ☐ Never ☐ Not relevant to my role

6. I decontaminate surfaces and devices after use.

☐ Always ☐ Often ☐ Sometimes ☐ Never ☐ Not relevant to my role

7. I wear a disposable facemask whenever there is a possibility of blood or other body fluids splashing in my face.

☐ Always ☐ Often ☐ Sometimes ☐ Never ☐ Not relevant to my role

8. I wear a laboratory coat whenever there is a possibility of blood or other body fluids splashing on my clothes.

☐ Always ☐ Often ☐ Sometimes ☐ Never ☐ Not relevant to my role

9. I do not recap needles after use.

☐ Always ☐ Often ☐ Sometimes ☐ Never ☐ Not relevant to my role

10. I wear eye protection (goggles/glasses) whenever there is a possibility of blood or other body fluids splashing in my face.

☐ Always ☐ Often ☐ Sometimes ☐ Never ☐ Not relevant to my role

11. I take extra care when using scalpels, needles, razors, or other sharp objects.

☐ Always ☐ Often ☐ Sometimes ☐ Never ☐ Not relevant to my role

12. I report injuries and spills accidents.

☐ Always ☐ Often ☐ Sometimes ☐ Never ☐ Not relevant to my role

Often: More than 50% of my work time.
Sometimes: Less than 50% of my work time.

5- Participants' perception regarding the implementation of the IPC guidelines:

1. Staff in this organisation have the same understanding of the purpose of the IPC guidelines.

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐ I don't know

2. I can see the potential value of the IPC guidelines for my work.

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐ I don't know

3. There are key people who drive the IPC guidelines forward and get others involved.

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐ I don't know

4. I believe that participating in the IPC guidelines is a legitimate part of my role.

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐ I don't know

5. I will continue to support the IPC guidelines.

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐ I don't know

6. The IPC guidelines disrupt working relationships.

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐ I don't know

7. Sufficient training is provided to enable staff to implement the IPC guidelines.

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐ I don't know

8. Sufficient resources and necessary equipment are available to support the IPC guidelines.

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐ I don't know

9. Management adequately supports the IPC guidelines.

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐ I don't know

10. Feedback about the IPC guidelines can be used to improve it in the future.

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐ I don't know

11. I can modify how I work with the IPC guidelines.

☐ Strongly agree ☐ Agree ☐ Neutral ☐ Disagree ☐ Strongly disagree ☐ I don't know

Appendix D The study information document and consent form

Participant's information sheet

<u>Knowledge, attitude and practice of health and safety guidelines among laboratory staff in Saudi Arabia.</u>

Dear staff

I invite you to participate in my study, part of doctoral research at Population Health Sciences Institute, Newcastle University. Before you decide whether to participate or not, I would like you to understand my research objectives. Please take your time to read the information sheet carefully and feel free to read it more than once.

If you have any comments, questions, or concerns, do not hesitate to contact me. My details appear at the bottom.

The aim and objectives of the study

The study aims to explore the implementation of the IPC programme from the laboratory staff's viewpoint and to assess their knowledge, attitude and practice of recommended infection control guidelines and biosafety measures. Specifically, this study aims to:
To assess laboratory staff, allied health professionals and infection control specialists' knowledge, attitude and practice of IPC/biosafety guidelines in KSA hospitals.
- To examine to what extent laboratory staff, allied health professionals and infection control specialists comply with IPC/biosafety guidelines in KSA hospitals.
- To examine the relationship between knowledge, attitude and practice (compliance with IPC guidelines) and staff personal characteristics (i.e., age, gender, education, training, years of experience, etc.).
- To determine the laboratory staff, allied health professionals, and infection control specialists' opinions of the implementation of the IPC/biosafety guidelines and their association with staff personal characteristics (i.e., age, gender, education, training, years of experience, etc.).
- To assess the relationship between knowledge of risk perception and staff practice.
- To determine whether relevant facilities meet the laboratory requirements (supplies, equipment, etc.).
- To determine the factors that hindered and/or facilitate the successful implementation of the IPC/biosafety guidelines.

Do I have to take part?

Your participation in the study is entirely voluntary. Therefore, you should not feel under any pressure to participate in this research, and whether you choose to take part or not, this will not affect your work in any way.

If you decide to take part, you will be given this information sheet to keep, and you will be asked to sign a consent form. You are still free to withdraw your data or request that it be destroyed at any time, even after signing the consent form and even after completing the study. You do not need to give a reason if you decide to withdraw.

