Knowledge, attitude and practice of infection prevention and control precautions among hospital laboratory staff: a mixed-methods systematic review

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Research Article

Keywords: Infection prevention and control guidelines, Laboratory safety, Hospital laboratory staff, Knowledge, Attitude, Practice

Posted Date: April 4th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1454572/v1

Abstract

Background

Clinical laboratories provide diagnostic testing services to support the effective delivery of care in today's complex healthcare systems. Processing clinical material and the use of chemicals or radiation presents potential hazard to laboratory workers, from both biological and chemical sources. Nevertheless, the laboratory should be a safe workplace if the identification of possible hazards, clear guidelines, safety rules and infection prevention and control (IPC) precautions are applied and followed. The main aim of this systematic review was to identify, critically appraise and synthesise the research evidence to gain a clear explanation of the implementation, knowledge, attitude and practice of infection prevention and control guidelines among hospital laboratory staff.

Methods

The review is based upon a narrative synthesis of quantitative, qualitative and mixed methods research papers that examine the implementation, knowledge, attitude and practice of infection prevention and control guidelines among hospital laboratory staff.

Results

After the full-text screening, a total of 34 articles remained and were included in the final review. The knowledge, attitude and practice of infection prevention and control, and biosafety guidelines were identified and grouped into several themes: awareness of IPC precautions; acceptability of IPC precautions; application of IPC precautions; perception of risk; exposure and post exposure prophylaxis; immunisation against infectious diseases; training and on infection prevention and control guidelines; associations between knowledge and practice; barriers and facilitators to poor practice and adherence.

Conclusion

There is a gap between knowledge, attitude and practice related to the implementation of infection prevention and control guidelines which indicate that hospital laboratory staff may be 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) of hospital laboratory staff to increase their knowledge about IPC precautions could improve their use of these precautions.

Background

Clinical laboratories provide diagnostic testing services to support the effective delivery of care in today's complex healthcare systems [1]. This includes microbiological, serological, biochemical, haematological, cytological, and pathological examinations of clinical specimens derived from patients for the purpose of affording information for the diagnosis, treatment or prevention of any disease. Around 70% of clinical decisions are based on information gathered from laboratory testing [2].

Processing clinical material and the use of chemicals or radiation presents potential hazard to laboratory workers, from both biological and chemical sources. Hospital Laboratory workers are at risk of exposure to biological hazards through a variety of routes such as: inhalation of aerosols); percutaneous inoculation (needlestick injuries and cuts from contaminated items); contact between contaminated materials (surfaces, hands) and mucous membranes; and through ingestion (smoking or eating, aspiration through a pipette) [3]. Laboratory acquired infection is of particular concern for pathogens such as hepatitis B and C viruses (HBV and HCV), human immunodeficiency viruses (HIV), Middle East Respiratory Syndrome (MERS-CoV) [4] and SARS-CoV-2 [49]. Moreover, the major source of most hepatitis and HIV infections among healthcare professionals is needle stick injury, which can occur during all the stages of needle use procedures [5]. Occupational risk and illnesses may occur due to incorrect practices, failure of the procedures to correctly eliminate or control the risk, poor communication about high-risk patients, lack of compliance, inexperience, ignorance and failure to follow recognised procedures and guidelines. However, the laboratory can be a safe workplace if the identification of possible hazards, clear guidelines, safety rules and infection prevention and control (IPC) precautions are applied and followed [6].

Implementing infection prevention and control guidelines provides a practical, evidence-based approach to prevent both patients and health workers from being harmed by avoidable infection and possible hazards. It comprises a set of recommendations created to minimise and prevent harm to healthcare workers and patients induced by exposure to infectious agents [9]. The IPC programme includes standard and transmission-based precautions that all laboratory and other healthcare workers must familiarise themselves with. These precautions involve practices of hand hygiene, the use of personal protective equipment (PPE) (gloves, gowns, masks, plastic aprons, face shields and protective eyewear), the safe use and disposal of sharps, routine environmental cleaning and waste management [10].

It should be clarified that in the UK, infection prevention and control guidelines related more to the clinical work and the prevention of infection transmission on wards only, and the IPC team consists of specialist nursing and medical staff [7] While in the UK clinical laboratories and the other facilities where people may be exposed to biological agents, health and safety guidance are applied [8]. In other countries such as Kingdom of Saudi Arabia, the IPC guidelines are applied to the clinical laboratories in addition to the wards and the laboratory staff can be part of the IPC team as well.

Since the main purpose of completing this systematic review is to conduct a mixed method research among laboratory staff in the Kingdom of Saudi Arabia, and as mentioned above that the IPC guidelines are applied to the work in the laboratories there, the IPC guidelines terminology were applied to laboratory work in all the sections of this review.

To date, there is a lack of evidence about knowledge, attitudes and practice (KAP) with respect to all IPC precautions collectively among laboratory staff. Moreover, no reviews have been conducted on the assessment of knowledge, attitude and practice of IPC guidelines worldwide. The aim of this systematic

review was therefore to identify, critically appraise and synthesise the research evidence to gain a clear explanation of the implementation, knowledge, attitude and practice of IPC guidelines among laboratory staff.

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

Methodology

Search strategy

This review aimed to identify studies that assess implementation, knowledge, attitude and practice of IPC guidelines among laboratory staff. To achieve this, a number of electronic databases were searched to locate the relevant studies using a combination of search terms. Databases searched include MEDLINE; EMBASE; Scopus; CINAHL (EBSCO). PubMed and grey literature were also searched. In addition, reference lists and citations of relevant documents identified from databases were searched to locate pertinent studies. No time limit was applying to the search as the aim of this review is to capture all articles existed. The last search of the articles was in November 2021.

Search performed using medical headings that cover the topic of interest which were then combined together by using the Boolean operator terms. 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 infection control practitioner OR allied health professionals OR laboratories OR hospital. The search strategy used in MEDLINE was modified for use on other databases searched.

An EndNote library (version X8) 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.

Screening

Figure.1 shows the number of included and excluded articles at each stage of review process. Rayyan Qatar Computing Research Institute (QCRI) (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 IM). Finally, decision of inclusion/exclusion was made by the reviewers and reasons for exclusion were recorded, and disagreement between reviewers was solved by discussion on each included and excluded paper.

Inclusion criteria

Studies eligible for inclusion are qualitative, quantitative, mixed-methods research that discuss risk perception, the knowledge, attitude and practice of IPC guidelines among laboratory staff in any healthcare setting including tertiary care sitting, primary care settings, long-term care, acute hospital settings or community settings. Studies that assessed awareness or compliance with specific infection control guidelines such as hand hygiene and waste disposal, and studies that cover occupational injuries such as sharp injuries were also included. Furthermore, studies that examined laboratory related infections and safety precautions associated with them and studies that focused on different vaccinations required for healthcare workers were included. Also, studies that cover infection control guidelines and safety measure policy and how they change over time in different countries were included. All published literature until November 2021 was included in this review. There were no restrictions on country of study. However, the included studies had to be published in English.

Exclusion Criteria

Cohort, case-control and randomised controlled trials were excluded from this review. This was because the identified studies did not address the questions and did not display data appropriate to the review question. Studies were excluded if they focused on healthcare workers, but did not include laboratory staff in the sample as participants, as well as studies on nurses and dental workers only. Studies in which data for laboratory staff could not be separated from the data gathered on other healthcare workers were excluded. Studies on students and university laboratories were excluded. Studies that assessed the effectiveness of interventions on the knowledge, attitude and practice of laboratory staff were excluded. Finally, general discussion papers such as letters, editorials and comments, conference abstracts and poster presentations were also excluded.

