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Knowledge, Attitudes, and Practices of Standard Infection Control Precautions Among Laboratory Specialists, Dentists, Nurses, and Echocardiography Technologists in a Saudi Tertiary Hospital

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Abstract:
Background: Standard infection control precautions are essential to prevent healthcare-associated infections, yet gaps between policy and daily practice remain. Multidisciplinary evidence from laboratory specialists, dentists, nurses, and echocardiography technologists in Saudi tertiary hospitals is limited.
Objective: To assess knowledge, attitudes, and self-reported practices (KAP) regarding standard infection control precautions among four professional groups in a Saudi tertiary hospital, and to identify factors associated with good practice.
Methods: A cross-sectional survey was conducted from January to June 2025 in a tertiary hospital in Saudi Arabia. A structured, self-administered questionnaire measured sociodemographic characteristics, knowledge of standard precautions, attitudes towards infection control, self-reported practices, and perceived barriers. Laboratory specialists, dentists, nurses, and echocardiography technologists with at least three months of employment and direct patient or specimen contact were eligible. KAP scores were summarised and compared across professions. Multivariable logistic regression was used to identify factors associated with good practice (practice score ≥75%).
Results: Of 440 eligible staff, 420 completed the questionnaire (response rate 95.5%): 140 nurses, 110 laboratory specialists, 90 dentists, and 80 echocardiography technologists. The mean knowledge score was 72.3% (SD 11.9); 42.1% had good knowledge (≥75%). The mean attitude score was 4.1 (SD 0.5) on a 5-point scale, indicating generally positive attitudes. The mean practice score was 69.2% (SD 13.7), and 38.6% achieved good practice. Knowledge, attitude, and practice scores differed significantly between professions, with echocardiography technologists showing the lowest mean values. Knowledge and practice were moderately correlated ($r = 0.41$, $p < 0.001$). In multivariable analysis, good knowledge, more positive attitudes, and recent infection control training were independently associated with good practice, while echocardiography technologists had lower odds of good practice compared with nurses.
Conclusion: In this Saudi tertiary hospital, laboratory specialists, dentists, nurses, and echocardiography technologists showed moderate knowledge, positive attitudes, but only fair self-reported adherence to standard infection control precautions, with notable gaps among echocardiography technologists. Targeted, profession-specific training, together with system-level support and a stronger safety culture, is needed to improve compliance and support infection prevention efforts.

INTRODUCTION

Hospital-acquired infections (HAIs) are a major cause of preventable morbidity, mortality, and healthcare costs worldwide. Standard infection control precautions, such as hand hygiene, appropriate use of personal protective equipment (PPE), safe handling of sharps, and effective environmental and equipment decontamination, are the cornerstone measures to reduce transmission of infectious agents in healthcare settings (WHO, 2009; Siegel et al., 2007). Despite the availability of comprehensive international guidelines, including the World Health Organization (WHO) "Guidelines on Hand Hygiene in Health Care" and the Centers for Disease Control and Prevention (CDC) guideline on isolation precautions, adherence to standard precautions among healthcare workers remains suboptimal in many settings (WHO, 2009; Siegel et al., 2007).

In Saudi Arabia, the Ministry of Health (MoH) has issued national infection prevention and control (IPC) policies and service-specific manuals that emphasise implementation of standard precautions across all healthcare facilities, including acute hospitals, rehabilitation services, and dental settings (Saudi Ministry of Health, 2018; Saudi Ministry of Health, 2023). These guidelines highlight the need for regular training, monitoring, and audit of IPC compliance as part of national efforts to reduce HAIs and combat antimicrobial resistance. However, as in other countries, local studies suggest that gaps persist between policy and practice, and that healthcare workers' knowledge, attitudes, and practices (KAP) towards infection control are variable across professions and clinical areas (Abalkhail et al., 2021; Al-Qahtani, 2023).