Overview of the study

If you are willing, we will invite you to participate in either a questionnaire or an interview to explore the implementation of and your adherence and compliance with the IPC guidelines. This questionnaire consists of five parts in total. You will also be asked some demographic information. All questionnaires should take about 15-20 minutes to complete. The interview will take 30-45 minutes, and if required, I will interview you through Zoom.
You will be asked to provide your contact information (including your email address). This is voluntary.

Will taking part in the study cost me anything?

No. The study will only involve your time. To reimburse you for your time you will be entered into a prize draw to win one of four 100 SR amazon vouchers, and 50 SR amazon vouchers for each interviewed participant.

What will happen to the information?

All the information from the questionnaires and interviews will be confidential. The collected data will be anonymised and kept confidential. Therefore, no one will be able to identify you from the study. The data will be put into a computer with a username and password, which no one will access apart from the researcher. At the end of the study, all the manuscripts, the notes taken by the researcher and the tapes will be kept safely, and only the researcher can access them. All data will be treated under the current Data Protection Act. The data will be stored on "One Drive" (UoD official cloud storage) for about ten years.

What will happen to the results of the study?

Upon completion of this research, your data will be anonymised. From that time, there will be no record that links the data collected from you with any personal data from which you could be identified (e.g., your name, address, email, etc.). Until the point at which your data have been anonymised, you can decide not to consent to have your data included in further analyses.
The fully anonymised data from this research may be put into a research repository so that it is available to be used by researchers who are also interested in this topic. You will not be personally identifiable from this data.

The findings of this research will be analysed and written into a report. There is a possibility that findings will be submitted for publication in a scientific journal and presented at a conference. You will not be identified in any publication or presentation. If this paper is approved for publication in a journal, this will be made available to you.

Please feel free to contact me if you have any questions, concerns or queries before, during or following your participation.

Thank you.

Haifa Aldhamy, PhD student, Population Health Sciences Institute, Newcastle University.

h.o.s.aldhamy2@newcastle.as.uk.

Thank you for taking the time to read this information sheet. We are very grateful for your participation in this study.

Consent form:

Please read the statements below carefully before clicking agree to consent:

1. I confirm that I have read and understood the Participant Information Sheet.
2. I understand that my participation is voluntary and that I am free to withdraw at any time without giving a reason.
3. I confirm that any questions about my participation in the study have been answered satisfactorily.
4. I am aware that a written debrief will appear at the end of this study.
5. I am aware of and accept the potential risks of taking part in this research.
6. I confirm that I am taking part in this research study voluntarily (without coercion).
7. I understand that only my anonymised data may be shared in public research repositories.
8. I agree to take part in phase one of this study
   - I agree
   - I disagree

Appendix E In-depth interview topic guide

<u>Interview topic guide:</u>

Sociodemographic questions:

1- What is your age, and gender?

2- Describe your work experience.

3- What is your profession? what are the roles and responsibilities of your job?

Respondent's perspectives about laboratory-associated infections:

1- Do you think laboratory-associated infections are a problem in your hospital/laboratory? Can you explain?

2- Is there any team/group of staff who responsible about management of laboratory-associated infections in hospital /laboratory? If yes, what do they do? Do they meet regularly to review and discuss health and safety?

3- Are there any hospital standards (i.e. policy or guidelines), and national standards related to laboratory-associated infections that you are aware of?

Implementation of the IPC guidelines:

Coherence type questions

1- Who is responsible about implementing and applying IPC guidelines in the hospital including the lab?

1- What do you know about the IPC guidelines?

2- What do you understand as the purpose of the IPC guidelines? Why do you think the guidelines have been implemented?

3- I think a lot of your daily work involves the prevention and control of infections - do you feel the IPC guidelines are appropriate for your work?

Cognitive Participation type questions

1- Do you think that access to resources and information to support the implementation of IPC guidelines is available for staff? If so, can you give some examples.

2- How do the different professionals on the laboratory use the guidelines? Do people engage differently with the guidelines depending on their profession / role? why?

3- From your perspective, what would help staff to engage better with the IPC guidelines?

4- Do you discuss about your experiences in using the IPC guidelines with you colleagues in the department or different health organisations? What have their experiences been? Do you feel that they are different or similar to yours? Why?

Collective Action type questions

1- Please explain how the guidelines helps/hinders working with others

2- How do the IPC guidelines affect you and others around you?

Reflexive monitoring

1- Would you say the IPC guidelines are useful or not? Explain

2- What do others think about it?

