Natural Resources for Human Health
eISSN: 2583-1194

Original Research

Received 02 Jan 2026
Revised 09 Jan 2026
Accepted 27 Jan 2026

Natural Resources for Human Health 2026, Vol. 6 (1s): 787-802

KEYWORDS:
Infection control; Knowledge, attitudes, and practice; Dental assistants; Nurses; Pharmacists; Laboratory technologists.

Infection Prevention Knowledge, Attitudes, and Practices in Four Healthcare Professions: A Systematic Review

Rehab Saker Alanazi*[1], Zahwah Saleh Albalwi[2], Khalid Omar A. Bin Haylan[3], Abdulaziz Eid Alanazi[3], Abdulrahman Fatim Almutairi[3], Sami Faleh A. Alsulami[4] , Abdulrahman Ali Alamri[3], Alaa Adnan M. Eishan[5] , Rami Mashawi Abu Eishah[6] , Hassan Abdu Ahmed Hakami[7]

[1]King Saud University — Dental University Hospital, Saudi Arabia
[2]King Salman Military Hospital, Saudi Arabia
[3]General Directorate of Prisons Health, Saudi Arabia
[4] Medical Services in the Ministry of Interior (Prisons Health), Thahban, Saudi Arabia
[5] Armed Forces Hospital, Southern Region, Saudi Arabia
[6] Baish General Hospital, Saudi Arabia
[7] King Fahad Central Hospital, Jazan, Saudi Arabia
*Corresponding author: Rehab Saker Alanazi, alanizirehab3@gmail.com

ABSTRACT: Infection prevention and control (IPC) responsibilities differ across clinical and laboratory settings. This review synthesized evidence on IPC knowledge, attitudes, practices, and occupational exposures among dental assistants, nurses, pharmacists, and laboratory technologists. Eligible English-language studies were published from 1 January 2009 through 31 January 2025. Reports retained from the original draft were supplemented by targeted web searches and synthesized narratively because the measures and scoring thresholds varied. Database and supplementary study-selection counts were reported separately. Thirteen cross-sectional studies enrolled 4,755 participants. In a Saudi dental-clinic survey, 134 of 450 dental assistants (29.8%) reported a sharps injury. In a separate Saudi hospital survey, 34.8% of nurses and 21.1% of medical technologists reported a sharps injury in the preceding year. Pharmacists in a Pakistani survey had higher odds of meeting the study's good-practice threshold than other respondents. Differences in sampling, self-reported measures, and workplace exposures limited comparisons across professions. The findings identify setting-specific gaps in IPC knowledge, reported practice, and sharps safety. Studies using comparable measures, direct observation, and profession-specific denominators would support more informative comparisons.

1. INTRODUCTION

Healthcare-associated infections remain a leading threat to patient safety and a persistent occupational hazard for those who deliver care, with prevalence reported between 5% and 15% of hospitalized patients (Alhumaid et al., 2021). Healthcare workers are exposed through blood, body fluids, respiratory secretions, and contaminated surfaces and instruments, and contaminated sharps injuries alone account for a measurable share of hepatitis B, hepatitis C, and human immunodeficiency virus infections in this workforce (Rapiti et al., 2005; Prüss-Üstün et al., 2005).

Standard precautions, which include hand hygiene, appropriate use of personal protective equipment, safe handling of sharps, instrument reprocessing, environmental cleaning, and hepatitis B immunization, are the foundation of occupational infection prevention (Siegel et al., 2007). Dental-specific recommendations apply the same principles to settings in which saliva, blood,

and aerosols are continuously generated (Kohn et al., 2003). The protection these measures offer, however, depends less on the existence of written guidelines than on whether workers understand them, value them, and apply them consistently in routine care.

Dental teams illustrate these challenges clearly. Hepatitis B virus transmission in dentistry has been described as a forgotten topic despite the availability of an effective vaccine (Mahboobi et al., 2010), and systematic evidence shows that adherence to infection control guidelines among dental personnel is inconsistent (Gordon et al., 2001). Needlestick and sharps injuries among dental care providers are shaped by individual characteristics and by practice-level factors, including compliance with protocols (Cheng et al., 2012).Dental assistants, who prepare instruments, process contaminated items, and work at close range to the operative field, are among the staff most exposed, yet they are less often the focus of research than dentists.

Emerging infectious diseases have repeatedly tested the preparedness of healthcare workers. Surveys conducted during the Middle East respiratory syndrome outbreaks in Saudi Arabia revealed uneven knowledge across healthcare workers (Alsahafi and Cheng, 2016), and during the COVID-19 pandemic, knowledge, attitude, and practice (KAP) surveys became a standard tool for gauging readiness across the health workforce (Zhang et al., 2020). The pandemic also disrupted dental practice internationally and exposed dental teams to heightened infection control demands (COVIDental Collaboration Group, 2021).

Infection prevention is, in practice, delivered by teams rather than by single professions. Nurses provide continuous patient care and perform most invasive bedside procedures; pharmacists prepare and dispense medicines, including sterile products, and increasingly contribute to infection prevention and antimicrobial stewardship; laboratory technologists handle blood, body fluids, and cultures daily; and dental assistants work chairside and reprocess dental instruments (Kohn et al., 2003). These groups share exposure pathways, but their education, regulation, supervision, and access to infection control resources differ considerably, so their knowledge, attitudes, and compliance would be expected to differ as well (Alhumaid et al., 2021).

Despite this, the available evidence is fragmented. Existing syntheses have treated healthcare workers as a single category and have highlighted gaps in knowledge of occupational vaccination, transmission, and sharps risks (Alhumaid et al., 2021), but they rarely separate the professions that are the subject of the present review, and most primary studies examine one profession or pool several together. Evidence from the Middle East, and from Saudi Arabia in particular, is growing but has not been integrated alongside international data that include dental assistants and pharmacists, two groups that are consistently under-represented.

This systematic review therefore aimed to synthesize published evidence on infection control knowledge, attitudes, and compliance among dental assistants, nurses, pharmacists, and laboratory technologists; to compare these groups where the data allow; and to identify the factors associated with better or worse performance. In doing so, it seeks to inform profession-specific training and policy and to define priorities for future research.

2. METHODS

2.1 Protocol and reporting

Reporting was guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (Page et al., 2021). The review was not registered in PROSPERO.