Data extraction

Data on studies that met the inclusion criteria were extracted by one reviewer (HA) and a standardised data extraction form was developed (Table.1).

Table.1

Data extraction form

The quality assessment exercise

As more than one type of research was included in this review, Joanna Briggs Institutes Critical Appraisal Tools (JBI-CAT) was the relevant option 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 the possibility of bias in its design, handling and analysis has been addressed in the study [3]. Two different checklists of JBI-CAT were employed based on the types of included studies (Appendix 1, 2). Two authors (HA and IM) contributed independently to appraisal 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 is YES (the item was mentioned in the study) and zero if the answer is NO or UNCLEAR (the item was not mentioned or was unclear). All studies (low and high quality) were included in the review, and the study quality would be used to inform the results and the conclusions made throughout. The quality assessment results are shown in (Table.2) and (Table.3).

Table.2

Quality assessment results (Cross-sectional studies)

Author/ Year	Main focus	Method	Country	Sample	Outcome measures	Results
[12] 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 refrigera-tor 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, puttingon of laboratory coats, immunization against hepati-tis B virus, washing of hands after removal of hand gloves and wearing of gloves.	All the participan wear gloves duri laboratory work. 20.8% of th participants had heard of it. 45.6% of the participants eat i laboratory, 47.0% them store foods water in the refrigerators mea for storage of bo fluids and chemicals, 31.5% them put on cosmetics in the laboratory, 91.5% not immunized against hepatitis virus (HBV). 82.0 the participants not feel that the of masks is necessary in laboratory 53.23 (n=82) of the participants had cuts or punc- tures from needle surgical blades, sharp device.
[13] Ibeziako and Ibekwe, 2007	Knowledge and practice of universal precaution	Cross-sectional study	Nigeria	246 participants (34 lab staff)	Knowledge and practice of infection control policy.	124 (50.4%) of th respondents were aware of univers precaution, while (35.8%) knew the correct definition universal precaut 34 (13.8%) had received training on universal precaution. Hands gloves we used by 86.6% of respondents and 43.9% practiced appropriate hand washing. Training significa associated with knowledge (P=0.006).
[14] Sadoh et al., 2006	Practice of Universal Precautions among Healthcare Workers	Cross-sectional study	Nigeria	433 participants (93 lab staff)	Practice of recapping and disposal of used needles, use of barrier equipment and handwashing.	About a third of a respondents alwa recapped used needles. Compliance with nonrecapping of used needles wa highest among trained nurses ar worst with docto 63.8% always us PPE. A high percentage (94.6 of participant observed handwashing aft handling patients

[15] Fadeyi et al, 2011	Awareness and practice of safety precautions among healthcare workers 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 wer aware of Safety Precaution. Participants atte availability of va safety devices ar equipment inclu hand gloves (86. disinfectants (84 HBV immunisati (46.2%) and post exposure prophy (PEP) for HIV an HBV (79.6%). Attitude to safety unsatisfactory a 60.0% eat and dr in the laboratory, 50.8% recap nee and 56.9% use sharps box. Even though 83.1% are willing to take PE only 1.5% will pre self following laboratory injury.
[16] Isara and Ofili, 2012	Prevalence of Occupational Accidents/Injuries among Health Care Workers	Descriptive cross-sectional study	Nigeria	167participants (20 laboratory workers)	Socio-demographic data of the HCWs and their exposures to needle pricks and other occupational accidents.	. 10 (50.0%) labor workers had had needle pricks, On (25.7%) of respondents repo to the staff clinic after susta accidents/injurie
[17] 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 la of compliance to infection control preventive meas among health-ca professionals
[18] 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 SP and associated factors.	General knowled SP was high,76.2 doctors and 67.6 MLSs. Use of personal protecti equipment as we safe handling of contaminated equipment or surfaces was hig amongst doctors Even though mor than half of respondents in b groups, 53.1 % among doctors a 58.1% among ML had received trai on standard precautions, this not reflect in the

						practice. MLS reported more us PPE (100% in ML and 35% of doct Recapping of syringes was hig amongst doctors (63.6%) than ML (55.1%). Constra that affected SP included non-availability of PP and emergency situations for bot groups.
[19] 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 responder were aware of th risk of acquiring in healthcare settings. Some h experienced accidents that m them take post-exposure prophylaxis..The also expressed th feelings that thei workplace was n the best place to work at.
[20] 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%, an 77.4% had adequ knowledge, favor attitude, and adequate practic score, respectivel Less than one-th (30.7%) of the st participants were vaccinated for hepatitis B virus. Regarding previo training, only 109 (36.8%) had take BMWM training.
[21] Sahiledengle et al., 2018	Infection Prevention Practices and Associated Factors among Healthcare Workers	Cross-sectional study	Ethiopia	605 participants (58 laboratory staff)	Awareness on infection prevention (IP) 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% health ca workers had goo infection prevent practices. Having good knowledge infection prevent meausures (AOR =1.53), having positive attitude towards infectior prevention practi (AOR=2.03).
[22] Desta et al., 2018	Knowledge, practice and associated	Cross-sectional study	Ethiopia	150 participants	The dependent variables studied were knowledge and practice of healthcare	84.7% of healtho workers were fou to be knowledge

	factors of infection prevention among healthcare workers			(13 laboratory technicians)	workers towards infection prevention. Whereas, the independent variables include institutional factors (training about infection prevention, availability of infection prevention supplies).	but only 86 (57.3 of respondents demonstrated a g practice on infec prevention. Healthcare professionals wh have taken Infect prevention trainir were 35.33%. In-service training, availability of infection prevent supplies and adherence to infection prevent guidelines was a associated with t practice of infect prevention.
[23] 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 n use any kind of P and almost 39.5 the respondents recapped used syringes regularl Although mouth pipetting is considered obsol 38% of the technicians conti to do so for vario purposes. Additionally, acci records were not maintained in 83 No formal biosaf training had beer provided to 85% the respondents.
[24] 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 fr Punjab, 35.7% from Sindh, 32 from Balochist a and 38.4% from Khyber Pakht Khawa (KPK) not use any PP Furthermore, 30. of the responden said they discard used syringes dir into municipal dustbins. The majority (66.7%) claimed there are no separat bins for sharp so they throw these in municip dustbins. Accident records were not maintai in 83.4%. No forr biosafety training had beer provided to 84.2 the respondents.