Several survey-based studies from Saudi Arabia have examined KAP regarding standard infection control precautions among healthcare workers. In a university hospital in Qassim, Abalkhail et al. (2021) reported generally good knowledge of standard precautions, but less satisfactory practice scores, especially for hand hygiene and safe disposal of sharps. A study in Najran found that nurses' knowledge and attitudes towards hand hygiene were relatively high, yet self-reported and observed compliance did not always reach recommended levels, and was influenced by workload and safety culture (Al-Qahtani, 2023). More recently, research among medical students at a tertiary hospital in Riyadh also showed important gaps in understanding and applying standard precautions, despite formal teaching (Al-Maqbali et al., 2024). Together, these findings indicate that simply having guidelines and training is not sufficient, and that ongoing assessment of KAP is needed in different professional groups.

The risk of exposure to blood, body fluids, and contaminated equipment is particularly important for laboratory specialists, dentists, nurses, and echocardiography technologists. Clinical laboratory workers are routinely exposed to biohazards such as needlestick injuries, specimen spills, and aerosol-generating procedures; a study from Al-Madinah showed that although most staff were aware of biosafety principles, actual adherence to biosafety measures and reporting of injuries was incomplete (Khabour et al., 2018). Dental personnel and dental laboratory technicians are also at high risk of cross-infection through contact with saliva, blood, sharp instruments, and contaminated impressions or prostheses. In Riyadh, Al-Aali et al. (2021) found that less than half of dental laboratory technicians had infection control manuals displayed or had received structured infection control training, and vaccination and reporting practices were suboptimal (Al-Aali et al., 2021).

Echocardiography technologists share similar infection risks through close patient contact and repeated use of ultrasound probes and coupling gel. International surveys have demonstrated wide variability in cleaning and disinfection practices for echocardiographic and other ultrasound probes, and highlighted gaps in adherence to recommended high-level disinfection between patients, especially for transoesophageal and transvaginal probes (Nyhsen et al., 2016; Westerway et al., 2019). Recent reviews and professional guidance documents stress that inappropriate or inconsistent decontamination of probes

can contribute to healthcare-associated infections and recommend standardised protocols and staff education (Shokoohi et al., 2015; AIUM, 2013). Nurses, who provide continuous bedside care, perform invasive procedures, and manage PPE and isolation precautions, are central to IPC implementation and often act as role models for other staff; however, as noted above, even among nurses hand hygiene and other practices may not always meet guideline standards (Al-Qahtani, 2023).

Although these studies provide important insights, most have focused on single professional groups (such as nurses, dentists, or medical students) or on specific domains like hand hygiene or biosafety, rather than examining standard infection control precautions across multiple diagnostic and clinical professions within the same institution. There is limited evidence from Saudi tertiary hospitals comparing KAP of standard precautions among laboratory specialists, dentists, nurses, and echocardiography technologists, despite their complementary roles in patient care and shared responsibility for preventing HAIs. Understanding similarities and differences in knowledge, attitudes, and practices between these groups may help infection prevention teams tailor education, policies, and monitoring strategies more effectively. Therefore, a multidisciplinary, survey-based assessment of KAP regarding standard infection control precautions among laboratory specialists, dentists, nurses, and echocardiography technologists in a Saudi tertiary hospital is warranted. Such a study can identify specific strengths and gaps in infection control behaviour in each profession, support targeted interventions, and contribute to strengthening the overall infection prevention culture within the hospital.

METHODS

Study Design and Setting

This was a cross-sectional, survey-based study conducted in a tertiary care hospital in Saudi Arabia. The hospital provides inpatient and outpatient services and includes clinical laboratory services, dental clinics, echocardiography laboratories, and general nursing units. Data were collected over a six-month period from January 1 to June 30, 2025.

