

Practices of Laboratory Healthcare Professionals and Barriers towards Infection Control and its Related Factors in Primary Healthcare of Saudi Arabia

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Abstract:

Background: Clinical laboratories enhance the efficient provision of treatment in the intricate healthcare systems of today by offering diagnostic testing services. Laboratory healthcare professionals (HCPs) may be at risk from biological and chemical hazards when processing clinical material and using chemicals or radiation. However, if potential risks are identified, clear guidelines, safety regulations, and infection prevention and control (IPC) measures are implemented and adhered to, the laboratory should be a safe place to work. Laboratory HCPs are exposed to a variety of risks since they handle a wide range of potentially hazardous materials. **The study aimed:** To assess the practices of laboratory HCPs towards safety, infection control, and its related factors in Primary healthcare of Saudi Arabia. **Methods and Materials:** A cross-sectional study was conducted among 175 laboratory HCPs in Primary healthcare of Makkah, Saudi Arabia from January to March 2024. Pre-tested, structured, self-administered questionnaires were used to collect data. SPSS version 28 was used to analyze the data, and a p-value of less than 0.05 was used. **Results:** The respondents' average age was 35.0 ± 2.45 years, and the majority was married (61.1%) and female (57.7%). Most (98.9%) showed a solid understanding of infection control. Hand washing was selected by 62.3% of respondents as the most crucial infection control measure, and the two diseases that respondents deemed most likely to be contracted were HIV and tuberculosis. Good practices were demonstrated by 84.6% of the responders in total. 98.1% of respondents cited the lack of personal protection equipment in the labs as a significant obstacle. The respondents demonstrated good infection control knowledge, attitude, and practice. **Conclusion:** The lack of personal protective equipment was the obstacle to infection management. In order to guarantee ongoing training and retraining together with the provision of personal protective equipment, coordinated efforts should be made.

Keywords: Infection Control Practices, Laboratory, Knowledge, Attitude.

Introduction:

Infection is one of the critical challenges in healthcare settings around the globe ⁽¹⁾. Healthcare professionals (HCPs), including medical laboratory technologists (MLTs) and nurses are at risk of infection because they are in close contact with infected patients, possibly leading to the transmission of pathogens ⁽²⁾. In order to facilitate the efficient provision of treatment in the intricate healthcare systems of today, clinical laboratories offer diagnostic

testing services ⁽³⁾. This encompasses morphological, cytological, hematological, biochemical, microbiological, and serological analyses of clinical specimens taken from patients in order to provide data for the diagnosis, management, or avoidance of any illness. Laboratory testing provides information for about 70% of clinical decisions ⁽⁴⁾.

According to the World Health Organization, infection prevention and control is empirical evidence that keeps patients and healthcare professionals safe from preventable infections ⁽⁵⁾. It comprises a hospital's or other healthcare facility's policies and practices to reduce the risk of transferring infections linked to healthcare or community-acquired illnesses that affect patients or staff ^(5, 6). The inhalation of pathogens by aerosols, contact, airborne droplets, or on snapping-closing specimen containers, as well as the dispensing or pipetting of infectious fluids or the centrifugation of infectious materials in open buckets, have all been reported to induce infection in laboratory settings ^(7, 8).

Hepatitis B (HBV), hepatitis C (HCV), HIV, TB, typhoid fever, other enteric pathogens, and parasitic illnesses are among the many specimens that laboratory HCPs are exposed to ^(9, 10). HCPs make up 12% of the working population globally, and their work-related activities expose them to a variety of risks ^(11, 12). Significant morbidity and death among these workers will undoubtedly result in the loss of qualified staff and have a negative effect on healthcare systems, which are already under pressure in many low- and middle-income nations ⁽¹³⁾. The World Health Organization (WHO) estimates that occupational exposures account for 40% of HBV and HCV infections among HCPs globally and 2.5% of HIV cases among HCPs ⁽¹⁴⁾.

Based on their work currently, laboratory staff awareness of infection prevention is typically below average ^(15, 16). Among other issues, there is still widespread recapping of used needles, noncompliance with basic precautions, misinformation, and absence of HBV immunization, infrequent staff training on universal precautions and proper laboratory processes, and improper waste management ^(15, 16). Medical laboratory employees are at a high risk of exposure, so infection control procedures are necessary. These procedures cover all daily activities and actions that limit, control, or influence the entry ⁽¹⁰⁾, development, and multiplication of infectious agents in laboratory HCPs.