[25] 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 health care workers Adopting precautionary measures i.e. using gloves for standard procedures, know how 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 tl standard methoc discarding needl without recappin 80.3 % were still recapping needle 90.9 % HCWs we vaccinated agair Hepatitis B. The prevalence c NSIs was 50 % a out of these, 31.3 had experienced NSI while recapp Only 24.2 % peop who experienced NSI were aware enough to take p exposure prophy a greater number which were the la technicians 11 (4 %)
[26] Alam, 2002	Knowledge, Attitude and Practices Among Health Care Workers on Needle-Stick Injuries	Cross-sectional study	Kingdom of Saudi Arabia	70 participants (10 laboratory staff)	Demographic data, job category, HBsAg, anti HCV and HIV status of the health care worker. The knowledge and use of preventive measures regarding needle-stick injuries.	74% had a histor needle -stick inju and only 21% reported the injur to the hospital authority. Only 6 were aware of Universal Precau Guidelines. 60% been vaccinated against hepatitis while 40% were n vaccinated agair hepatitis B.
[27] Khan et al., 2014	Knowledge and attitude of healthcare workers about middle east respiratory syndrome	Cross sectional study	Kingdom of Saudi Arabia	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 knowlec and attitude was significant (correlation coefficient: 0.12; <0.001. Although majority of respondents sho positive attitude towards the use protective measu (1.52 ± 0.84), the attitude was neg towards their act participation in infection control program (2.03 ± 0.97).
[28] Rabaan et al., 2017	Iinfection prevention and control in healthcare facilities in regards to Middle East Respiratory Syndrome	Cross sectional study	Kingdom of Saudi Arabia	607 Participants (233 laboratory staff)	Attitudes to, and awareness of, infection prevention and control policies and guidelines among healthcare workers.	Carelessness of healthcare worke was the top-cited factor contributir causes of outbre (65.07% of total group), and hosp infrastructure an design was the to cited factor

						contributing to spread of infecti the hospital (54.2 followed closely lack and shortag staff (53.71%) ar no infection cont training program (51.73%). An electronic surveillance syst was considered t most effective by staff (81.22%).
[29] Khabour, 2018	Assessment of biosafety measures in clinical laboratories	Cross-sectional study	Kingdom of Saudi Arabia	208 medical laboratory staff	Attitude, knowledge, and practices of medical laboratory staff.	About 89% of sample had ve good to excell awareness about infection routes. majority (> 80%) followed guidelir for disposing me wastes, decontamination sample spills, an use of protective coats, gloves, etc However, among participants, 24.2 used to eat, drink use gum, 18.3% u cosmetics and 24 used the mobile phone in the lab. About 18.4% repo that they continu working with a fi cut.
[30] 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 deter-mined.	32% (20.8) of participants were aware of Univers Work Precaution. the participants v gloves during laboratory work b 81.2% wear a sin pair. 17.5 % of th participants clair to know what to exposed to infection. 45.6% the participants e the laboratory, 47 of them store foo and water in the refrigerators, 31.5 of them put on cosmetics in the laboratory, 12.6% smoke in the laboratory, 10.0% their finger nails teeth in the laboratory. 91.5% not immunized against hepatitis virus (HBV). 99.0 them do not take shower immedia after laboratory v 82.0% of the participants do n feel that the use

						masks is necess in laboratory 53.23% of the participants had injury.
[31] 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% o study subjects w having average a 50% were having good scores whil biochemistry 25% had average and had good scores in microbiology 1 of study subjects good grade. For attitude, in patho dept 83.3% had average and 16.7 had good grades biochemistry 12. had poor grades, had average grad and 12.5% had g grades. In microbiology 100 had good grades For practice in pathology dept 1 had poor grades, 66.7% had avera grades and 16.7% had good grades biochemistry 81. had average grad and 12.5% had g grades. In microbiology 100 of study subjects good scores.
[32] Thomas et al., 2004	Factors Promoting Consistent Adherence to Safe Needle Precautions Among Hospital Workers	Cross-sectional study	The United State of America	1,454 participants (151Medical laboratory staff)	Consistent adherence, structural support, equipment availability , key leader support and HCW perceptions and attitudes.	Positive predicto consistent adher included infectio control personne hours per full-tim equivalent emplo frequency of standard precaut education. facilit providing person protective equipr and managemen support for safet (OR, 1.05). Negat predictor was increased job demands.
[33] Benzekri et al., 2010	Laboratory worker knowledge, attitudes and practices towards smallpox vaccine	Cross-sectional study	The United State of America	45 laboratory workers	Adherence to ACIP recommendations, assess potential barriers to vaccination and determine the influence of training on laboratory worker attitudes.	87% had receive smallpox vaccina in their lifetime; 7 received vaccina in the past 10 yea The main barrier vaccination may fear associated v possible vaccine

						adverse effects a willingness to ris accidental infect rather than be vaccinated.
[34] Davidson and Gillies, 1993	Safe working practices and HIV infection: knowledge, attitudes, perception of risk, and policy in hospital	Cross-sectional study	The United Kingdom	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 infection from needlestick injury (98%, 904/922). In all, 32% of stat (303/958) indica that they thought they were at som risk of HIV infect in their occupatic setting, only 23% doctors and laboratory worke and 38% (48/127 nurses considere themselves to be risk.
[35] Akagbo, 2017	Knowledge of standard precautions and barriers to compliance among healthcare workers	Cross-sectional study	Ghana	100 participants (5 lab technicians)	Knowledge, compliance and barrier to compliance with standard precautions.	knowledge of SP low; only 37.0% c HCWs knew that includes hand washing before a after any direct contact with the patient. 50% of respondents alwa protect themselves from blood and body f injections. About quarter of the respondents do r recap needles aft use. 48% of HCW had regular traini in SP HCWs were thought that wea PPEs—such as gloves, aprons, gowns and gogg might cause pati to panic sometim (63.0%) and complying with S sometimes interf with the ability to provide care (38.! Sometimes, beca of the demands c patient care, HCW do not have enou time to comply w the rigours of SP (44.0%) and sometimes PPEs not available.
[36] 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 educatio health professior limited laborator capacity; inappropriate use antibiotics; low compliance with hand hygiene; po

						disinfection and sterilization; and implementation o occupational hea programmes
[37] 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 an public laboratory staff, 67% and 3 had received trai on biosafety (*P* < .001), respectivel Overall, only 38% respondents had good knowledge LSP, 49% had fai knowledge, and 1 had poor knowle Only 32% of respondents had good practice of 59% had fair pra level, and 9% hac poor practice.
[38] 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%) o participants had adequate knowle of universal precautions. Out 200 HCWs, 154 (77.0%) practice universal precautions. trai on universal precautions was significantly associated with practice of unive precautions (P < 0.001). There wa strong correlatio between knowlec and compliance (practice) with universal precau (r=0.76). Lack of lack of knowledg and emergency situations accou for the most frequently menti reasons for poor compliance.
[39] Fayaz et al., 2014	Knowledge and practice of universal precautions among health care workers	Cross sectional study	Afghanistan	300 participants (133 allied medical professionals)	Knowledge and practice of universal precautions.	Among the 30 respondents, th mean knowledg score was 5.2 with a standa deviation (SD) 1.5. On the practice score mean was 8.7 =2.2). A total 90.6% and 70. of HCWs believe that UPs were necessary in co with urine/fec and tears, respectively, although UPs a

						not necessary these cases. O the other han 57.8% reported that they always recapped the needle after giving an injec and 31.8% didnot always change gloves between patie There were no associations between the knowledge and reported practice of UPs.
						.
[40] Kahhaleh and Jurjus, 2005	Adherence to universal precautions among laboratory personnel	Cross sectional study	Lebanon	290 participants	Vari-ables included the knowledge, attitudes and practices of laboratory technicians concer-ning 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 workin they should take protective measu by wearing labor gowns or gloves that they should dispose of used needles and syrin in special contai 45 (20.3%) had training on how t perform HIV testi It was, however, observed that the technicians actu wore gloves in or 27 laboratories a laboratory coats only 63.
[41] 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.	43 (41.8%) thoug their infection wa related to protect equipment, utiliz of common equipment (mask and gloves). The main perceived n of transmission not maintaining protection when working at a clos distance and hav intimate contact infected cases.
[42] Ngwa et al., 2018	Assessment of the knowledge, attitude and practice of health care 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 participants 58% poor knowledge Post Exposure Prophylaxis and 60.6% of particip proved to have a positive attitude towards post exposure prophylaxis. 50.9 (110/216) of all