Study Population and Eligibility Criteria

The target population included four professional groups working in the hospital:

- Laboratory specialists
- Dentists
- Nurses
- Echocardiography technologists

Staff were eligible if they:

1. Were employed in the hospital for at least three months before the start of data collection.
2. Had direct contact with patients or patient specimens.
3. Were available during the study period and agreed to participate.

We excluded staff who were on long-term leave (e.g., maternity, sick, or unpaid leave) during the whole data collection period, interns or students, and staff working only in purely administrative roles with no clinical or laboratory contact.

Sample Size and Sampling Procedure

The sample size was calculated using the single-proportion formula:

n = \frac{Z^{2} \, p (1 - p)}{d^{2}}

We assumed a proportion (p) of adequate infection control practice of 0.5 (50%) to obtain the maximum sample size, with a 95% confidence level (Z = 1.96) and a margin of error (d) of 0.05. This gave a minimum required sample of 384 participants. To account for an anticipated non-response rate of 15%, we increased the target sample to approximately 440 participants.

All eligible staff in the four professional groups were invited to participate using convenience sampling. Department heads in the laboratory, dental, nursing, and echocardiography units were contacted, and staff were approached during departmental meetings and shifts. Participation was voluntary.

Questionnaire Development and Content

Data were collected using a structured, self-administered questionnaire developed by the research team. The questionnaire was based on existing infection prevention and control knowledge–attitude–practice (KAP) surveys and on international and national guidelines on standard infection control precautions. Items were adapted to reflect local policies and the specific work activities of laboratory specialists, dentists, nurses, and echocardiography technologists.

The questionnaire consisted of five sections:

1. Sociodemographic and professional characteristics
   - Age, gender, profession, department, highest qualification, years of experience, type of unit (e.g., inpatient, outpatient), and previous training in infection control in the last two years.
2. Knowledge of standard infection control precautions
   - Multiple-choice and true/false items covering:
     - Hand hygiene indications and techniques.
     - Use of personal protective equipment (PPE).
     - Safe handling and disposal of sharps and specimens.
     - Environmental cleaning and disinfection.
     - Equipment and instrument decontamination (including dental instruments and ultrasound probes).
     - Isolation and transmission-based precautions.
3. Attitudes towards infection control
   - Statements rated on a 5-point Likert scale (strongly disagree to strongly agree), assessing perceived importance of infection control, perceived risk of healthcare-associated infections, support from management, and personal responsibility.
4. Self-reported infection control practices
   - Frequency-based items (always, often, sometimes, rarely, never) on hand hygiene in different clinical moments, use of PPE, handling of sharps, cleaning and disinfection of surfaces and equipment, and reporting of occupational exposures.
5. Perceived barriers and facilitators
   - Items exploring barriers such as lack of time, workload, shortage of supplies, insufficient training, and unclear policies, as well as suggestions for improving compliance.

The questionnaire was prepared in English and translated into Arabic using forward–backward translation by bilingual experts to ensure clarity and equivalence. Participants could choose either language version.

Pilot Testing and Reliability

The draft questionnaire was pilot tested with 20 healthcare workers (five from each professional group) who were not included in the final analysis. The pilot study assessed clarity, length, and relevance of items. Based on feedback, minor wording changes were made, and a small number of redundant or unclear items were removed.

Internal consistency reliability was assessed using Cronbach's alpha for the main domains. In the final version, alpha values were 0.78 for the knowledge domain, 0.81 for the attitudes domain, and 0.83 for the practice domain, indicating acceptable to good reliability.

Scoring of KAP Domains

For the knowledge domain, each correct answer was given a score of 1 and each incorrect or "don't know" answer a score of 0. A total knowledge score was calculated for each participant and converted to a percentage. Knowledge levels were categorised as:

- Poor: <50%
- Moderate: 50–74%
- Good: ≥75%

For attitudes, responses on the 5-point Likert scale were scored from 1 (strongly disagree) to 5 (strongly agree). Negatively worded items were reverse-scored. A mean attitude score was calculated; higher scores indicated more positive attitudes towards infection control.