According to data from the Kingdom of Saudi Arabia (KSA), hospital infections continue to rank among the most prevalent health issues in the country, with 2.2% of hospital infections occurring each month ⁽¹⁷⁾. According to Al Ra'awji et al., (2018) ⁽¹⁸⁾, there is a significant need for training for HCPs in the Kingdom of Saudi Arabia, since almost one-fourth (37%) of them lacked adequate knowledge of hand hygiene. In an effort to raise the bar for infection control efforts, the Kingdom of Saudi Arabia has been working to implement all infection control guidelines ⁽¹⁹⁾.

Occupational risks and illnesses can arise from improper practices, procedures that fail to effectively reduce or control the risk, inadequate communication regarding high-risk patients, noncompliance, inexperience, ignorance, and disregard for established protocols and recommendations. But if potential risks are recognized, and if safety regulations, guidelines, and infection prevention and control (IPC) measures are implemented and adhered to, the laboratory can be a safe place to work ⁽²⁰⁾. By following IPC standards, healthcare professionals and patients can avoid unnecessary infections and potential risks in a realistic, evidence-based manner. In order to reduce and avoid the harm that infectious agent exposure causes to patients and HCPs, a set of recommendations has been developed ⁽²¹⁾.

Consequently, research is necessary because efforts must be focused on raising awareness of infection control procedures and making sure they are used as efficiently and effectively as possible to provide a number of benefits for public health improvement. Therefore, the present study aimed to assess the knowledge, compliance to safety practices and identified barriers to infection control practices among laboratory HCPs in Makkah, Saudi Arabia.

Methods and Materials:

A cross-sectional study was conducted to assess compliance and barriers to infection control practices among laboratory HCPs in four Primary Health Care (PHC) centers of Makkah, Saudi Arabia from January to March 2024. All teams of laboratory HCPs in all the registered and functioning medical laboratories who gave informed consent participated. A convenient sample size was conducted among 181 all the laboratory HCPs working in the four PHC centers.

A self-administered questionnaire was modified to assess socio-demographic factors like age, gender, marital status, cadre, and years of work experience; laboratory HCPs' knowledge of infection control, including questions about its definition, guidelines, and preventive measures; and their attitude toward infection control, including whether they believe it is essential to always follow infection control practices (ICPs). Additionally, questions about the availability and application of infection control guidelines, regularly applied infection control measures, and infection control training were used to gauge the participants' infection control practices, which are the most significant ICPs. Hand hygiene, PPE use, laboratory cleaning schedules, waste segregation, and obstacles to infection control practices were also taken into consideration.

A pre-tested was conducted among 10 % laboratory HCPs at another PHC center. This was carried out to validate the appropriateness of the questionnaire developed. Necessary corrections were made before the questionnaire was used in this study. Data analysis was conducted using the SPSS version 28 software. Descriptive statistics were computed to generate frequencies, mean, and percentages. One mark was given for each right response, and zero for each incorrect response, in order to gauge knowledge level. The sum of the marks earned by each respondent was used to determine their overall score. Respondents were classified as having strong knowledge if their scores were above the median and as having poor knowledge if their scores were below it ⁽²²⁾.

One mark was given for having a positive or good attitude, and zero for having a negative or terrible attitude. Respondents with scores above the median were considered to have a good attitude, while those with scores below the median were considered to have a negative attitude ⁽²²⁾. Similarly, each practice response that was right received one mark, while each incorrect practice received a zero. The median score was determined by adding all of the scores. Individuals who received a score below the median were classified as having bad practice, while those who received a score above the median were classified as having good practice ⁽²²⁾. Significance level set at p-value < 0.05. Chi-square and Fisher's exact tests were used to measure the association between categorical variables.

Results

Table (1) shows that the majority were females (57.7%), married (61.1%), and the most prevalent age group was those less than 29 years (37.1%) and the mean age of respondents was 35.0 ± 2.45 .