						participants had least one occupational exposure with a l uptake 19.1(21/1 of Post Exposure Prophylaxis reco among participa who were expose
[43] 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 the were at risk wher processing these specimens. Less one-third of thos receiving specim believed they we adequately traine The mean (±SD) knowledge score 9.25±4.5/24; individuals who h received training scored significan higher than those who were untrain (P<0.01). 81% of respondents wou be more comfort processing specimens if nat guidelines existe and were used in their laboratory. There is a high perception of risk few perceived benefits of processing prion-associated specimens. It is concerning that c onehalf of respondents w worked in laboratories repo that their protoco include standard precautions.
[44] Njagi et al., 2012	Knowledge, Attitude and Practice of Health-Care Waste Management and Associated Health Risks	Cross-sectional study	Kenya	At 599 participants at KNH and 261 at MTRH.	Identification of gaps in knowledge, attitude and practice in the management of health-care waste.	Most of them acquired knowle on waste-management thr on-job training fr seminars and informally throug organized talks a work- places. The hospital attendar had also an opportunity to acquire the knowledge throu organized trainin work places. The training improve workers' complia to hepatitis B vaccinations and of personal prote equipment when handling health-c waste. handling medica waste.

[45] Woith et al., 2012	Barriers and Facilitators Affecting Tuberculosis Infection Control Practices of Russian Health Care Workers	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 motivators existed to use of infection control.	Barriers and motivators relate knowledge, attitu and beliefs, and practices were identified. Three barriers were a) knowledge defici including the beli that TB was transmitted by du linens, and eatin utensils; b) negai attitudes related the discomfort o respirators; and c practices with res to quality and ca respirators. Education and training, fear of infecting loved o and fear of punishment were main motivators.

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
[12]	Yes	Yes	Yes	Not applicable	No	Unclear	Yes	Yes	6/8
[13]	Yes	Yes	Yes	Not applicable	No	Yes	Yes	Yes	7/8
[14]	Yes	Yes	Yes	Not applicable	No	Unclear	Yes	Yes	6/8
[15]	Yes	Yes	Unclear	Not applicable	No	Unclear	No	Yes	4/8
[16]	Yes	Yes	Yes	Not applicable	No	Unclear	Yes	Yes	6/8
[17]	Yes	Yes	Yes	Not applicable	No	Yes	Yes	Yes	7/8
[18]	Yes	Yes	Yes	Not applicable	No	No	Yes	Yes	6/8
[20]	Yes	Yes	Yes	Not applicable	No	Yes	Yes	Yes	7/8
[21]	Yes	Yes	Yes	Not applicable	Unclear	Yes	Yes	Yes	7/8
[22]	Yes	Yes	Yes	Not applicable	Yes	Yes	Yes	Yes	8/8
[23]	Unclear	Yes	Unclear	Not applicable	No	No	Yes	Unclear	3/8
[24]	No	Yes	Unclear	Not applicable	No	Yes	Yes	Yes	5/8
[25]	No	Yes	Unclear	Not applicable	No	No	Yes	Yes	4/8
[26]	Yes	Yes	Unclear	Not applicable	No	Unclear	Yes	Yes	5/8
[27]	Yes	Yes	Yes	Not applicable	No	No	Yes	Yes	6/8
[28]	No	Yes	Unclear	Not applicable	No	No	Yes	Yes	4/8
[29]	Yes	Yes	Yes	Not applicable	Unclear	Yes	Yes	Yes	7/8
[30]	Yes	Yes	Yes	Not applicable	No	Unclear	Yes	Yes	6/8
[31]	Yes	Yes	Yes	Not applicable	No	No	Yes	Yes	6/8
[32]	Yes	Yes	Yes	Not applicable	No	Unclear	Unclear	Yes	5/8
[33]	Yes	Yes	Unclear	Not applicable	No	Unclear	Yes	Yes	5/8
[34]	Yes	Yes	Yes	Not applicable	No	Unclear	Yes	Yes	6/8

[35]	Yes	Yes	Yes	Not applicable	No	No	Yes	Yes	6/8
[37]	Yes	Yes	Yes	Not applicable	Unclear	Yes	Yes	Yes	7/8
[38]	Yes	Yes	Yes	Not applicable	No	Unclear	No	Yes	5/8
[39]	Yes	Yes	Yes	Not applicable	No	Yes	Yes	Yes	7/8
[40]	Yes	Yes	Yes	Not applicable	No	No	Yes	Yes	6/8
[41]	Yes	Yes	Yes	Yes	No	Unclear	Yes	Yes	6/8
[42]	Yes	Yes	Yes	Not applicable	No	No	Yes	Yes	6/8
[43]	Yes	Yes	Yes	Not applicable	No	Unclear	Yes	Yes	6/8
[44]	Unclear	Yes	Yes	Not applicable	No	Unclear	Yes	Yes	5/8

Table.3

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 interpretation	Locating the researcher culturally or theoretically	Influence of the researcher on the research, and vice-versa	Representation of participants and their voices	E a b a b
[19]	Yes	Yes	Yes	Yes	Yes	Unclear	No	Yes	Y
[36]	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Y
[45]	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Y

Data synthesis and analysis

A complete reading of the included studies was carried out. Afterward, 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.

Due to the nature of data in this mixed-methods review, and the limited availability of numerical (quantitative) data for applying meta-analysis approach, a narrative synthesis approach was followed. Narrative synthesis approach is defined as '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' [11]. This approach can be utilised by both qualitative, quantitative and mixed methods studies and assists integration of both qualitative and quantitative data together to achieve the aim of the review.

Results

2442 articles were identified through the systematic literature search. After removal of duplicates and title and abstract screening, 2146 articles were excluded and the number remaining was 136. After the full-text screening, a total of 34 articles remained and were included in the final review (Figure.1)

Location

Seven of the 34 studies were conducted in **Nigeria** [12]; [13]; [14]; [15]; [16]; [17]; [18], four in **Ethiopia** [19]; [20]; [21]; [22] three in **Pakistan** ([23]; [24]; [25]), four in **Saudi Arabia KSA (**[26]; [27]; [28]; [29], Two in **India** ([30]; [31]), Two in the **USA** ([32]; [33]), and one each in the **UK** [34], **Ghana** [35], **Magnolia** [36], **Yemen** [37] **Tanzania** [38] **Afghanistan** [39], **Lebanon** [40], **China** [41], **Cameron** [42] **Canada** [43] **Kenya** [44] **Russia** [45].

Study design

Thirty-one of the articles reported studies which were of cross-sectional design (quantitative studies) [12-18]; [20-35]; [37-44]; three were qualitative studies [36]; [19]; [45].

Assessment of quality

Thirty papers ([12-14]; [16-22]; [24]; [26-27]; [29-45] were considered to be of high quality. The remaining four were considered to be of low quality, mainly due to lower representativeness of inclusion/exclusion criteria of study participants, outcome measures and statistical analysis.

Knowledge, attitude and practice of infection control guidelines

For the purposes of this review KAP 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 [50;51]:

Knowledge: Information possessed on the IPC guidelines.

Attitudes: Opinion on and behavior towards the IPC guidelines.

Practices: Observable actions towards the IPC guidelines.