2.2 Review question and eligibility criteria

The review question was: among dental assistants, nurses, pharmacists, and laboratory technologists, what are the levels of infection control knowledge, attitudes, and compliance, and how do they differ between professions and settings?

- **Population:** dental assistants (including dental nurses and auxiliaries), nurses, pharmacists, and medical laboratory technologists or technicians (including dental laboratory technicians), working in clinical or laboratory settings. Studies of mixed healthcare workers were eligible when at least one target profession was explicitly included.
- **Intervention/exposure:** infection prevention and control (IPC) knowledge, attitudes, and practices; occupational exposure to infection hazards (needlestick and sharps injuries); hepatitis B vaccination; and IPC training.
- **Comparator:** between-profession comparisons (for example, target professions versus physicians or dentists) or comparisons across subgroups within a profession. Single-group studies were eligible for descriptive outcomes.

- **Outcomes:** primary, the proportion with adequate knowledge, positive attitude, and good practice or compliance; secondary, needlestick injury frequency, vaccination uptake, training coverage, perceived barriers, and factors associated with outcomes.
- **Study designs:** randomized controlled trials, cohort, case-control, cross-sectional, and case series studies.

2.3 Inclusion and exclusion criteria

Eligible reports were peer-reviewed, written in English, and published between 1 January 2009 and 31 January 2025 inclusive. The search date and the publication window are distinct. There was no geographic restriction. The supplementary searches focused on Saudi multi-profession studies and hospital pharmacy studies. Mixed-profession samples were eligible when at least one of the four target professions was explicitly represented and the report provided a relevant, extractable outcome.

Studies confined to students or trainees, and those reporting patient outcomes alone, were excluded. Reviews, editorials, letters, conference abstracts, case reports, exclusively qualitative reports, overlapping reports without distinct eligible data, and reports without an accessible full text were also excluded. An outcome was considered relevant if it addressed IPC knowledge, attitudes, practices, or an occupational outcome specified above. Outcomes for mixed samples were interpreted at the level at which they were reported.

2.4 Information sources and search strategy

The supplied study-selection flow documents the aggregate yield from databases and the separate contribution of other methods. Database names, platforms, execution dates, and database-specific yields could not be confirmed against the original exports. The draft also mentioned Google Scholar and reference-list screening, but neither source could be assigned a separate yield from the available documentation.

The supplementary update checked draft citations against journal and bibliographic records and used targeted web searching for Saudi multi-profession studies of COVID-19 knowledge, attitudes, and practices and for studies of hospital pharmacists. The publication cutoff applied to studies identified by both routes. Two supplementary reports were assessed in full and included.

The proposed PubMed strategy in the draft combined three concepts: infection control, knowledge or behavior, and healthcare occupations. The query below records that proposed strategy. Its execution could not be confirmed.

("infection control"[MeSH] OR "universal precautions"[MeSH] OR "standard precaution*" OR "infection prevention" OR "hand hygiene" OR "needlestick injur*" OR "sharps injur*") AND (knowledge OR attitude* OR practice* OR compliance OR adherence OR awareness) AND ("dental assistant*" OR "dental nurse*" OR "dental auxiliar*" OR nurse* OR pharmacist* OR "laboratory technolog*" OR "laboratory technician*" OR "dental technician*" OR "health personnel" OR "healthcare worker*") AND ("2009/01/01"[dp] : "2025/01/31"[dp]) AND english[la].

2.5 Study selection

Study selection distinguished bibliographic records at title and abstract screening from reports sought for full-text retrieval and studies entering the synthesis. The database flow supplied with the manuscript reports duplicate removal, title and abstract exclusions, retrieval, and full-text eligibility decisions. At full text, the reported exclusion categories concerned the target population, extractability of IPC data, or outcome evaluability. The two supplementary reports were assessed in full under the same eligibility criteria. Figure 1 reports the two routes separately. Reviewer assignment, independent duplicate screening, and resolution of disagreements could not be verified from the available screening documentation.

2.6 Data extraction

Study-level information recorded in Tables 1–3 included the first author, publication year, country and setting, study design and survey period where reported, sample size, professional composition, measurement instrument, and scoring threshold. Extracted outcomes included knowledge and attitude scores or proportions, practice and compliance measures, sharps injuries, vaccination, training, and reported barriers. The tables retain study-defined thresholds, effect estimates, confidence intervals, and recall periods where the reports supplied them.

Profession-specific results were used where the source gave a subgroup denominator or presented an occupational comparison. Estimates reported for the entire sample were attributed to the mixed workforce when profession-specific data were unavailable. Injury estimates were interpreted using the study's recall period and denominator, with injury reporting distinguished from injury occurrence.

2.7 Risk of bias assessment

Table 4 presents a provisional appraisal that covers how participants were recruited, how the outcomes were measured, and whether the analysis addressed confounding. Particular attention was given to nonprobability recruitment, self-report and recall, and the limitations of adjusted and unadjusted comparisons. The appraisal supports interpretation of the findings. Completion of an item-level Joanna Briggs Institute appraisal and independent duplicate assessment could not be verified (Munn et al., 2015; Moola et al., 2020).

2.8 Data synthesis

Findings were synthesized narratively by outcome and, when the data permitted, by profession. The synthesis distinguished knowledge, attitudes, reported practices, training or vaccination, and occupational exposures. Individual estimates were interpreted using their study-defined scoring thresholds and denominators. Within-study contrasts between professional groups were reported in their original setting. Differences between studies were considered in light of the instrument, workplace, sampling method, and exposure or recall period. Differences in these features precluded pooling.

2.9 Certainty of evidence

Certainty was considered qualitatively. Formal outcome-level ratings using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach were unavailable (Guyatt et al., 2008).

3. RESULTS

3.1 Study selection

The database stream comprised 1,800 records, of which 700 were removed as duplicates. Of 1,100 records screened, 1,060 were excluded at the title and abstract stage. Of 40 reports sought, 1 was unavailable and 39 were assessed in full. The 28 full-text exclusions left 11 database studies. Two additional full-text reports from targeted web searching were eligible, bringing the total to 13 studies (Figure 1).

Figure 1. PRISMA 2020 flow diagram of study selection via databases and other methods.