3- Has the use of IPC guidelines altered the way you work/think about laboratory-associated infections?

4- To what extent do you and/or others have the ability to provide feedback / influence improvements to the IPC guidelines? What helps or hinders this ability?

5- Would you change anything about the IPC guidelines?

Understanding barriers of adherence to the infection prevention and control guidelines:

1- Do staff ever seem reluctant to follow the IPC guidelines? [if yes], what have they said? What have their reasons been?

2- If any, what barriers are there to you complying with implementing the IPC guidelines?
- Personal barriers?
- Organisational barriers?

3- Do you have any ideas for improving compliance with the IPC guidelines?

Is there anything more you would like to add?

Thank you for your time

Appendix F In-depth interview topic guide (Infection Control Specialists)

<u>Interview topic guide:</u>

Sociodemographic questions:

1- What is your age, and gender?

2- Describe your work experience.

3- What is your profession? what are the roles and responsibilities of your job?

Implementation of the IPC guidelines:

Coherence type questions

1- Who is responsible about implementing and applying IPC guidelines in the hospital including the lab?

2- What do you know about the IPC guidelines?

3- What do you understand as the purpose of the IPC guidelines? Why do you think the guidelines have been implemented?

Cognitive Participation type questions

1- Do you think that access to resources and information to support the implementation of IPC guidelines is available for staff? If so, can you give some examples.

2- How do the different professionals on the laboratory use the guidelines? Do people engage differently with the guidelines depending on their profession / role? why?

3- From your perspective, what would help staff to engage better with the IPC guidelines?

4- Do you discuss about your experiences in using the IPC guidelines with you colleagues in the department or different health organisations? What have their experiences been? Do you feel that they are different or similar to yours? Why?

Collective Action type questions

1- Please explain how the guidelines helps/hinders working with others

2- How do the IPC guidelines affect you and others around you?

Reflexive monitoring

1- Would you say the IPC guidelines are useful or not? Explain

2- What do others think about it?

3- Would you change anything about the IPC guidelines?

Understanding barriers of adherence to the infection prevention and control guidelines:

1- Do staff ever seem reluctant to follow the IPC guidelines? [if yes], what have they said? What have their reasons been?

2- If any, what barriers are there to you complying with implementing the IPC guidelines?
- Personal barriers?
- Organisational barriers?

3- Do you have any ideas for improving compliance with the IPC guidelines?

Is there anything more you would like to add?

Thank you for your time

Appendix G Newcastle University ethical approval

22/03/2021

Policy & Information Team, Newcastle University

Dear Haifa,

Title: Knowledge, attitude and practice of infection prevention and control precautions among laboratory staff in Saudi Arabia.
Ref: 9143/2020
Lead Investigator: Haifa Omar S Aldhamy
Expected to run from 15/08/2021 to 10/02/2023

The University Ethics Committee grants its approval for you to start working on your project. Please be aware that if you make any significant changes to your proposal then you should complete this form again, as further review may be required.
This confirmation may be used within a research portfolio as evidence of ethical approval.
Please note: this confirmation will be the only correspondence you should expect to receive as evidence of ethical approval.
There will be no other confirmation provided. You may now proceed with research. If you have any queries, please review the internal and external ethics FAQ pages before contacting res.policy@ncl.ac.uk.

Best wishes,

Research, Policy, Intelligence and Ethics Team,
Newcastle University Research Office

Appendix H King Abdulaziz Medical City ethical approval

جامعة الملك سعود بن عبدالعزيز للعلوم الصحية
King Saud bin Abdulaziz University for Health Sciences

King Abdullah International Medical Research Center (KAIMRC)

Direct: 012-224-6657
Internal – 84-46657
6123
Via email: KAIMRC-WR-RO@ngha.med.sa
Via ECTS: KAIMRC-WR-RO@ngha.med.sa

MEMORANDUM

Research Office, KAIMRC, W.R.
Ref No # roj-data/om/2021/rc/264

DATE: (G) 20th July 2021
(H) 10th D. Hijjah 1442

TO: **Dr. Majed S. Althaqafy**
Consultant, Public Health & Epidemiology, KAMC
Assistant Professor, Preventive Medicine, KSAU-HS
Ministry of National Guard for Health Affairs
Western Region

FROM: **Dr. Alqassem Hakami**
Head, Research Office, KAIMRC, WR
Assistant Dean, Academic Affairs, COM, KSAU-HS
Ministry of National Guard for Health Affairs
Western Region

SUBJECT: **SP21J/335/06 – Knowledge, Attitude and Practice of Infection Prevention and Control Precautions among Laboratory Staff in Saudi Arabia**

This is in reference to the above mentioned research project of Ms. Haifa Omar Aldhamy, PhD Student from Newcastle University, United Kingdom, received in this office for consideration and approval.