Of the 34 included studies, the KAP of infection prevention and control, and biosafety guidelines were identified and grouped into several themes, the specific definition of each theme was identified from the included studies (Table 4)

Table.4

Themes definitions

Theme	Specific definition
(1) **Awareness of IPC precautions**	Awareness of IPC precaution refers to the knowledge and understanding of the conditions the IPC guidelines should be followed.
(2) **Acceptability of IPC precautions**	Acceptability refers to determining how well IPC guidelines are adopted in everyday practice.
(3) **Application of IPC precautions**	Application refers to the actual exercise and use of measures that minimize the risk of physical harm in workplace.
(4) **Perception of risk**	Perception of risk refers to individual's intuitive risk assessment, reflecting attitudes or beliefs about potential harm while working in the laboratory.
(5) **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 block or reduce the injury or infection.
(6) **Immunisation against infectious diseases**	Immunisation against infectious diseases refers to the participants' compliance with the recommended vaccination for laboratory staff such as HBV.
(7) **Training and association with IPC guidelines**	Training and association with IPC guidelines refer to any training undertaken on the IPC guidelines by laboratory staff to inform compliance with the guidelines.
(8) **Associations between knowledge and practice**	Associations between knowledge and practice refer to the extent to knowledge and understanding of the IPC guidelines associated with the participants' attitude and their actual practice.
(9) **barriers and facilitators to poor practice and adherence**	Barriers and facilitators refer to factors the enable or inhibit the implementation of IPC guidelines.

(1) Awareness of IPC precaution

There were no standardised criteria for classifying knowledge and awareness as poor, moderate or good across studies. However, it has been observed that the term 'poor awareness' was generally used when < 50% of participants had adequate awareness on the specific information about the IPC guidelines. Similarly, the terms 'moderate' and 'good' awareness were used when the participants with adequate specific information about the guidelines was between 50–70% and >70%, respectively, and this was also applied for the remaining themes below.

Awareness was examined in 17 studies. In Nigeria, three studies [15]; [13] and [12] reported poor knowledge and awareness of IPC precautions among laboratory personnel. In Fadeyi et al's study [15] only 58.2% of the participants were aware of safety precaution principles, while in Ibeziako and Ibekwe study [13] about 50.4% of the respondents were aware of IPC precaution. Results of Izegbu et al's study [12] showed that only 20.8% of the participants had heard of the IPC precautions and only 37.5% of these could define and state it's objectives. These results may contradict with the results reported in one study conducted in Nigeria as well [18] which reported good results for awareness. Ndu et al's study [18] attempted to differentiate between the knowledge

among two groups of health care professionals: doctors and laboratory staff. Although the study found there were differences between the two groups on the knowledge and awareness of components of IPC, both showed a good level of knowledge (76.2% in doctors and 67.6% in laboratory staff).

Three studies in Ethiopia [22]; [20]; [21] showed that between 55.4%- 84.7% of laboratory staff had a good level of awareness. It should be clarified that the number of laboratory staff included in these studies was very low compared to other healthcare workers (13/150; 29/49; 58/605), respectively.

Similar results were reported in two Saudi studies [29]; [26]; [28] (84%; 66%; 81.97). As a small number of laboratory staff (10) participated in study [26], it may not be a good representative of laboratory staff as well. The Rabaan et al's study [28] assessed the awareness of, infection prevention and control policies and guidelines, but it is considered to be a study of low quality because of no information regarding the inclusion/exclusion criteria of its study sample.

In Pakistan, one study examined awareness regarding IPC precautions and reported only 51% of participants knew that the standard method of discarding needles is without recapping [25]. However, this study has flaws in its quality assessment tool, because no information regarding the inclusion/exclusion criteria of its study sample was reported. Furthermore, the instrument used for data collection was not pretested to check its validity and reliability.

Both Indian studies included in this review examined the laboratory staff's awareness of IPC precautions, one found a good level (75%) [31], and one found a poor level (32%) [30]. This difference in the results may be due to the awareness and knowledge present among the included staff and the level of training they have received.

Studies conducted in Lebanon [40] and Yemen [37] showed a good and poor level of awareness, respectively. Almost all the technicians were knowledgeable about the IPC precautions (100%) in [40]. In contrast, only 38% of respondents had good level of awareness in the Yamani study [37]. All studies considered to be high quality studies have ensured that an adequate number of laboratory staff participated.

One study shows good level of awareness (82%), this was Chalya et al's study [38] in Tanzania. In contrast, the only Akagbo et al's study that was conducted in Ghana and included in this review reported poor awareness (37.0%) of IPC precautions among laboratory staff [35]. It is important to highlight that the findings of this study were drawn from only 5 laboratory members of staff out of 100 healthcare workers.

The participants of a qualitative study in Mognolia included in this review claimed that many infection control decisions are made by those who have a non-medical background or non-knowledgeable in infection control. In addition, all the study participants acknowledged their poor knowledge of infection control and reported that IPC is not well taught at the under- and post-graduate levels of education. Poor knowledge on disinfection and sterilization were also reported as the standards and guidelines for disinfection and sterilisation have not been updated in the laboratory [36] (see table.5).

Another qualitative study which conducted in Russia showed that laboratory staff were most knowledgeable about Tuberculosis IPC guidelines as they believed wearing hospital-laundered lab coats and disposable shoe coverings was protective against TB transmission. Participants also described the necessity of showering and changing clothes so they did not carry the bacillus home [45] (see table.5).

Finally, the findings regarding awareness level of these studies may be subjected to recall bias as they used self-administered questionnaires for data collection.

(2) Acceptability of IPC precautions

The attitude and acceptability of laboratory staff toward IPC were examined in 9 studies.

Two studies in Nigeria reported different findings of acceptability, moderate [15] and poor [12]. In Fadeyi et al's study [15] 60.0% of participants were willing to eat and drink in the laboratory, while in Izegbu et al's study [12] 45.6% of the participants eat in the laboratory and 47.0% of them stored food and water in the refrigerators meant for the storage of body fluids and chemicals, attitudes which indicate a disregard toward IPC and safety precautions.

Different situations appear in Ethiopian studies ([20]; [21]) where both found moderate level of acceptability among laboratory staff (66.2%; 66.1%), respectively.

In India, one study reported good acceptability level [31] while the other reported the opposite [30]. Good acceptability level in [31] were observed in three departments in the laboratory: 83.3% in the pathology department, 75% in the biochemistry department and 100% in the microbiology department. Yet the results in Zaveri et al's study [30] surprisingly matched in an exact way the findings from Izegbu et al's study [12] conducted in Ethiopia (45.6% of the participants eat in the laboratory, 47.0% of them store foods and water in the refrigerators).

The studies [40] conducted in Lebanon and [27] and [29] in Saudi Arabia observed good and positive acceptability and behavior among laboratory staff. Only 8 of the 73 (11.0%) technicians showed some behavioural lack inside the laboratory: eating, drinking, smoking or pipetting with their mouths [40]. In Khan et al [27], 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 program (24.2). Meanwhile, in Khabour et al [29] only 24.2% of participants were willing to eat, drink or use gum, 18.3% used cosmetics and 24.6% used their mobile phones in the laboratory.

(3) Application of IPC precautions

The majority of studies (23) in this review examined laboratory staff application of IPC precautions.

Six studies were Nigerian and those included in this review assessed how IPC precautions were practiced in laboratories. Poor application results were reported in two studies [12] (43%) and [17] (45.6%). Moderate findings were reported in Fadeyi et al [15] as about 69.2% of participants wore gloves when handling samples and in Sadoh et al [14], 63.8% of participants always used personal protective equipment. The findings in Ndu et al's study [18] demonstrated that laboratory staff reported good application and greater use of personal protective equipment such as gloves and coveralls than doctors (100% and 35%, respectively). The same good practice and application level was reported in Ibeziako and Ibekwe's study [13] as gloves were used by 86.6% of respondents while only 43.9% of them practiced appropriate hand washing.