Identification	**Records identified from databases (n = 1,800)** Registers (n = 0)	→	**Records removed before screening** Duplicates (n = 700) Removed for other reasons (n = 0)
	↓		**Other methods** Targeted web searching Reports assessed in full (n = 2) Reports included (n = 2)
Screening	**Records screened (n = 1,100)**	→	**Records excluded at title and abstract (n = 1,060)**
	↓		
	Reports sought for retrieval (n = 40)	→	**Reports not retrieved (n = 1)**

	↓		
	Reports assessed for eligibility (n = 39)	→	**Reports excluded (n = 28)** Wrong population (n = 14) No extractable relevant IPC data (n = 8) Outcome not evaluable (n = 6)
	↓		
Included	**Studies included (n = 13)** Reports of included studies (n = 13)		**Database stream (n = 11)** Other methods (n = 2)

Database counts and exclusion reasons are from the supplied study-selection record. The two reports from other methods were assessed in full and included. The record did not give a separate automation count or database-specific yields. Adapted from the PRISMA 2020 flow diagram (Page et al., 2021).

3.2 Characteristics of the included studies

The 13 included studies (Haridi et al., 2016; AlDakhil et al., 2019; Saqlain et al., 2020; Rabbani and Al Saigul, 2021; Mahdi et al., 2021; Asdaq et al., 2021; Almohammed et al., 2021; Abalkhail et al., 2021; Aljohani and Sulaiman, 2021; Abalkhail et al., 2022; Amnuaiphanit et al., 2022; AlRasheed et al., 2021; Zeenny et al., 2020), published between 2016 and 2022, enrolled 4,755 participants in total (Table 1). All were cross-sectional surveys. Nine were conducted in Saudi Arabia (3,013 participants), two in Pakistan (484), one in Thailand (1,177), and one in Lebanon (81). Sample sizes ranged from 70 to 1,177 participants. Seven studies were published in 2021, and seven examined COVID-19-related knowledge, attitudes, or practices (Saqlain et al., 2020; Rabbani and Al Saigul, 2021; Asdaq et al., 2021; Almohammed et al., 2021; Amnuaiphanit et al., 2022; AlRasheed et al., 2021; Zeenny et al., 2020).

Dental assistants were studied exclusively in two studies (AlDakhil et al., 2019; Mahdi et al., 2021), together with dentists in one (Haridi et al., 2016), and together with other dental professionals in another (Amnuaiphanit et al., 2022). Professional representation varied across the studies (Table 3). Several studies pooled professions in their main analyses, which limited direct between-profession comparison.

3.3 Knowledge

Proportions with adequate or good knowledge were 93.2% among healthcare workers in Pakistan (Saqlain et al., 2020), 67.8% in a Saudi hospital sample (Almohammed et al., 2021), 67.6% in a university hospital in Qassim (Abalkhail et al., 2021), and 51.0% in primary health care in Buraidah (Aljohani and Sulaiman, 2021) (Table 2). Within the Saudi hospital sample, 83.6% of laboratory staff had adequate knowledge (Almohammed et al., 2021). Among dental assistants, 58.0% of those surveyed in Jeddah had poor knowledge (AlDakhil et al., 2019), and the Karachi sample obtained a mean knowledge score of 74.54 on asepsis and sterilization (Mahdi et al., 2021). In a nationwide COVID-19 survey, 81% of physicians but only 44% of non-physicians (a group that included nurses, pharmacists, and technologists) correctly knew that antibiotics are ineffective against the virus (Rabbani and Al Saigul, 2021). In the Saudi survey by AlRasheed et al. (2021), the median knowledge score was 8 out of 10 (IQR 7–9). In Lebanon, hospital pharmacists answered more than 90% of several basic knowledge items correctly (Zeenny et al., 2020).

3.4 Attitudes

Positive attitudes were reported by 72.2% of hospital workers in one Saudi study (Almohammed et al., 2021) and 61.5% in the Qassim study (Abalkhail et al., 2021), and by 89.6% of laboratory staff within the former (Almohammed et al., 2021). Thai dental professionals, including dental assistants, reported an average worry score above 4.1 out of 5, and more than 96% sought updated knowledge (Amnuaiphanit et al., 2022).

3.5 Practice and compliance

Good or appropriate practice was reported by 88.7% of Pakistani healthcare workers (Saqlain et al., 2020), 80.2% of Saudi hospital workers (Almohammed et al., 2021), and 73.2% of Qassim university hospital workers (Abalkhail et al., 2021). In the nationwide Saudi COVID-19 survey, 87.0% always cleaned their hands, but only 41.2% always wore a surgical mask at work (Rabbani and Al Saigul, 2021). Among Thai dental professionals, 86.7% adapted to the new infection control guidelines and 75.5% reported appropriate N95 respirator use (Amnuaiphanit et al., 2022). In Hail, 90.1% of dental workers reached the study threshold on the self-reported compliance scale (Haridi et al., 2016).

3.6 Occupational exposure, vaccination, and training

Needlestick and sharps injuries affected 29.8% of dental assistants in Jeddah, and the absence of an infection control unit in the clinic was associated with higher odds of injury (adjusted odds ratio [aOR] 2.28; 95% confidence interval [CI] 1.45–3.57) (AlDakhil et al., 2019). In a national hospital survey, the one-year incidence was 22.2% (95% CI 18.0–26.8), and 53.8% of injured respondents did not report their most recent injury; incidence was 36.0% among physicians, 34.8% among nurses, 29.2% among dentists, and 21.1% among medical technologists (Abalkhail et al., 2022). Hepatitis B vaccination coverage was 85.8% among Jeddah dental assistants, and 73.6% reported formal infection control training (AlDakhil et al., 2019), whereas 32.86% of Karachi dental assistants reported training in safe sharps handling to a great extent and 7.14% held a dental assistant diploma (Mahdi et al., 2021).

3.7 Profession-specific and comparative findings

In the Thai survey of dental professionals, the overall COVID-19 infection rate was 3.99%, compared with 2.30% in the general population, with the highest rate among dental assistants (13.16%, versus 1.12% among dentists); dental assistants also had lower odds of changing their protocols than dentists (aOR 0.39; 95% CI 0.19–0.83) (Amnuaiphanit et al., 2022). In Pakistan, pharmacists had higher odds of good practice (odds ratio 2.247; 95% CI 1.11–4.55), and limited infection control supplies were the most common barrier (50.7%) (Saqlain et al., 2020). Nurses in the Saudi hospital sample had less favorable attitudes but among the best practice scores (Almohammed et al., 2021), and laboratory staff reported high levels of knowledge (83.6%), attitude (89.6%), and practice (88.1%) in the same sample (Almohammed et al., 2021) and a lower reported one-year sharps injury proportion than nurses in the national injury survey (Abalkhail et al., 2022).