For practices, frequency responses were scored from 1 (never) to 5 (always). A composite practice score was obtained by summing relevant items and converting to a percentage. Practice levels were categorised similarly to knowledge (poor, moderate, good) using predefined cut-offs.

DATA COLLECTION PROCEDURES

Data collection was conducted by trained research assistants from within the hospital. After obtaining permission from department heads, the research team visited clinical areas at times agreed with unit managers to minimise disruption of service.

The purpose of the study was explained verbally and in a written information sheet. Staff who agreed to participate completed the anonymous paper or online questionnaire during their break or at the end of their shift, and returned it in sealed envelopes or through a secure online survey link. No names or employee numbers were collected. Participants were informed that participation was voluntary, there would be no direct benefits or penalties, and they could decline to answer any question.

Completed questionnaires were checked for completeness, assigned unique identification numbers, and entered into a password-protected database by the principal investigator and a trained data entry clerk. Double data entry and random cross-checks were performed to reduce data entry errors.

Variables

The main outcome variables were:

- Knowledge level (poor, moderate, good).
- Attitude score (continuous) and attitude category (negative, neutral, positive).
- Practice level (poor, moderate, good).

Key independent variables included profession (laboratory specialist, dentist, nurse, echocardiography technologist), years of experience, previous infection control training, department/unit type, and gender.

Statistical Analysis

Data were analysed using IBM SPSS Statistics for Windows, Version 29.0 (IBM Corp., Armonk, NY, USA).Continuous variables were summarised as means and standard deviations (SD) or medians and interquartile ranges (IQR) according to distribution. Categorical variables were presented as frequencies and percentages.

Knowledge, attitude, and practice scores were compared across the four professional groups using one-way ANOVA or Kruskal–Wallis tests for continuous or ordinal variables, and chi-square tests for categorical variables. Post-hoc pairwise comparisons with appropriate corrections were performed where overall tests were significant.

Pearson or Spearman correlation coefficients were used to examine relationships between knowledge, attitude, and practice scores. Multivariable logistic regression models were constructed to identify factors independently associated with "good" infection control practice (≥75%), including profession, knowledge level, attitude score, previous training, and years of experience as covariates. Adjusted odds ratios (ORs)

with 95% confidence intervals (CIs) were reported. A p-value <0.05 was considered statistically significant.

Ethical Considerations

The study protocol was reviewed and approved by the institutional ethics committee of the tertiary hospital. As the study involved anonymous questionnaires with no collection of identifiable personal data, written informed consent was waived; completion and return of the questionnaire were taken as implied consent. All procedures followed the principles of the Declaration of Helsinki and complied with local regulations on research involving human participants.

RESULTS

Participant Characteristics

Out of 440 eligible staff invited, 420 completed the questionnaire (response rate 95.5%). The sample included 140 nurses (33.3%), 110 laboratory specialists (26.2%), 90 dentists (21.4%), and 80 echocardiography technologists (19.0%). The mean age of participants was 33.5 ± 7.8 years, and the median years of professional experience was 7 years (IQR 4–12). Overall, 62.1% of respondents were female, with females predominating among nurses and laboratory specialists.

Most participants (78.1%) reported having received formal infection control training within the previous two years, with the highest proportion among nurses (85.0%) and the lowest among dentists (70.0%). Basic demographic and professional characteristics by profession are shown in Table 1.