One Ethiopian study reported good level of application [21] (66.1%). On the other hand, [22] and [20] show poor (57.3%) and moderate (77.4%) results.

In KSA, it had been revealed that only 27% of participants were using gloves all the time while 48 (69%) were doing so only occasionally [26]. It was furthermore documented that 10%-25% injuries in laboratory occurred while recapping a used needle [26]. Nevertheless, Khabour et al's study [29] demonstrated good application level among laboratory staff and the majority (> 80%) of participants followed guidelines for disposal of medical waste, decontamination of sample spills, and use of protective lab coats and gloves, among other measures.

Indian studies reported good application levels [30] and [31]. All the participants wore gloves during laboratory work [30], and 66.7%, 81.5% and 100% of participants in the pathology, biochemistry and microbiology departments, respectively, had correct answers to the practice questions in the study questionnaire [31].

All three studies conducted in Pakistan demonstrated a poor level of application and practice. There was a lack of awareness of good laboratory practices reported in Nasim et al's studies [23] (as 46.2% of the participants did not use any kind of PPE, and almost 39.5% recapped used syringes regularly) and (33.6%) in [24]. Qazi et al's study [25] yielded poor results, as 80.3 % of 208 participants were recapping needles, which meant that 31.3 % had experienced a needle stick injury while recapping.

The studies conducted in Lebanon [40], Kenya [44] and Tanzania [38] reported good levels of application. 93.2% of participants wear gloves while working in the laboratory [40], 97.8% of participants used personal protective equipment (PPE), gloves, overalls, gumboots, mouth masks and other protective equipment when handling medical waste [44] and 77.0% of participants applied the universal precautions [38].

Conversely, the studies from Afghanistan [39], Yamani [37] and Ghana [35] revealed poor application level. 57.8% of respondents reported that they always recapped the needle after giving an injection in [39], only 32% of respondents had good practice of IPC precautions in [37]. Only 50% of respondents always protect themselves from injections and about a quarter of the respondents do not recap needles after use as reported in [35].

The participants of Ider et al's study [36] conducted in Mognolia perceived that hand-hygiene practice among health professionals of Mongolia is low. They also wonder that, despite most hospitals conducting staff hand-hygiene training once or twice a year, hand-hygiene practice remained poor. The main reasons behind that may be due to unavailability of hot water and sinks and a poor supply of soap, poor supply of alcohol-based hand sanitizers, skin care products and high workload of health professionals [36] (see table.5).

One study conducted in China aimed to assess the infection control practices among COVID-19 infected healthcare workers [41]. 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 participants thought their infection was related to protective equipment and utilisation of common equipment (masks and gloves), either due to inadequate provision of PPE or to insufficient protection provided by the PPE they had.

Poor application of tuberculosis IPC guidelines was reported in Woith et al's study [45] in Russia. Poor application was on the use of respirators and masks because they are uncomfortable especially during hot weather and wearing respirators interfered with using microscopes in the lab and the quality of the respirators available at their facilities is poor (see table.5).

It is important to clarify those discrepancies between studies might be due to a difference in knowledge of IPC guidelines, the sample size, methodological and sociodemographic differences, lack of training and supplies and the professionals' nonadherence to IPC precautions.

(4) Perception of risk

Only three studies in this review reported 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 the high knowledge of safe working practice and practical working experience or they worked in a safe lab using safe practices [34]. A Canadian study assessed prion disease risk perception among laboratory staff and found that 18% believed that 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 [43]. One qualitative study in Ethiopia [19] explored healthcare workers' perceptions on occupational risk of HIV transmission. The study of Alemie [19] reported that all the participants were aware of the risk 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.5).

(5) Exposure and post exposure prophylaxis

Ten articles reported exposure to injuries and post exposure prophylaxis (PEP) following injuries.

In Nigeria, 53.23% of the participants had had cuts or punctures from needles and were treated in the laboratories [12]. Although 94% of the laboratories have first aid boxes, only 28.78% of the staff make use of these [12]. In Fadeyi et al's study [15], despite the fact that 79.2% of respondents were aware of the availability of Post Exposure Prophylaxis for HIV and HBV (hepatitis B virus), only 1.5% positively responded to presenting themselves and did Post Exposure Prophylaxis follow any laboratory accidents [15]. 50.0% of the laboratory workers who participated in the study [16] 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 [19] in Ethiopia had experienced accidents: needle stick injuries, exposure to blood or other body fluid and their explanations of the incidents indicated the accidents were frequent. Many of the injuries/accidents were followed by commencement of post exposure prophylaxis which, however, was mentioned by some to be less practiced although they were well aware of post exposure prophylaxis [19] (see table.5).

In Pakistan, no percentages of accidents were reported according to studies [23] and [24], but 83.4% and 89.3% of laboratories did not maintain any accident records, respectively. In Rabaan et al's study [28], about 31.3 % of participants had experienced a needle stick injury while recapping, however, only 24.2 % of participants who experienced an injury were aware that they should take post exposure prophylaxis.

A similar situation was noted in a Saudi study, where 74% of participants had a history of needle stick injuries, and only 21% of the 74% reported the injuries to the hospital authority [26].

In India, 53.23% of the participants had been injured by needles and sharp instruments. However, only 28.78% of them made use of first aid supplies after their injury [30].

A Cameroonian study [42] reported exposure and Post Exposure Prophylaxis and agreed with the findings of [30]. It showed that a high proportion of participants (58%) had poor knowledge on PEP and 60.6% had a positive attitude towards PEP. About 50.9% of all participants had at least one occupational exposure, but only 19.1 % of Post Exposure Prophylaxis incidents were recorded among exposed participants.

The reported data on occupational accidents/injuries relies on the participants' memories of past exposure, which may therefore be prone to recall bias.

(6) Immunisation against infectious diseases

The assessment of the immunisation status of laboratory staff has been reported in 8 studies.

In KSA, 60% of respondents who worked on laboratory had been vaccinated against hepatitis B [26], and 87% had received a smallpox vaccination in their lifetime [33].

However, in Nigeria, the situation is different. The findings revealed that the awareness about HBV vaccine is not good enough, as only 46.2% were aware of the availability of HBV vaccination in their workplace even though 72.3% of participants were willing to be vaccinated [15]. It was furthermore found that 91.5% of participants were not immunised against the Hepatitis B virus [12].

In India, the results were similar, as 91.5% were not immunised against HBV [30]. Meanwhile, in Pakistan, 90.9 % of participants were vaccinated against the Hepatitis B virus [25].

A Kenyan study found that all the staff participated in the study were aware of the importance of the vaccination, but since it is optional in their institution, they chose to remain unvaccinated [44]. While in Afghanistan, 78.0% of participants were vaccinated despite the fact that vaccination against HBV is not covered by the government and healthcare workers have to pay from their own funds to receive this vaccination [39].

The main barriers to vaccination may be fear associated with possible adverse effects of the vaccine and thus a greater willingness to risk accidental infection rather than be vaccinated [33]. Moreover, low compliance with vaccination might be due to the fact that staff could not remember the vaccination under reference and they may confuse this vaccination with others they had received before [44].

(7) Training on IPC guidelines

Twelve studies reported the results of training on IPC precautions.

In Nigeria, only 13.8% had received training on universal precautions [13], and the study investigated how low and unequal levels of training among staff contributes to the poor knowledge of and compliance with the precautions. The training level was similar between medical doctors and laboratory staff (53.1% of medical doctors and 58.1% of laboratory staff). However, in Ndu et al's study [18] 73.5% of the laboratory staff received training on wearing and removing PPE, this may contribute to the low use of PPEs among doctors compared to laboratory staff.