3.8 Factors associated with outcomes

Training was associated with better outcomes in the Qassim survey. In Qassim, training was associated with higher odds of good knowledge (aOR 13.3) and good practice (aOR 3.5) (Abalkhail et al., 2021). In Buraidah, younger age ($p = 0.020$) and non-Saudi nationality ($p < 0.001$) were associated with better knowledge (Aljohani and Sulaiman, 2021). Institutional factors were associated with compliance among dental workers in Hail (Haridi et al., 2016).

3.9 Synthesis and certainty of evidence

Although knowledge and practice proportions were available for several studies, cut-offs, item sets, and scoring systems differed (percent-correct thresholds, Likert means, and adherence indices), and professional subgroups were rarely reported separately. Pooled estimates would therefore not have been interpretable, and a narrative synthesis was used. Comparisons across professions remain uncertain owing to the observational design, reliance on self-reported outcomes and non-probability sampling, inconsistency in instruments and results, and indirectness arising from different infection control topics (standard precautions, COVID-19, and sharps injuries).

3.10 Risk of bias

Risk of bias is summarized in Table 4. One study was judged low to moderate risk (AlDakhil et al., 2019), seven moderate (Haridi et al., 2016; Asdaq et al., 2021; Almohammed et al., 2021; Abalkhail et al., 2021; Aljohani and Sulaiman, 2021; Abalkhail et al., 2022; Amnuaiphanit et al., 2022), and three moderate to high (Saqlain et al., 2020; Rabbani and Al Saigul, 2021; Mahdi et al., 2021), mainly because of non-probability online sampling, small samples, and self-reported outcomes. Two additional studies are described by bias domain in Table 4. Ratings are provisional.

Natural Resources for Human Health
eISSN: 2583-1194

Table 1. Characteristics of the included studies

Study (ref.)	Country / setting	Design and survey period	n	Professional groups included	Instrument and outcomes assessed
Haridi et al. (2016)	Saudi Arabia – Hail Region, dental facilities	Cross-sectional survey; 2014	307	Dentists and dental assistants	Self-administered questionnaire on compliance with standard precautions; response rate 73.1%
AlDakhil et al. (2019)	Saudi Arabia – Jeddah, 40 private dental clinics	Cross-sectional; June–September 2017	450	Dental assistants	Questionnaire on needlestick injury history, infection control knowledge, hepatitis B vaccination, and training
Saqlain et al. (2020)	Pakistan	Cross-sectional online survey; 2020	414	Physicians (120), pharmacists (189), nurses (105)	Questionnaire on COVID-19 knowledge, attitude, practice, and perceived barriers
Rabbani et al. (2021)	Saudi Arabia – nationwide	Cross-sectional online survey; March–April 2020	398	Physicians, dentists, nurses, laboratory/radiology/dental technologists, pharmacists, other staff	Questionnaire on COVID-19 knowledge, attitudes, and practices (hand hygiene, mask use)
Mahdi et al. (2021)	Pakistan – Karachi, private and hospital dental workplaces	Cross-sectional survey	70	Dental assistants	Questionnaire on knowledge, attitudes, and perceptions of dental asepsis and sterilization; response rate 66.6%
Asdaq et al. (2021)	Saudi Arabia – Riyadh	Cross-sectional survey	146	Physicians (74), nurses (44), pharmacists (28)	Validated questionnaire on COVID-19 knowledge, attitude, and practice
Almohammed et al. (2021)	Saudi Arabia – hospitals	Cross-sectional online survey; 2020	510	Physicians, nurses, pharmacists, laboratory technicians, non-medical staff	Questionnaire on COVID-19 knowledge, attitudes, and practices
Abalkhail et al. (2021)	Saudi Arabia – Qassim, university hospital	Cross-sectional survey	213	Physicians, dentists, nurses, pharmacists, technologists (respondent breakdown not extracted)	Questionnaire on knowledge, attitude, and practice of standard infection control precautions
Aljohani and Sulaiman (2021)	Saudi Arabia – Buraidah, primary health care	Cross-sectional survey	200	Doctors, nurses, laboratory workers	Questionnaire on knowledge and practice of standard precautions
Abalkhail et al. (2022)	Saudi Arabia – hospitals	Cross-sectional online survey	361	Medical technologists, nurses, dentists, pharmacists, physicians	Questionnaire on needlestick and sharps injuries: incidence, reporting, associated factors

Study (ref.)	Country / setting	Design and survey period	n	Professional groups included	Instrument and outcomes assessed
Amnuaiphanit et al. (2022)	Thailand – public and private dental facilities	Online cross-sectional survey, convenience sampling; September–October 2021	1,177	Dentists, dental nurses, dental assistants, dental technicians	Questionnaire on COVID-19 perception, infection control practice changes, infection and vaccination history
AlRasheed et al. (2021)	Saudi Arabia	Cross-sectional survey, beginning June 2020	428	50 pharmacists and 378 other healthcare professionals	COVID-19 knowledge, attitude and practice questionnaire
Zeenny et al. (2020)	Lebanon – hospital pharmacies	Cross-sectional online survey	81	Hospital pharmacists	COVID-19 knowledge, attitudes, reported practice and preparedness

n, number of participants. Professional counts are shown only where reported in the abstract or text.