Table (1): Socio-demographic characteristics of study participants

Variables	Frequency (n=175)	Percentage
Age group		
< 29	65	37.1
30-39	48	27.4
40 and above	62	35.5
Mean \pm SD 35.0 ± 2.45 years		
Gender		
Male	74	42.3

Variables	Frequency (n=175)	Percentage
Female	101	57.7
Marital status		
Singled	68	38.9
Married	107	61.1

Table (2) displays almost all the study participants have heard of the term ‘infection control’ (95.4%). The majority of this information came from lectures and seminars (67.7%), seminars and workshops (63.5%), and coworkers (51.5%). Nonetheless, 80.8% of respondents demonstrated that they understood the meaning of "infection control." Hand washing (100.0%), personal protective equipment (93.4%), disinfection (92.8%), sterilization (92.8%), and proper medical waste disposal (88.9%) were among the infection control practices they were aware of. Hand washing was ranked as the most crucial infection control measure (62.3%), followed by PPE use (48.0%). Nonetheless, 23 respondents (13.1%) stated that it was challenging to follow certain infection control procedures, such as hand washing (27.3%), sterilization (39.4%), isolation (48.5%), and the use of personal protective equipment (36.4%) and disinfection (33.3%).

Table (2): Knowledge of study participants on infection control

Variables	Frequency	%
Ever heard of infection control(n=175)		
Yes	167	95.4
No response	8	4.6
Source of information (n=167) *		
Seminar/ Workshop	106	63.5
Co-workers/ colleagues	86	51.5
Textbook /Journals	84	50.3
Media	62	37.1
Classroom/ Lectures	113	67.7
Understanding of the term "infection control" (n=167)		
Good	135	80.8
No response	32	19.2
Heard of infection control guidelines (n=167)		
Yes	147	88.0
No	16	9.6
No response	4	2.4
known or heard control measures (n=167) *		
Hand washing	167	100.0
Personal protective wear	156	93.4
Safe injection and sharps use	146	87.4
Safe medical waste disposal	148	88.6
Isolation	117	70.1
Disinfection	155	92.8
Sterilization	155	92.8
Housekeeping	93	55.7
Others	7	4.2

Table (3) shows that Over 80% of respondents confirmed that their units or sections have a copy of infection control guidelines, whereas those who did not cited inadequate documentation in their laboratory unit (31.8%), non-provision (40.9%), and poor organization (27.3%) as explanations. Although the majority of respondents (78.3%) had read the infection control recommendations, 44.4% did not follow them because they were too busy (16.7%), forgot the guidelines, or the materials were unavailable (22.2%).

Table (3): Infection control practices by the study participants.

Variables	Frequency	%
Had a copy of the infection control guidelines		
Yes	144	82.3
No	22	12.5
No response	9	5.2
Reason for not having a copy of the guideline in the unit (n=22)		
Lack of proper documentation	7	31.8
Poor organization	6	27.3
Not provided	9	40.9
Ever read the infection guideline		
Yes	137	78.3
No	18	10.3
No response	20	11.4
Frequency of use of infection control guideline		
Occasionally	33	18.9
Often	20	11.4
Always	87	49.7
Never	6	3.4
No response	29	16.6
Reasons why the guideline was not followed (n=18)		
Forgot	8	44.4
Differences in each unit as regards infection control practices.	1	5.6
High workload	3	16.7
Material unavailability concerning waste disposal	4	22.2
Believing that I know all the basics in the guideline	2	11.1

Table (4) shows that the main obstacle to effective infection control was the lack of personal protective equipment (98.1%), the lack of time to attend infection control seminars or workshops (47.3%), the absence of post-exposure prophylactic measures (40.3%), the lack of color-coded waste bags for waste segregation (39.6%), the lack of sharps/puncture-proof bins (36.9%), and the excessive workload caused by a staffing shortage, which made it nearly impossible to perform proper hand hygiene procedures (25.7%).

Table (4): Barriers to infection control in the laboratory

Barriers to infection control	Agree n (%)	Disagree n (%)	Indifferent n (%)	Total n (%)
Limited availability of Personal protection equipment (PPE)	99 (98.1)	2 (1.9)	0 (0.0)	101 (100)
Limited time to attend seminars/ workshops on infection control	69 (47.6)	72 (49.7)	4 (2.7)	145 (100)
Color coded waste bags for waste segregation are not always available	59 (39.6)	84 (56.4)	6 (4.0)	149 (100)
Lack of political will on the part of the management towards workers' safety	58 (42.0)	71 (51.5)	9 (6.5)	138 (100)
No provision for post-exposure prophylaxis	56(40.3)	70(50.3)	13(9.4)	139(100)
Sharps/ Puncture-proof bins are not always available	55 (36.9)	89 (59.7)	5 (3.4)	149 (100)
Soap, alcohol hand rub/ sanitizers are not always available	53 (35.3)	91 (60.7)	6 (4.0)	150 (100)
There is an inadequate water supply for proper hand washing	51 (33.6)	99 (65.1)	2 (1.3)	152 (100)
Unavailability of policy on infection control guidelines	49(33.1)	88(59.5)	11(7.4)	148(100)
Excessive workload due to staff shortage, making it practically impossible to carry out proper hand hygiene between laboratory procedures	39(25.7)	108(71.0)	5(3.3)	152(100)