Table 1. Sociodemographic and professional characteristics of participants by profession (n = 420)

Characteristic	Total (n=420)	Nurses (n=140)	Lab specialists (n=110)	Dentists (n=90)	Echo technologists (n=80)
Age, years, mean ± SD	33.5 ± 7.8	32.4 ± 7.2	34.1 ± 7.9	34.8 ± 8.1	33.3 ± 7.6
Female, n (%)	261 (62.1)	112 (80.0)	70 (63.6)	32 (35.6)	47 (58.8)
Years of experience, median (IQR)	7 (4–12)	6 (3–10)	8 (5–13)	7 (4–11)	7 (4–12)
Bachelor degree or higher, n (%)	352 (83.8)	118 (84.3)	94 (85.5)	84 (93.3)	56 (70.0)
Inpatient setting, n (%)	236 (56.2)	104 (74.3)	64 (58.2)	24 (26.7)	44 (55.0)
Infection control training in last 2 y, n (%)	328 (78.1)	119 (85.0)	88 (80.0)	63 (70.0)	58 (72.5)

Knowledge of Standard Infection Control Precautions

The overall mean knowledge score was 72.3% ± 11.9. Using predefined cut-offs, 12.1% of participants had *poor* knowledge (<50%), 45.7% had *moderate* knowledge (50–74%), and 42.1% had *good* knowledge (≥75%).

Knowledge scores differed significantly across professions (one-way ANOVA, $p < 0.001$). Nurses and laboratory specialists had the highest mean knowledge scores, while echocardiography technologists had the lowest. Staff who had attended infection control training in the previous two years demonstrated significantly higher knowledge scores than those without recent training (74.5% vs. 64.8%, $p < 0.001$).

Attitudes Towards Infection Control

Attitudes towards infection control were generally positive. The overall mean attitude score was 4.1 ± 0.5 on a 5-point scale. Most respondents agreed or strongly agreed that adherence to standard precautions protects both patients and staff and that infection control is a shared responsibility. There were modest but

statistically significant differences in mean attitude scores between professions (p = 0.03), with nurses and dentists reporting slightly more positive attitudes than laboratory specialists and echocardiography technologists.

Self-Reported Infection Control Practices

The mean practice score was 69.2% ± 13.7, with 17.1% of participants classified as having *poor* practice, 44.3% *moderate* practice, and 38.6% *good* practice (≥75%).

Self-reported hand hygiene "always" before patient contact was reported by 64.3% of nurses, 59.1% of laboratory specialists, 53.3% of dentists, and 48.8% of echocardiography technologists. Consistent use of appropriate PPE during exposure-prone procedures was reported by 77.1% of nurses, 73.6% of laboratory specialists, 68.9% of dentists, and 62.5% of echocardiography technologists. Regular cleaning and disinfection of shared equipment between patients was highest among nurses and laboratory staff and lowest among echocardiography technologists.

Overall knowledge, attitude, and practice scores by profession are summarised in Table 2.

Table 2. Knowledge, attitude, and practice scores by profession

Domain	Total (n=420)	Nurses (n=140)	Lab specialists (n=110)	Dentists (n=90)	Echo technologists (n=80)	p-value*
Knowledge score (%), mean ± SD	72.3 ± 11.9	75.4 ± 10.8	73.6 ± 11.3	70.2 ± 12.1	68.5 ± 12.4	<0.001
Knowledge level – good, n (%)	177 (42.1)	70 (50.0)	48 (43.6)	32 (35.6)	27 (33.8)	0.01
Attitude score (1–5), mean ± SD	4.1 ± 0.5	4.2 ± 0.4	4.0 ± 0.5	4.2 ± 0.5	4.0 ± 0.6	0.03
Practice score (%), mean ± SD	69.2 ± 13.7	73.1 ± 12.5	71.0 ± 13.0	66.0 ± 13.8	63.4 ± 14.2	<0.001
Practice level – good, n (%)	162 (38.6)	65 (46.4)	45 (40.9)	29 (32.2)	23 (28.8)	0.004

*p-values from one-way ANOVA (continuous scores) or χ^2 tests (categorical levels).

There was a moderate positive correlation between knowledge and practice scores (r = 0.41, p < 0.001), and between attitude and practice scores (r = 0.36, p < 0.001), indicating that higher knowledge and more positive attitudes were associated with better self-reported infection control practices.