Table 2. Key findings of the included studies

Study (ref.)	Knowledge	Attitudes	Practice / compliance	Other quantified outcomes
Haridi et al. (2016)	Not extracted	Not extracted	90.1% reached the 75% self-reported compliance threshold.	Institutional factors associated with compliance; dental assistants and private-sector staff flagged for attention
AlDakhil et al. (2019)	Poor knowledge: 58.0%	–	Hepatitis B vaccinated: 85.8%; formal infection control training: 73.6%	Needlestick/sharps injury prevalence: 29.8%; no infection control unit: aOR 2.28 (95% CI 1.45–3.57)
Saqlain et al. (2020)	Good knowledge: 93.2% (386/414)	Assessed; proportion not extracted	Good practice: 88.7% (367/414)	Pharmacists more likely to have good practice: OR 2.247 (95% CI 1.11–4.55); limited infection control supplies as barrier: 50.7%
Rabbani et al. (2021)	Knew antibiotics are ineffective against COVID-19: physicians 81% vs non-physicians 44% (p<0.001)	Not extracted	Always cleaned hands: 87.0%; always wore surgical mask at work: 41.2%	–
Mahdi et al. (2021)	Mean knowledge score 74.54 (range 24–96); private 76.30 vs hospital 74.25 (p=0.005) (scale as reported)	Assessed; not extracted	–	Reported extensive training in safe sharps handling: 32.86%; held dental assistant diploma: 7.14%

Study (ref.)	Knowledge	Attitudes	Practice / compliance	Other quantified outcomes
Asdaq et al. (2021)	Mean score 11.43 (SD 1.34)	Mean score 3.89 (SD 0.93)	Mean score 3.85 (SD 0.81)	Knowledge–attitude correlation r = 0.172 (as reported)
Almohammed et al. (2021)	Adequate knowledge: 67.8%; laboratory services: 56/67 (83.6%)	Positive attitude: 72.2%; laboratory services: 60/67 (89.6%)	Appropriate practice: 80.2%; laboratory services: 59/67 (88.1%)	Nursing department: positive attitude 52/89 (58.4%); appropriate practice 87/89 (97.8%).
Abalkhail et al. (2021)	Good knowledge: 67.6%	Good attitude: 61.5%	Good practice: 73.2%	Training associated with knowledge (aOR 13.3) and practice (aOR 3.5)
Aljohani and Sulaiman (2021)	Adequate knowledge: 51.0% (102/200)	–	Not extracted	Trained in previous 3 years: 68.5%; younger and non-Saudi staff had better knowledge (p=0.020)
Abalkhail et al. (2022)	–	–	–	One-year needlestick/sharps incidence 22.2% (95% CI 18.0–26.8); 43/80 injured respondents (53.8%) did not report their most recent injury; by profession: physicians 36.0%, nurses 34.8%, dentists 29.2%, medical technologists 21.1%; handling sharps: OR 5.9 (95% CI 2.69–12.97)
Amnuaiphanit et al. (2022)	Information from social media: 91.8%	Mean worry score >4.1/5; >96% sought updated knowledge	Adapted to new guidelines: 86.7%; appropriate N95 use: 75.5%	COVID-19 infection 3.99% (general population 2.30%); dental assistants 13.16% vs dentists 1.12%; dental assistants changing protocols vs dentists: aOR 0.39 (95% CI 0.19–0.83)
AlRasheed et al. (2021)	Median 8/10 (IQR 7–9)	Median 76/80 (IQR 70–80)	Median 74/80 (IQR 68–78)	Scores shown for the whole sample.
Zeenny et al. (2020)	More than 90% correct on several basic items	Concern about occupational and household exposure	Approximately 67% reported following safety recommendations	Shortages and delays in obtaining masks and sanitizers

aOR, adjusted odds ratio; CI, confidence interval; OR, odds ratio; SD, standard deviation. Dashes indicate that the outcome was not assessed or not reported.

Table 3. Professional groups represented and principal conclusions

Study (ref.)	Dental team	Nursing	Pharmacy	Laboratory	Principal conclusion / implication
Haridi et al. (2016)	● (assistants)	–	–	–	Dental healthcare workers reported high compliance with standard precautions; institutional factors mattered, and dental assistants and private-sector staff warrant targeted attention.
AlDakhil et al. (2019)	● (assistants)	–	–	–	Needlestick injuries were common among dental assistants, with knowledge gaps and the lack of an infection control unit as modifiable factors; targeted training is warranted.
Saqlain et al. (2020)	–	●	●	–	Knowledge and practice were generally good despite supply barriers; pharmacists were more likely to report good practice.
Rabbani et al. (2021)	● (dentists, dental technicians)	●	●	●	Large knowledge differences between physicians and other staff, and inconsistent mask use despite high hand hygiene, point to the need for role-specific education.
Mahdi et al. (2021)	● (assistants)	–	–	–	Dental assistants showed moderate knowledge of asepsis and sterilization with limited formal sharps training; structured training and credentialing are needed.
Asdaq et al. (2021)	–	●	●	–	Healthcare professionals showed good knowledge, positive attitudes, and good practice; continued training is recommended.
Almohammed et al. (2021)	–	●	●	●	Adequate knowledge, positive attitudes, and appropriate practice predominated; continuous infection control training and support for staff with lower education are recommended.
Abalkhail et al. (2021)	● (dentists)	●	●	●	Knowledge, attitude, and practice were acceptable but incomplete; training was the strongest modifiable factor.
Aljohani and Sulaiman (2021)	–	●	–	●	Only about half of primary care staff had adequate knowledge; periodic refresher training is warranted.
Abalkhail et al. (2022)	● (dentists)	●	●	●	Needlestick injuries were frequent and under-reported across hospital professions, highlighting the need for reporting systems and safety-device training.

Study (ref.)	Dental team	Nursing	Pharmacy	Laboratory	Principal conclusion / implication
Amnuaiphanit et al. (2022)	● (assistants, nurses, dentists)	● (dental nurses)	–	● (dental technicians)	Dental teams broadly adopted enhanced infection control, but dental assistants carried the highest infection burden and were less likely to adapt protocols.
AlRasheed et al. (2021)	–	–	●	–	Included pharmacists and comparison healthcare occupations.
Zeenny et al. (2020)	–	–	●	–	Hospital pharmacists reported preparedness measures and supply constraints.

● group named in the study sample (counts only where stated in Table 1); ○ eligible workforce category, respondent numbers not confirmed; – not included. "Dental team" denotes dental assistants, dental nurses, dentists, or dental technicians, as indicated. Conclusions are paraphrased from the reported abstracts and results.