Table (5) shows that nearly every respondent who took part in the study demonstrated a solid understanding of infection control procedures. With the exception of 17.1% and 15.4%, respectively, the majority also demonstrated positive attitudes and practices.

Table (5): Evaluation of study participants’ knowledge, attitude, and practice of infection control

Parameter	Poor	Good	Total
	Frequency (%)	Frequency (%)	Frequency (%)
Knowledge	2 (1.1%)	173 (98.9%)	175 (100.0%)
Attitude	30 (17.1%)	145 (82.9%)	175 (100.0%)
Practice	27 (15.4%)	148 (84.6%)	175 (100.0%)

Table (6) shows that age, gender, post-qualification experience, staff cadre, and infection control practices did not significantly correlate with respondents' infection control practices ($p>0.05$). Nonetheless, there is a statistically significant correlation between the numbers of years spent learning effective infection control techniques. Compared to those who received training later, a greater percentage of respondents who participated in infection control training between 2023 and 2022 had good infection control practices ($p<0.05$).

Table (6): Association between respondents’ infection control practices and their socio-demographic characteristics

Variables	Practice		Total Frequency (%)	Test of significance	
	Good Frequency (%)	Poor Frequency (%)		χ^2	p value
Age					
<40	96(85.0)	17(15.0)	113(100.0)		
40 and above	52(83.9)	10(16.1)	62(100.0)	0.03	0.849
Total	148(84.6)	27(15.4)	175(100.0)		
Gender					
Male	62(83.8)	12(16.2)	74(100.0)		
Female	86(85.1)	15(14.9)	101(100.0)	0.1	0.835
Total	148(84.6)	27(15.4)	175(100.0)		
Staff cadre					
Lab. Scientist	97(84.3)	18(15.7)	115(100.0)		
Junior Staff	43(82.7)	9(17.3)	52(100.0)	0.1	0.788
Total	140(83.8)	27(16.2)	167(100.0)		
Post Qualification Experience					
≤ 5	35(74.5)	12(25.5)	47(100.0)		
6 – 10	45(86.5)	7(13.5)	52(100.0)	2.7	0.257
>10	43(84.3)	8(15.7)	51(100.0)		
Total	123(82.0)	27(18.0)	150(100.0)		
Most recent training					
2023	64(85.3)	11(14.7)	75(100)		
2022	36(92.3)	3(7.7)	39(100)	6.3	0.042*!
2021 and later	45(73.8)	16(26.2)	61(100)		
Total	145(82.9)	30(17.1)	175(100)		

*Statistically significant ! Fisher’s p-value

Discussion:

Healthcare professionals are more susceptible to infections due to healthcare-associated illnesses, which have been directly linked to higher rates of morbidity and mortality among hospitalized patients ⁽²³⁾. In order to maintain safety while performing their tasks, laboratory health care personnel must possess an understanding of infection control. Only 80.8% of the respondents showed a strong grasp of the meaning of infection control, despite the fact that nearly all (95.4%) had heard of it and its standards. In contrast to prior research that claimed that opinions of infection prevention and control guidelines are based on evidence gathered in acute care settings, this study demonstrated a good understanding of infection control and therefore are not always practical or appropriate in the facility where resources are more constrained ^(24, 25).

Additionally, the respondents' strong understanding of infection control procedures aligned with the guidelines for infection control ⁽²⁶⁾. Additionally, while providing laboratory services, the participants showed a good understanding of how to use Personal Protective Equipment (PPE) such as safety glasses, lab coats, footwear, hand gloves, and face shields. This is consistent with a report that further listed the protective roles of PPE against infection when used appropriately ⁽²⁷⁾. According to this study, the most often recommended methods for maintaining proper hand hygiene in the laboratory were antiseptic soaps, water, and alcohol-based hand rubs. This is consistent with WHO standards on hand hygiene in healthcare ⁽²⁸⁾.