In the study of Desta et al [22], study 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 the overall unsatisfactory level of knowledge, attitude, and practice scores in study [20].

Training status was reported in two Saudi studies. For instance, 68% of participants reported receiving training in laboratory safety either through a course during college education or through training workshops in their workplace [29]. However, the results showed that some of the unacceptable behaviors in

laboratories were associated with lack of training IPC precautions. 23.06% of participants reported having received no training [28], and when the participants were asked to identify factors that contribute to the spread of infection in the hospital, 51.73% reported no infection control training program as a factor.

A Tanzanian study reveal that the percentage of the study sample who received training on universal precautions was 98.5%. and the previous training was significantly associated with good practice (P < 0.001) [38].

These findings match the results reported in Pakistan, as no formal biosafety training had been provided to 84.2% of the participants [24]. In Ghana it was reported that only 48% of participants had regular training in IPC precautions [35], and in Yemen 67% and 32% of private and public laboratory staff had received training, respectively [37]. No associations between training and practice were reported in [24], [35] and [37].

(8) Associations between knowledge, attitude and practice

Only four of the included studies examined the associations/correlations between knowledge, attitude and practice. A Tanzanian study found a significant correlation between knowledge and practice regarding IPC precautions (r=0.76, p<0.001) [38]. The same strong correlation was reported in KSA [23] and Ethiopia [22]. The correlation between knowledge and attitude was significant (r: 0.12; P <0.001) [27] and there was an association between adherence to IPC guidelines and the practice of infection prevention [22].

(9) Barriers and facilitators to poor practice and adherence

Four quantitative and two qualitative studies explored barriers and facilitators of poor adherence and practice.

As Nigeria is one of the middle-income countries, a study conducted there reported that the main reason for the poor practice was the unavailability of required resources and poor access to PPE [18]. In addition, some respondents found it difficult to use PPE during emergency situations in hospital [18]. The same results explored in Tanzania, where lack of PPE, emergency situations, and lack of knowledge accounted for the most frequently mentioned reasons for poor compliance [38].

Several reasons for poor compliance were given in Ghana. Participants thought that wearing PPEs such as gloves, gowns and goggles might cause patients to panic meaning that complying with the IPC precautions sometimes interferes with their ability to provide care. It was moreover the case that PPEs were not always available [35].

It is interesting to clarify that lack of availability and poor access to safety equipment was considered to be the most common reason for poor practice and adherence to IPC precautions in middle and lower and middle-income countries included in this review.

In the USA it has been found that the factors that positively promote consistent adherence were: education in standard precautions, providing facilities with personal protective equipment, and strong management support for safety. An increase in workplace demands and expectations negatively affected consistent adherence [32].

In Mongolia, a qualitative study assessed the perceptions of laboratory staff regarding the main barriers and challenges to implementation of effective infection control in the hospital. It found that poor IPC education, limited laboratory capacity, poor disinfection and sterilisation and low compliance with hand hygiene were the major barriers for implementation [36] (see table 5). Although this study examined issues from the participants' perceptions, there were shortcomings with how this study was conducted, and that it could be improved using large-scale quantitative and mixed-method investigations.

A study was conducted in urban and rural regions in Russia to explore the barriers and facilitators affecting tuberculosis IPC practice using focus groups. It reported that the main barriers were knowledge deficits regarding the transmission of TB, negative attitudes related to the discomfort of respirators and practices with respect to the quality and care of respirators [45] (see table.5).

Table.5

Summary of the results with the original quotes (OQ) from the studies included in this review, which exemplify the themes of interest.

Theme	Original quotes
Awareness of IPC precautions	" *"It is extremely difficult to convince people at the 'top' because they are non-medical" [Military hospital doctor]"* [Ider et al., 2012] (OQ1)[36] " *"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)[36] " *"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)[36] " *"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 felt that was I supposed to be teaching them, not them teaching me." [Hospital ICP]"* [Ider et al., 2012] (OQ4)[36]
Application of IPC precautions	" *"People know that they should wash their hands, but they don't. It's poor accountability…We are planning to install camera systems in hospital delivery rooms to monitor hand washing"[MoH]."* [Ider et al., 2012] (OQ5)[36] " *"Everybody knows when and how to wash their hands but they don't"* [Hospital manager]" [Ider et al., 2012] (OQ6)[36] " *"It [disinfection and sterilization]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)[36] *" "respirators sliding down the nose and requiring constant repositioning," and respirators "are difficult to wear when the wearer has rhinitis," "cause the face to perspire," and "are unattractive." "* [Woith et al., 2012] (OQ8)[45] *" "The fabric is stiff and because of that there is not a good fit to the bridge of the nose" [Support staff]"* [Woith et al., 2012] (OQ9)[45] *In some institutions, respirators were worn from one to four weeks and changed as needed, described as when they "are dirty or damaged," "are expired," or "no longer fit."* [Woith et al., 2012] (OQ10)[45]
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)[19]
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." (A 26-year-old medical laboratory technologist) "* [Alemie et al., 2012] (OQ12)[19]
Barriers and facilitators to poor practice and adherence	"*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)[36] " *"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)[36] " *"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)[36]

" *"Tuberculosis can be spread through sexual transmission, although this seldom occurs." [Support staff]* " [Woith et al., 2012] (OQ16)[45]

" *"We eat well before going to examine patients because then the infection can't survive" [Physician]* " [Woith et al., 2012] (OQ17)[45]

" *"For the first six months working here, everyone is afraid of getting TB. Then there is a feeling of complacency, we are afraid of nothing." [Support staff]* " [Woith et al., 2012] (OQ18)[45]

Discussion

This review looked at the level of knowledge of, attitudes to and practice of IPC precautions/guidelines among staff working in laboratory in hospital in different countries.

This has been done through unpacking the knowledge, attitude and practice into particular themes and the definition of each theme was identified from the studies included in this. Several differences of KAP were observed between and within countries. Generally, the available evidence shows that there was good[1] knowledge, good[1] attitudes and moderate[2] immunisation status, but there was still poor[3] practice of IPC precautions among laboratory workers. Evidence is lacking on risk perception and it was low based on the available articles. Exposure to blood and body fluids through cuts or punctures from needles and sharp instruments was high among laboratory staff; despite the high incident rate, the reporting of these accidents to the management team and use of post exposure prophylaxis was low. There was an inadequate level of training received among laboratory staff and some studies revealed a strong association between training and knowledge to the thorough practice of IPC. Although the evidence was not abundant, there is a clear association between knowledge, attitude and practice. The lack of guidelines, the poor access to safety equipment (PPE), the lack of training and education and the immense pressure of emergency situations were the main barriers highlighted in this review. The findings show that there is a need to improve the availability of guidelines, the availability of PPE and to provide regular training on IPC guidelines.

Different definitions of knowledge and awareness were used in different studies, which reflects the lack of stable policies and guidelines, and may be because different IPC recommendations are made by the Centres for Disease Control and Prevention (CDC) and the World Health Organisation (WHO). Different levels of awareness was reported in different countries, and even within those countries. However, some of them were considered to be of low quality according to the Joanna Briggs Institutes Critical Appraisal Tools and in addition the number of laboratory staff included in the study 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 of the laboratory staff attitudes toward and acceptability of IPC guidelines were more focused on eating, drinking, storage of food in refrigerators, and the use of mobile phones. None of the studies reported the reasons behind this poor behavior. 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? There is a need to clarify the reasons behind these risky behaviors and poor attitudes, since they must be urgently addressed in order to prevent the establishment of a poor work culture.