Table 4. Risk of bias of the included studies (Joanna Briggs Institute criteria)

Study (ref.)	Sampling and response	Measurement of outcomes	Confounding and analysis	Overall (provisional)	Appraisal basis
Haridi et al. (2016)	Moderate: regional sample; response 73.1%	Moderate: self-reported compliance; validity not extracted	Unclear	Moderate	Abstract and secondary sources
AlDakhil et al. (2019)	Low: 40 clinics, n=450	Moderate: self-reported injuries and knowledge (recall)	Low: adjusted odds ratios reported	Low–moderate	Full text
Saqlain et al. (2020)	High: online, non-probability	Moderate: investigator-designed instrument	Low–moderate: odds ratios reported	Moderate–high	Abstract and preprint
Rabbani et al. (2021)	High: online convenience sample	Moderate: self-reported	Moderate: group comparisons	Moderate–high	Full text
Mahdi et al. (2021)	Moderate: n=70; response 66.6%	Moderate: self-reported	Unclear: descriptive and group comparison	Moderate–high	Full text
Asdaq et al. (2021)	Moderate: n=146	Moderate: validated instrument per authors	Moderate: bivariate analyses only	Moderate	Abstract

Study (ref.)	Sampling and response	Measurement of outcomes	Confounding and analysis	Overall (provisional)	Appraisal basis
Almohammed et al. (2021)	High: online	Moderate: self-reported	Low–moderate: multivariable regression	Moderate	Full text consulted for reported outcomes
Abalkhail et al. (2021)	Moderate: single institution	Moderate: self-reported	Low: multivariable analysis	Moderate	Abstract
Aljohani and Sulaiman (2021)	Low–moderate: random selection of primary care staff	Moderate: self-reported	Unclear	Moderate	Abstract
Abalkhail et al. (2022)	High: online	Moderate: recall of injuries	Low–moderate: odds ratios reported	Moderate	Full text consulted for reported outcomes
Amnuaiphanit et al. (2022)	High: online convenience sampling	Moderate: self-reported	Low: adjusted odds ratios	Moderate	Full text
AlRasheed et al. (2021)	Online cross-sectional sample	Self-reported KAP scores	Adjusted associations reported; residual confounding possible	Provisional	Full text
Zeenny et al. (2020)	Small online survey sample	Self-reported practices	Mainly descriptive; selection and confounding possible	Provisional	Full text

Ratings summarize the available information for each study. A complete item-level JBI assessment and independent duplicate appraisal could not be verified (Munn et al., 2015; Moola et al., 2020).

4. DISCUSSION

Infection prevention in clinical and laboratory environments is a shared responsibility, and its success depends on whether each member of the team understands the routes of transmission, values protective measures, and applies them consistently. This review examined these three dimensions among dental assistants, nurses, pharmacists, and laboratory technologists, four groups that share exposure to patients, body fluids, and contaminated instruments but differ in training pathways, supervision, and daily tasks. Taken together, the evidence shows that most workers in these groups have a reasonable foundation of knowledge and favorable attitudes, but that the strength of this foundation varies by profession, by setting, and by access to training.

A consistent finding was that self-reported practice was usually better than knowledge, and that good knowledge did not guarantee good compliance. This dissociation has been described in nurses by Batran et al. (2018), who found that most nurses practiced well even though fewer than half demonstrated good knowledge, and the systematic review of Alhumaid et al. (2021) similarly concluded that gaps in knowledge of occupational vaccination, transmission routes, and sharps risks coexist with variable compliance. Practice tends to be driven by routine, institutional protocols, and the visible presence of supplies and supervision, whereas knowledge reflects formal education and refresher training that many workers never receive. In the Pakistani survey, limited infection control supplies were a frequently reported barrier (Saqlain et al., 2020). These findings suggest that workplace resources may influence practice alongside individual knowledge.

Several studies identified specific infection prevention gaps among dental assistants. They showed important knowledge deficits, limited formal training in safe sharps handling, and a high burden of needlestick injury, and in the Thai survey they were less likely than dentists to modify their protocols and carried the greatest burden of infection (Amnuaiphanit et al., 2022; AlDakhil et al., 2019; Mahdi et al., 2021). These results agree with the Jordanian survey of Mahasneh et al. (2020), in which dental support staff showed lower compliance with infection control guidelines than dentists and a considerably larger share were unvaccinated against hepatitis B, and they reinforce the concern about hepatitis B in dentistry raised by Mahboobi et al. (2010) and the inconsistent adherence documented by Gordon et al. (2001). They partly conflict, however, with the French survey of Jungo et al. (2021), in which dental assistants had a lower infection rate than dentists; differences in national pandemic policies, supply of protective equipment, and the proportion of aerosol-generating procedures performed may explain this discrepancy. Several mechanisms plausibly explain the vulnerability of dental assistants observed here. Assistants perform much of the chairside instrument handling, decontamination, and surface disinfection, tasks with the greatest contact with sharps and contaminated materials, yet they often enter practice without standardized credentials, and their training depends on the employer, particularly in private clinics. They also work at close range to the operative field, where aerosols and splatter are generated, and respirator reuse, the absence of fit testing, and the lack of a dedicated infection control unit leave them with weaker organizational protection.

Nurses showed a different profile. Their practice scores were generally among the best, even when attitudes were less favorable and needlestick injuries remained frequent (**Almohammed et al.**, 2021; **Abalkhail et al.**, 2022). The strong practice scores probably reflect the protocolized, supervised, and repetitive nature of bedside care, in which hand hygiene, glove use, and device handling are embedded in daily workflows and audited by infection control teams. The frequent injuries, in turn, reflect the volume of injections, cannulations, and sharps handled per shift and the pressure of time. These observations are consistent with those of **Batran et al.** (2018) and suggest that, for nurses, the priority is not general awareness but safer devices, workload management, and a culture of reporting.

Pharmacists were consistently represented with good knowledge and practice. In the included studies they were more likely than comparison groups to demonstrate good practice (Saqlain et al., 2020), and hospital pharmacists in Lebanon likewise answered most knowledge items correctly and mostly followed recommended precautions, although shortages of masks and sanitizers constrained them, as reported by **Zeenny et al.** (2020). Their strong performance probably reflects a curriculum rich in microbiology and pharmacology and comparatively limited direct exposure to blood and sharps. Knowledge can nevertheless be topic specific: **Sallam et al.** (2022) reported variation in mpox knowledge by occupational group among healthcare workers in Jordan. Good general knowledge among pharmacists should therefore not be assumed to extend to every emerging threat.

Laboratory technologists generally showed strong knowledge and good practice and reported a lower frequency of needlestick injury than physicians, nurses, and dentists (Almohammed et al., 2021; Abalkhail et al., 2022). Specimen-handling routines, biosafety cabinets, standard operating procedures, and accreditation requirements promote disciplined behavior and probably account for this advantage. Yet, **Halatoko et al.** (2024), studying laboratory professionals in Togo, reported that fewer than half had good knowledge even though practice was better, and that training improved knowledge but not attitudes or practice. This partly conflicts with the favorable laboratory findings here and underscores that laboratory performance depends heavily on the resources and regulatory environment of the setting, and that training alone may not change practice when equipment and supervision are inadequate.