Furthermore, respondents' belief that gloves are required for HCPs to wear when performing tasks like dressing wounds, transfusions, surgeries, injections, collecting specimens, or processing samples is appropriately consistent with a Malaysian study's recommendations that gloves be worn for both direct and indirect contact with blood, bodily fluids, or mucous membranes. ⁽²⁹⁾ Hand washing was ranked as the most important infection control practice by just 62.3% of the respondents, which did not reflect their good practices for laboratory infection control. This contrasted with the findings of several previous researchers who found that the most effective, straightforward, and least costly way to lower the incidence of laboratory-acquired diseases and the spread of antibiotic resistance was to practice good hand hygiene ^(30, 31).

Additionally, the responders were more worried about the significant danger of HIV and TB from handling specimens. Healthcare workers' enrollment among high-risk groups for tuberculosis ⁽³²⁾ served as justification for their attitude toward these illnesses, while Beltrami et al. (2000) reported that the risk of HIV infection may be related to the disease's blood-borne transmission, which primarily occurs through percutaneous or mucosal exposure of workers to the blood or bodily fluids of infected patients ⁽³³⁾. Regarding the application of infection control standards, the good practices noted were comparable to those found in another study ⁽²⁵⁾.

The infection control measure routinely practiced by respondents ranged from hand washing, using gloves, wearing laboratory coat, disinfection, sterilization, waste segregation, and disposal of sharps in a puncture-proof bin agree with other studies ^(34, 35). Whereas among all the measures, isolation was observed as the poorly practiced control measure, a possible reason could be because simple protective isolation offered no advantage over routine care for most immune-compromised patients ^(35, 36). Training of laboratory worker as was experienced by almost 80.0% of the respondents in this study had been recognized as a strategy to protect workers from exposure to pathogens and impact their adherence to a standard guideline. This was in close similarity with a study done in another African country ⁽³⁶⁾. This study also highlighted the significant roles played by the colleagues at work in disseminating information on infection control which was near was obtained in other studies ^(25, 35).

The major barriers to infection control practices in the current study were incomplete availability of personal protection equipment, lack of political will of the management towards worker's safety, lack of provision for post-exposure prophylaxis and sharps/puncture-proof bins not always. Only the most recent training received by the respondents exhibited a significant relationship with the knowledge of infection control practices. The capacity building undergone by the laboratory scientists could account for the significant impact of the good knowledge displayed. A similar result of laboratory scientists demonstrating good knowledge of infection control has been reported⁽³⁷⁾. This is consistent with the deductions that in terms of infection control, knowledge, and practice (KAP) surveys can identify knowledge gaps, cultural beliefs, or behavioral patterns that may impede infection control efforts⁽³⁸⁾.

Conclusions:

The study revealed that although the respondents exhibited strong knowledge and good behaviors for infection control and safety, there was a lack of personal protective equipment available to them. An additional benefit will be the training and retraining of these laboratory health workers.

References:

1. World Health Organization (2011). The burden of health care-associated infection. Available: https://apps.who.int/iris/bitstream/handle/10665/80135/9789241501507_eng.pdf.
2. Centers for Disease Control and Prevention (2020) mCoronavirus Disease 2019 (COVID-19). Interim Guidance on Testing Healthcare Personnel for SARS-CoV-2(2020). Available: <https://www.cdc.gov/coronavirus/2019-ncov/hcp/testing-healthcare-personnel.html>.
3. Care V. Value Of Clinical Laboratory Services In Health Care. Ascls.org. 2005. Available at: <https://ascls.org/position-papers/177-value-of-clinical-laboratory-services/153-value-of-clinical-laboratory-services>
4. Coelho A, García Díez J. Biological Risks and Laboratory-Acquired Infections: A Reality That Cannot be Ignored in Health Biotechnology. *Frontiers in Bioengineering and Biotechnology*. 2015. Available at: <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4412124/>
5. World Health Organisation. Infection Prevention and Control Policy, 2019. <http://www.who.int/teams/integrated-health-services/infection-prevention-control>
6. Alakija W. Essentials of community health, primary healthcare and health management. 2nd ed. Benin: Ambik press; 2000.5:299.
7. AL-Dwairi ZN. Infection control procedures in commercial dental laboratories in Jordan. *J Dent Educ*. 2007 September; 71(9): 1223-1227. <https://doi.org/10.1002/j.0022-0337.2007.71.9.tb04388.x>
8. Cheesbrough M. Medical laboratory manual for tropical countries. Tropical health technology and Butterworth-Heinemann Ltd. 1987.1:2-37.
9. Izegbu MC, Amole OO, Ajayi GO. Attitudes, perception and practice of workers in laboratories in two colleges of Medicine and their teaching hospitals in Lagos State, Nigeria as regards universal precaution measures. *Biomedical research* 2006; 17(1): 49-54.
10. Leyten EM, Mulder B, Prins C, Weidingh K, Andersen P, Ottenhoff TH, et al. Use of enzyme-linked immunospot assays with M. Tuberculosis after accidental laboratory exposure. *J Clin Microbiol*. 2006; 44(3):1197-1201. <https://doi.org/10.1128/jcm.44.3.1197-1201.2006>