Factors Associated with Good Infection Control Practice

In multivariable logistic regression, good practice (practice score ≥75%) was used as the dependent variable. Independent variables included profession, knowledge level, attitude score, infection control training in the last two years, and years of experience.

After adjustment, good knowledge (≥75%) and more positive attitudes remained significantly associated with good practice. Participants with good knowledge were more than twice as likely to report good practice compared with those with poor or moderate knowledge. Each one-point increase in the attitude score was associated with higher odds of good practice. Having recent infection control training was also an independent predictor of good practice. Compared with nurses, echocardiography technologists had significantly lower odds of good practice, while laboratory specialists and dentists did not differ significantly from nurses after adjustment. Results are presented in Table 3.

Table 3. Multivariable logistic regression analysis of factors associated with good infection control practice (practice score ≥75%; n=420)

Variable	Category / unit	Adjusted OR	95% CI	p-value
Profession	Nurses (reference)	1.00	–	–
	Lab specialists	0.89	0.54–1.47	0.65
	Dentists	0.78	0.45–1.34	0.36
	Echo technologists	0.56	0.31–0.99	0.047
Knowledge level	Good (≥75%) vs. poor/moderate	2.43	1.64–3.60	<0.001
Attitude score	Per 1-point increase (1–5 scale)	1.81	1.25–2.63	0.002
Infection control training (last 2 y)	Yes vs. no	1.64	1.06–2.54	0.027
Years of experience	Per 5-year increase	1.08	0.96–1.22	0.20

DISCUSSION

This survey described knowledge, attitudes, and self-reported practices about standard infection control precautions among laboratory specialists, dentists, nurses, and echocardiography technologists in a Saudi tertiary hospital. Overall, participants showed moderate knowledge, generally positive attitudes, and only fair levels of reported practice, with clear variation between professions. Knowledge and attitude scores were positively related to practice, and recent infection control training was an important independent predictor of good practice. Echocardiography technologists had the lowest mean scores, suggesting a specific gap in this group.

Our findings are broadly consistent with Saudi and international KAP studies, which also report reasonable knowledge but less than optimal routine practice (Abalkhail et al., 2021; Al-Qahtani, 2023). Similar to previous work among laboratory staff and dental personnel, we found that workers who handle blood, saliva, and sharp instruments on a daily basis still report inconsistent use of PPE, hand hygiene, and incident reporting (Khabour et al., 2018; Al-Aali et al., 2021). The inclusion of echocardiography technologists adds new information; lower scores in this group echo international surveys showing wide variability and deficiencies in ultrasound probe decontamination practices (Nyhsen et al., 2016; Shokoohi et al., 2015).

The positive associations between knowledge, attitudes, and practice support the value of structured training, but also highlight a persistent “knowledge–practice gap”. Organisational barriers such as workload, time pressure, and supply issues likely contribute to this gap, as reported in earlier Saudi studies (Al-Qahtani, 2023). Based on our results, infection control programmes should combine regular, profession-specific education (for example, probe disinfection for echocardiography staff, aerosol-generating procedures and instrument reprocessing for dentists, biosafety and incident reporting for laboratory staff) with system-level support, audit, and feedback. Multidisciplinary teaching sessions can also help create a shared safety culture across professions.

This study has several strengths: it includes four key professions in one institution, uses a structured KAP instrument with acceptable internal consistency, and applies multivariable analysis to identify predictors of good practice. Important limitations include the cross-sectional design, reliance on self-reported practice, convenience sampling, and conduct in a single tertiary hospital, which may limit generalisability.

CONCLUSION

In summary, staff in this Saudi tertiary hospital show encouraging awareness and positive attitudes towards infection control, but practice remains variable and suboptimal, particularly among echocardiography technologists. Targeted, profession-specific training, better resources, and a stronger

safety culture are needed to improve adherence to standard precautions and support hospital efforts to reduce healthcare-associated infections.

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