Across professions, training was the most consistent modifiable determinant. Structured training was strongly associated with better knowledge and, to a lesser extent, practice in the hospital study from Qassim (**Abalkhail et al.**, 2021), and institutional factors shaped compliance among dental teams in Hail (**Haridi et al.**, 2016). Differences between professions also reflect educational background: **Alsahafi and Cheng** (2016) reported that physicians had better knowledge of MERS coronavirus than other healthcare workers, which parallels the knowledge gap between physicians and non-physician staff in the nationwide COVID-19 survey of **Rabbani et al** (Rabbani and Al Saigul, 2021).. Such gaps are likely to arise because medical curricula devote more time to microbiology and transmission, whereas the education of assistants and technicians is more task oriented and less standardized.

The strengths of this review include its deliberately cross-professional scope, an international evidence base that complements regional data, and an explicit discussion of study limitations. Its limitations reflect those of the primary literature: the included studies were cross-sectional, depended on self-reported outcomes and often on non-probability online sampling, used

heterogeneous instruments and cut-offs that prevented pooling, were concentrated in one country and in the early pandemic period, and seldom reported results separately for each profession. Self-reported compliance is also vulnerable to social desirability, which may affect the accuracy of adherence estimates. These considerations mean that between-profession differences should be interpreted as signals rather than precise estimates. Future research should use standardized, validated instruments, report outcomes by profession, include direct observation of compliance, and test whether role-specific, competency-based training changes behavior and injury rates. In practice, employers and regulators should prioritize credentialed training and secure supplies for dental assistants, safer devices and reporting systems for nurses, and resource-supported biosafety programs for pharmacy and laboratory staff. The absence of database-specific search strategies, dates, and record-level screening documentation limits reproducibility and makes it difficult to assess the completeness of study identification. The study-level risk-of-bias judgments are provisional.

5. CONCLUSION

Across 13 cross-sectional studies, gaps in infection prevention and control knowledge, reported practices, and sharps safety varied by profession and work setting. Studies of dental assistants identified gaps in training and documented sharps injuries, while hospital surveys reported differences in injury frequency and self-reported practices across occupational groups. Variation in sampling, measurement tools, and recall periods limited direct comparisons between professions. Healthcare organizations should assess training and sharps-safety needs by role and setting. Future studies should use validated measures, report profession-specific denominators, and combine self-reports with direct observation to evaluate whether targeted training improves adherence to infection prevention practices.

FUNDING

No external funding was received for this work.

ACKNOWLEDGEMENTS

None.

AUTHOR CONTRIBUTIONS

All authors equally contributed to this work (Conceptualization, Methodology, Data Curation, Formal Analysis, Writing – Original Draft, Writing – Review & Editing, and Supervision).

CONFLICT OF INTEREST

The authors declare no conflict of interest.

Ethics Statement

This study is a systematic review of previously published, de-identified data and did not involve new human or animal subjects; formal ethics approval was therefore not required.

Data Availability Statement

The data extraction tables supporting this review are available from the corresponding author upon reasonable request. All included studies are publicly available in the cited peer-reviewed sources.

REFERENCES

[1] Abalkhail, A., Al Imam, M.H., Elmosaad, Y.M., et al., 2021. 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 18(22), 11831.

[2] Abalkhail, A., Kabir, R., Elmosaad, Y.M., et al., 2022. Needle-stick and sharp injuries among hospital healthcare workers in Saudi Arabia: a cross-sectional survey. Int J Environ Res Public Health 19(10), 6342. https://doi.org/10.3390/ijerph19106342

[3] AlDakhil, L., Yenugadhati, N., Al-Seraihi, O., Al-Zoughool, M., 2019. Prevalence and associated factors for needlestick and sharp injuries (NSIs) among dental assistants in Jeddah, Saudi Arabia. Environ Health Prev Med 24, 60. https://doi.org/10.1186/s12199-019-0815-7

[4] Alhumaid, S., Al Mutair, A., Al Alawi, Z., Alsuliman, M., Ahmed, G.Y., Rabaan, A.A., et al., 2021. Knowledge of infection prevention and control among healthcare workers and factors influencing compliance: a systematic review. Antimicrob Resist Infect Control 10, 86. https://doi.org/10.1186/s13756-021-00957-0

[5] Aljohani, H.S., Sulaiman, A.A., 2021. Assessment of health care workers' knowledge and practice toward infection standard precautions in primary health care setting, Buraidah, Saudi Arabia. World Fam Med 19(8), 81–90. https://doi.org/10.5742/MEWFM.2021.940103

[6] Almohammed, O.A., Aldwihi, L.A., Alragas, A.M., Almoteer, A.I., Gopalakrishnan, S., Alqahtani, N.M., 2021. Knowledge, attitude, and practices associated with COVID-19 among healthcare workers in hospitals: a cross-sectional study in Saudi Arabia. Front Public Health 9, 643053. https://doi.org/10.3389/fpubh.2021.643053

[7] AlRasheed, M.M., AlShahrani, A.H., AlMuhaini, S.A., AlKofide, H.A., Alhawassi, T.M., Aldemerdash, A., et al., 2021. Knowledge, attitude, and practice towards COVID-19 among pharmacists: a cross-sectional study. Risk Manag Healthc Policy 14, 3079–3090. https://doi.org/10.2147/RMHP.S317779

[8] Alsahafi, A.J., Cheng, A.C., 2016. Knowledge, attitudes and behaviours of healthcare workers in the Kingdom of Saudi Arabia to MERS coronavirus and other emerging infectious diseases. Int J Environ Res Public Health 13(12), 1214.

[9] Amnuaiphanit, P., Thumbuntu, T., Gaewkhiew, P., Ampornaramveth, R.S., 2022. Paradigm shift in infection control practices in dental clinics in response to COVID-19 among dental professionals in Thailand. Front Oral Health 3, 979600. https://doi.org/10.3389/froh.2022.979600

[10] Asdaq, S.M.B., Alshrari, A.S., Imran, M., Sreeharsha, N., Sultana, R., 2021. Knowledge, attitude and practices of healthcare professionals of Riyadh, Saudi Arabia towards COVID-19: a cross-sectional study. Saudi J Biol Sci 28(9), 5275–5282.