11. Goniewicz M, Włoszczak-Szubzda A, Niemcewicz M, Witt M, Marciniak- Niemcewicz A, Jarosz MJ. “Injuries caused by sharp instruments among healthcare workers- international and Polish perspectives.” *Ann Agric Environ Med.* 2012; 19(3): 523–527.
12. Manyele SV, Ngonyani HA, Eliakimu E. “The status of occupational safety among health service providers in hospitals in Tanzania.” *Tanzan J Health Res.* 2008; 10(3): 159–165. <https://doi.org/10.4314/thrb.v10i3.14356>
13. Ndejjo R, Musinguzi G, Yu X, Buregyeya E, Musoke 52D, Wang J. Occupational health hazards among healthcare workers in Kampala, Uganda. *J Environ Public Health.* 2015; 2015: 1-9. <https://doi.org/10.1155/2015/913741>
14. World Health Organization. *The World Health Report 2002: Reducing risks, promoting healthy life.* Geneva: World Health Organization. 2002. p. 7-14. <https://doi.org/10.1016/j.agecon.2003.11.006>
15. Abubakar S. Implementation of an infection control programme in Kano, Northern Nigeria. *Int J Infect Contr.* 2007; 3:1. <https://doi.org/10.3396/03-01-04-007>
16. Sadoh WE, Fawole AO, Sadoh AE, Oladimeji AO, Sotiloye OS. Practice of universal precautions among healthcare workers. *J Natl Med Assoc.* 2006; 98: 722-726. <https://doi.org/10.2307/30032442>
17. Memish Z.A. Infection control in Saudi Arabia: Meeting the challenge. *Am. J. Infect. Control.* 2002;30:57–65. doi: 10.1067/mic.2002.120905.
18. Al Ra’awji B.A., Almogbel E.S., Alharbi L.A., Alotaibi A.K., Al-Qazlan F.A., Saquib J. Knowledge, attitudes, and practices of health-care workers regarding hand hygiene guidelines in Al-Qassim, Saudi Arabia: A multicenter study. *Int. J. Health Sci.* 2018;12:3.
19. Hamid H.A., Mustafa M.M., Al-Rasheedi M., Balkhi B., Suliman N., Alshaafee W., Mohammed S.A. Assessment of hospital staff knowledge, attitudes and practices (KAPS) on activities related to prevention and control of hospital acquired infections. *J. Infect. Prev.* 2019;10 doi: 10.5923/j.ijpt.20190801.01.
20. Medicine.utah.edu. 2019. Available at: <https://medicine.utah.edu/pathology/medical-laboratory-science/programs/files/mls-laboratory-safety-manual.pdf>
21. World Health Organization. *Infection Prevention and Control.* 2020. Available at: <https://www.who.int/infection-prevention/about/ipc/en/>
22. Asekun-Olarinmoye EO, Omobuwa O, Adebimpe WO, Asekun-Olarinmoye IO. Handwashing: Knowledge, attitude and practice amongst mothers of under-five children in Osogbo, Osun State, Nigeria. *J Biol Agric Healthcare* 2014; 4(16): 40-46. <https://doi.org/10.2147/ahmt.s54339>
23. Iliyasu G, Dayyab FM, Habib ZG, Tihamiyu AB, Abubakar S, Mijinyawa MS, et al. Knowledge and practices of infection control among healthcare workers in a tertiary referral centre in North-Western Nigeria. *Ann Afr Med.* 2016; 15(1): 34–40. <https://doi.org/10.4103/1596-3519.161724>
24. Smith PW, Bennett G, Bradley S, Drinka P, Lautenbach E, Marx J, et al. SHEA/APIC guideline: infection prevention and control in the long-term care facility, July 2008. *Infect Control Hosp Epidemiol.* 2008 Sep; 29(9):785–814. <https://doi.org/10.1086/592416>
25. Siegel JD, Rhinehart E, Jackson M, Chiarello L, Healthcare Infection Control Practices Advisory Committee. 2007 Guideline for isolation precautions: preventing transmission of infectious agents in healthcare settings. *Am J Infect Control.* 2007 Dec; 35(10 Suppl 2): S65-164. <https://doi.org/10.1016/j.ajic.2007.10.007>
26. Allain K, Rose SR. *Infection prevention and control: guidelines for long-term care facilities.* Nova Scotia: IPCNS; 2015: 11-52.