As acting Principal Investigator of this project and upon support and recommendation from her University Supervisor, please note that the Research Office, KAIMRC, W.R. hereby supported and granted scientific approval for this study.

This proposal will be forwarded to Institutional Review Board (IRB) for evaluation of ethical content and kindly note that acceptance by this committee does not constitute final approval and that the study should not start without the approval from the IRB.

For the purpose of audit, our office will contact you from time to time to ascertain the status of your study and we do hope in due course to be informed of the progress and final outcome of the project.

Best wishes for the successful completion of your study.

Kind regards.

cc: Prof. A. Al Sayarri, Chairman, Institutional Review Board, KAIMRC, MNG-HA

ص.ب. ٣٦٦٠ الرياض ١١٤٨١ هاتف: ٤٢٩٩٩٩٩ ١١ ٩٦٦
P.O. Box 3660 Riyadh 11481 Tel . 966 11 429 9999
www.ksau-hs.edu.sa

Appendix I King Fahad Specialist Hospital ethical approval

KINGDOM OF SAUDI ARABIA
MINISTRY OF HEALTH
GENERAL DIRECTORATE OF HEALTH AFFAIRS
AL-QASSEM REGION

وزارة الصحة
Ministry Of Health

المملكة العربية السعودية
وزارة الصحة
المديرية العامة للشئون الصحية بمنطقة القصيم

الرقم : ١٤٤٢-٢١٥٧٨٢١ التاريخ : ٢/١٢/١٤٤٢ هـ المشفوعات :
الموضوع :

Monday, July 12, 2021

To:	**Haifa Omar Aldhamy,** Principal Investigator هيفاء الدهامي PhD Student, Population Health Sciences Institute, Newcastle University, UK.
Supervisor:	**Prof. Mark Pearce,** Professor of Applied Epidemiology, Population Health Sciences Institute, Newcastle University, UK.
Site Supervisor:	**Mr.Musaed Abdullah Al-Raqi'i,** Laboratory and Blood Bank Infection Control Coordinator, King Fahad Specialist Hospital (KFSH), Qassim, KSA
From:	**Regional Research Ethics Committee,** Registered at National Committee of Bio & Med. Ethics (NCBE) Registration No. H-04-Q-001
Research title:	**"Knowledge, attitude and practice of infection prevention and control precautions among laboratory staff in Saudi Arabia"**
Study Setting:	**KFSH, Buraydah, Qassim, KSA**
Study design:	**A cross-sectional study**
Revision type:	**☑ Expedited ☒ Exemption ☒ Full Board**

Decision: Approval, for: ☑Implementation ☒Publication

Dear P.I,
We are pleased to inform you that the local research ethics committee had approved your research proposal. Your efforts to meet the criteria requested by NCBE are highly appreciated

- **The General Directorate of Research at MOH Quarter office approval** has to be granted to the study PI **before** starting any field work.
- You should protect the confidentiality of participants data.
- Please, note that MOH regulations mandates registering all projects at its website, use this link to register: https://marifah.gov.sa
- This approval is for study implementation **ONLY**. In case of publication, kindly submit
- Kindly, update us on your project advancement every 6 months. On completion of your project, kindly send us a summary of the project final report.
- Finally, be aware that this approval embraces no financial, or any other, obligations or responsibilities on Saudi Ministry of Health or its health affiliates.

Note: Any corrections and/or alterations of this certificate will make it invalid.

For queries, please call Dr. Amel Sulaiman at telephone No. 00966163693429 ext. 105, and e-mail: irb-qassim@moh.gov.sa or qassim_ethcom@yahoo.com
Best regards,

Dr. Abdullah M. Al Saigul
Chairman, Regional Research Ethics Committee - Qassim Province
12-07-2021

Dr. Amel A. Suliman
Coordinator, Regional Research Ethics Committee - Qassim Province

www.qh.gov.sa
بريدة – ص.ب :٢٢٩٥ هاتف : ٣٢٣١٧١٨ – ٣٢٣٥٥٠٦ تلكس : ٣٠١٢٩٩ فاكس : ٣٢٣١١٥٨

١/٢