In line with the reason of poor practice and application reported above, it should be clarified that, most of the studies that assessed practice in this review were limited by a self-reporting method. This method may have produced a less favorable picture of practice than is actually the case, and the participants may tend to overestimate the extent to which they practice and comply with IPC precautions. Using a combination of observation methods, interviews and a questionnaire to assess practice (used in [40] and [20]) 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 perception was very low in this review and very few laboratory staff members were included in the data and it is difficult to draw meaningful conclusions from such sparse data. Therefore, further studies on perceptions of risk in the workplace and especially for laboratory staff are needed. Moreover, measurements of the relationship between risk perception and attitude and practice of IPC guidelines may be useful to assess how risk perception affects the actual practice. The same applied to the associations between knowledge, attitude and practice. Although there is a clear association reported in this review, the available evidence was greatly lacking and so more studies on this area are recommended.

The lack of reporting on the incident rate and on the use of PEP may be due to the lack of awareness of the importance of post exposure prophylaxis, fears of stigmatisation and job insecurity [14]. The use of post exposure prophylaxis is a genuine tool in the fight against HIV and other infections such as HBV, and according to the WHO, post exposure prophylaxis can reduce the risk of HIV infection by over 80% if started soon after exposure [48]. Therefore, hospital authorities should establish a continuing health education programme to inform laboratory staff on IPC measures with particular attention on the immediate action to take after injuries, reporting injuries, and the use of post exposure prophylaxis. In addition, setting up a monitoring team is needed to actively keep looking at all occupational injuries and exposures, so as to guarantee that they are managed and reported properly.

The overall training level was unsatisfactory, and it has been shown from the evidence above that training programs for laboratory staff can impact their adherence to, knowledge of, behavior towards and practice of IPC precautions. It is therefore recommended that they receive enough training regarding IPC precautions and examination before gaining the license to practice a laboratory profession.

Similar to this review, a recent review about the occupational hazards among healthcare workers in Africa reported a lack of PPE as a common reason for poor practice [47]. This indicated that there is a need for national policies to address low availability and in some cases the complete absence of PPE in many low-income countries. The findings of the Ghanaian study [39] highlighted how complying with the IPC precautions sometimes interferes with their ability to provide care. The study reflected how the warmer climate in such countries meant that healthcare workers were exposed to heat stress which may limit their compliance and may also make the use of PPE more uncomfortable than in cooler climates and could even be life-threatening [46]. Consequently, the standards for the production of PPE should take warmer climates in these countries into consideration to promote adherence.

There is a need for more mixed-methods studies to assess the KAP of laboratory staff in order to reduce biases during the data collection. Furthermore, the majority of articles in this review focused on either standard or universal precautions with very few mentions of both of them together. Thus, studies on both kinds of precautions are required since they are equally important and recommended by the WHO. Larger-scale studies are needed to collect more evidence about risk perception among laboratory staff in laboratory.

The study had some limitations. Some of the included studies in this review were focused on laboratory staff alone as participants, while others focused on all healthcare workers such as nurses and doctors as well as laboratory staff, therefore and for sure a higher level of knowledge, attitude and practice will be gotten and reported in the one that only focused on laboratory staff than other boarder studies. In addition, because a narrative synthesis approach was followed and no enough numerical data was available in this review, there was no assessment of publication bias carried out as it does not allow funnel plots to be presented. Finally, only studies published in the English language were included. Thus, the potential language bias is considered to be a limitation of this review.

Conclusion

This systematic review advanced the current knowledge regarding the level of knowledge, attitude and practice about IPC precaution among laboratory staff. It clearly shows via evidence that there is a gap between knowledge, attitude and practice which indicates that hospital 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) of laboratory staff to increase their knowledge about IPC precautions could improve their use of these precautions.

Abbreviations

IPC: infection prevention and control.

KAP: knowledge, attitude and practice.

PPE: Personal protective equipment.

KSA: Kingdom of Saudi Arabia.

UK: United Kingdom.

CDC: Disease Control and Prevention.

WHO: World Health Organisation

Declarations

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Acknowledgements

Not applicable.

Funding

No funding.

Author Contributions

The initial research question was developed by HA with MP and GM. HA conducted the literature search, with IM assisting with the inclusion and exclusion and quality assessment of identified articles. Analysis and overall synthesis of findings for the review, and the initial drafting of the manuscript, were

conducted by HA, under the supervision of MP, GM, VM and MA. All authors contributed to revisions of the manuscript and have approved the manuscript for submission.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

None to declare.

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Figures

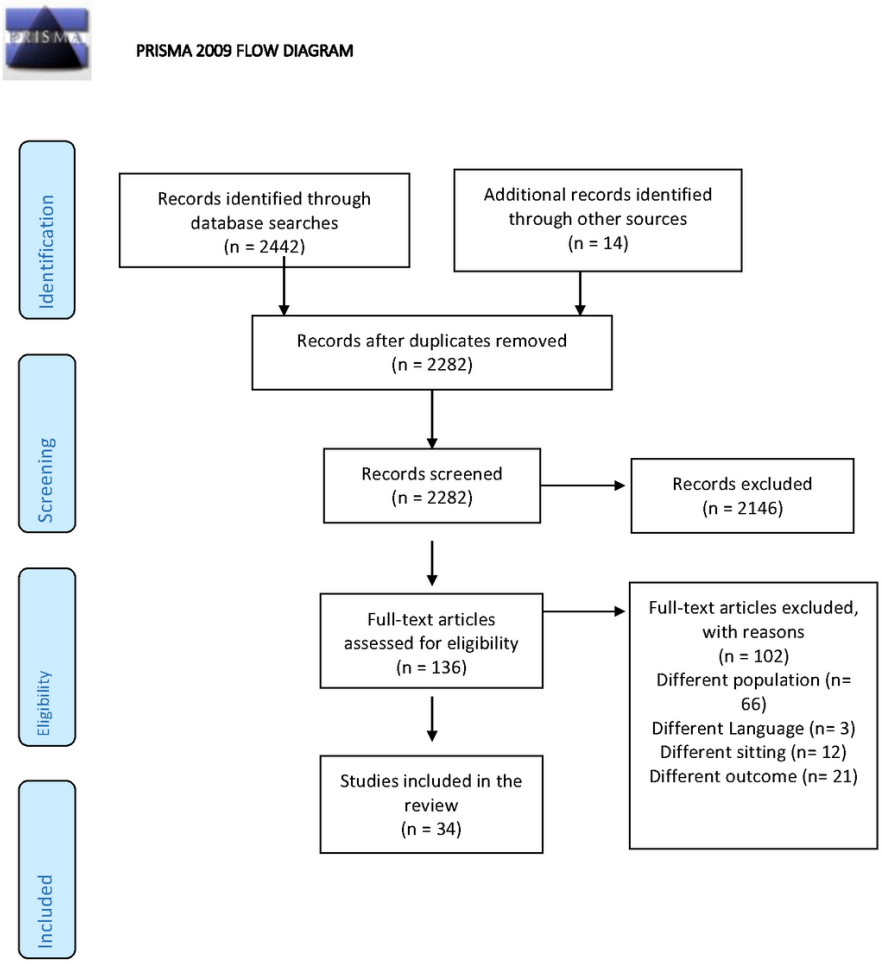

Figure 1

Flow chart of included and excluded studies

Supplementary Files

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- Appendix.docx