27. U.S. Food & Drug Administration. Personal Protective Equipment for Infection Control. CDRH-Center for Devices and Radiological Health, Food and Drug Administration, 10903 New Hampshire Avenue WO66-5429 Silver Spring. 2016. Available from: <https://www.fda.gov/MedicalDevices/ProductsandMedicalProcedures/GeneralHospitalDevicesandSupplies/PersonalProtectiveEquipment/default.htm>
28. World Health Organisation. WHO Guidelines on hand hygiene in Health care: a summary. First Global Patient Safety Challenge Clean Clear is Safer Care. 2009. <https://doi.org/10.1086/502513>
29. Ministry of Health Malaysia. Universal control precautions. AIDS/STDs Section, Ministry of Health Malaysia. Kuala Lumpur: Ministry of Health, Malaysia; 2005; 6-44. [https://doi.org/10.21103/article5\(2\)_mme1](https://doi.org/10.21103/article5(2)_mme1)
30. Mathur P. Hand hygiene: Back to the basics of infection control. *Indian J Med Res.* 2011; 134(5): 611–620. <https://doi.org/10.4103/0971-5916.90985>
31. Boyce JM, Pittet D. Guideline for Hand Hygiene in Health-Care Settings. Recommendations of the Healthcare Infection Control Practices Advisory Committee and the HICPAC/SHEA/APIC/IDSA Hand Hygiene Task Force. *Morb Mortal Wkly Rep.* 2002; 51: 1–44. <https://doi.org/10.1086/503164>
32. Department of Health. At-Risk Populations for Tuberculosis. Department of Health, State of Rhode Island 3 Capitol Hill Providence. 2017. Available from: <http://www.health.ri.gov/diseases/tuberculosis/about/atriskpopulations/>
33. Beltrami EM, Williams IT, Shapiro CN, Chamberland ME. *Risk and Management of Blood-Borne Infections in Health Care Workers.* *Clin Microbiol Rev.* 2000; 13(3):385–407. <https://doi.org/10.1128/cmr.13.3.385>
34. Mehta, Y., Gupta, A., Todi, S., Myatra, S., Samaddar, D. P., Patil, V., Ramasubban, S. Guidelines for prevention of hospital- acquired infections: Peer-Reviewed, Official Publication of Indian Society of Critical Care Medicine. *Indian J Crit Care Med.* 2014; 18(3): 149–163. <https://doi.org/10.4103/0972-5229.128705>
35. French GL, Otter JA, Shannon KP, Adams NM, Watling D, Parks MJ. Tackling contamination of the hospital environment by methicillin-resistant *Staphylococcus aureus* (MRSA): A comparison between conventional terminal cleaning and hydrogen peroxide vapour decontamination. *J Hosp Infect.* 2004;57: 31–37. <https://doi.org/10.1016/j.jhin.2004.03.006>
36. Reda AA, Fisseha S, Mengistie B, Vandeweerd JM. Standard precautions: occupational exposure and behaviour of health care workers in Ethiopia. *PLoS One.* 2010; 5(12): e14420. <https://doi.org/10.1371/journal.pone.0014420>
37. Tobin EA, Asogun DA, Odia I, Ehidiemhen G. Knowledge and practice of infection control among health workers in a tertiary hospital in Edo State, Nigeria. *Direct Res J Health and Pharma (DRJHP).* 2013; 1(2): 20-27.
38. Tenna A, Stenehjem EA, Margoles L, Kacha E, Blumberg HM., Kempker RR. Infection Control Knowledge, Attitudes, and Practices among Healthcare Workers in Addis Ababa, Ethiopia. *Infect Control Hosp Epidemiol.* 2013; 34(12): 1289–1296. <https://doi.org/10.1086/673979>