[11] Batran, A., Ayed, A., Salameh, B., Ayoub, M., Fasfous, A., 2018. Are standard precautions for hospital-acquired infection among nurses in public sector satisfactory? Arch Med Health Sci 6(2), 223–227. https://doi.org/10.4103/amhs.amhs_84_18

[12] Cheng, H.C., Su, C.Y., Yen, A.M., Huang, C.F., 2012. Factors affecting occupational exposure to needlestick and sharps injuries among dentists in Taiwan: a nationwide survey. PLoS One 7(4), e34911.

[13] COVIDental Collaboration Group, 2021. The COVID-19 pandemic and its global effects on dental practice. An international survey. J Dent 114, 103749.

[14] Gordon, B.L., Burke, F.J., Bagg, J., Marlborough, H.S., McHugh, E.S., 2001. Systematic review of adherence to infection control guidelines in dentistry. J Dent 29(8), 509–516.

[15] Guyatt, G.H., Oxman, A.D., Vist, G.E., Kunz, R., Falck-Ytter, Y., Alonso-Coello, P., et al., 2008. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. BMJ 336(7650), 924–926.

[16] Halatoko, W.A., Sondou, E., Sopoh, G.E., Kassegne, A., Katawa, G., Salou, M., et al., 2024. Knowledge, attitudes and practices in biosafety and biosecurity in medical biology laboratories in Togo, 2021. Front Environ Health 3, 1387476. https://doi.org/10.3389/fenvh.2024.1387476

[17] Haridi, H.K., Al-Ammar, A.S., Al-Mansour, M.I., 2016. Compliance with infection control standard precautions guidelines: a survey among dental healthcare workers in Hail Region, Saudi Arabia. J Infect Prev 17(6), 268–276.

[18] Jungo, S., Moreau, N., Mazevet, M.E., Ejeil, A.L., Biosse Duplan, M., Salmon, B., et al., 2021. Prevalence and risk indicators of first-wave COVID-19 among oral health-care workers: a French epidemiological survey. PLoS One 16(2), e0246586.

[19] Kohn, W.G., Collins, A.S., Cleveland, J.L., Harte, J.A., Eklund, K.J., Malvitz, D.M., 2003. Guidelines for infection control in dental health-care settings—2003. MMWR Recomm Rep 52(RR-17), 1–61.

[20] Mahasneh, A.M., Alakhras, M., Khabour, O.F., Al-Sa'di, A.G., Al-Mousa, D.S., 2020. Practices of infection control among dental care providers: a cross sectional study. Clin Cosmet Investig Dent 12, 281–289. https://doi.org/10.2147/CCIDE.S261171

[21] Mahboobi, N., Agha-Hosseini, F., Mahboobi, N., Safari, S., Lavanchy, D., Alavian, S.M., 2010. Hepatitis B virus infection in dentistry: a forgotten topic. J Viral Hepat 17(5), 307–316.

[22] Mahdi, S.S., Ahmed, Z., Allana, R., et al., 2021. Knowledge, attitudes, and perceptions of dental assistants regarding dental asepsis and sterilization in the dental workplace. Int J Dent 2021, 5574536. https://doi.org/10.1155/2021/5574536

[23] Moola, S., Munn, Z., Tufanaru, C., Aromataris, E., Sears, K., Sfetcu, R., et al., 2020. Chapter 7: Systematic reviews of etiology and risk. In: Aromataris, E., Munn, Z. (Eds.), JBI Manual for Evidence Synthesis. Adelaide: JBI.

[24] Munn, Z., Moola, S., Lisy, K., Riitano, D., Tufanaru, C., 2015. Methodological guidance for systematic reviews of observational epidemiological studies reporting prevalence and cumulative incidence data. Int J Evid Based Healthc 13(3), 147–153.

[25] Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., et al., 2021. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 372, n71. https://doi.org/10.1136/bmj.n71

[26] Prüss-Üstün, A., Rapiti, E., Hutin, Y., 2005. Estimation of the global burden of disease attributable to contaminated sharps injuries among health-care workers. Am J Ind Med 48(6), 482–490.

[27] Rabbani, U., Al Saigul, A.M., 2021. Knowledge, attitude and practices of health care workers about corona virus disease 2019 in Saudi Arabia. J Epidemiol Glob Health 11(1), 60–68. https://doi.org/10.2991/jegh.k.200819.002

[28] Rapiti, E., Prüss-Üstün, A., Hutin, Y., 2005. Sharps injuries: assessing the burden of disease from sharps injuries to health-care workers at national and local levels. Environmental Burden of Disease Series, No. 11. Geneva: World Health Organization.

[29] Sallam, M., Al-Mahzoum, K., Al-Tammemi, A.B., Alkurtas, M., Mirzaei, F., Kareem, N., et al., 2022. Assessing healthcare workers' knowledge and their confidence in the diagnosis and management of human monkeypox: a cross-sectional study in a Middle Eastern country. Healthcare (Basel) 10(9), 1722. https://doi.org/10.3390/healthcare10091722

[30] Saqlain, M., Munir, M.M., Rehman, S.U., Gulzar, A., Naz, S., Ahmed, Z., et al., 2020. Knowledge, attitude, practice and perceived barriers among healthcare workers regarding COVID-19: a cross-sectional survey from Pakistan. J Hosp Infect 105(3), 419–423. https://doi.org/10.1016/j.jhin.2020.05.007

[31] Siegel, J.D., Rhinehart, E., Jackson, M., Chiarello, L., Healthcare Infection Control Practices Advisory Committee, 2007. 2007 guideline for isolation precautions: preventing transmission of infectious agents in health care settings. Am J Infect Control 35(10 Suppl 2), S65–S164.

[32] Zeenny, R.M., Ramia, E., Akiki, Y., Hallit, S., Salameh, P., 2020. Assessing knowledge, attitude, practice, and preparedness of hospital pharmacists in Lebanon towards COVID-19 pandemic: a cross-sectional study. J Pharm Policy Pract 13, 54. https://doi.org/10.1186/s40545-020-00266-8

[33] Zhang, M., Zhou, M., Tang, F., Wang, Y., Nie, H., Zhang, L., et al., 2020. Knowledge, attitude, and practice regarding COVID-19 among healthcare workers in Henan, China. J Hosp Infect 105(2), 183–187.