



Contents lists available at ScienceDirect

Journal of King Saud University – Science

journal homepage: www.sciencedirect.com

Original article

Role of X-ray equipment and ultrasound machines as possible vectors of nosocomial bacteria in the community



Momina Javaid^a, Hawa Qasim^b, Farwa Naseem^c, Muhammad Essa^d, Muhammad Amjad Bashir^{e,i,l,*}, Netasha Nazar^f, Ahmad Abbas^g, Turki M. Dawoud^h, Lariab Fatimaⁱ, Rizwan Asghar^j, Muhammad Yaseen^k, Anam Ibrahim^m, Wajahat AliKhan^o, Shujaat Ali Khanⁿ

^a Women Medical Officer, BHU, Rangeel Pur Lahore, Punjab, Pakistan

^b Women Medical Officer, BHU, HEIR Lahore, Punjab, Pakistan

^c Women Medical Officer, RHD, Badduke Lahore, Punjab, Pakistan

^d Postgraduate resident obstetrics and gynecology (FCPS) at King Edward Medical University Lahore Punjab, Pakistan

^e Department of Plant Protection Faculty of agricultural sciences, Ghazi University Dera Ghazi Khan Punjab, Pakistan

^f Lady Willington Hospital King Edward Medical University Lahore Punjab, Pakistan

^g Chest Department, Faculty of Medicine, Zagazig University, Zagazig, Egypt

^h Department of Botany and Microbiology, College of Science, King Saud University, P.O. 2455, Riyadh 11451, Saudi Arabia

ⁱ Civil hospital Sakhi Sarwr Dera Ghazi Khan Punjab, Pakistan

^j Rural health Centre Miana Gondal District Mandi Bahauddin Punjab, Pakistan

^k DHQ Hospital Mandi Baha.ud.Din Punjab, Pakistan

^l United States Department of Agriculture (USDA) Washington DC, USA

^m Senior Registrar, DHQ Teaching Hospital Sargodha Punjab, Pakistan

ⁿ Shaikh Khalifa Bin Zayed Al-Nahyan Medical & Dental Colleg Lahore Punjab, Pakistan

^o King Edward Medical University Lahore Punjab, Pakistan

ARTICLE INFO

Article history:

Received 4 March 2022

Revised 16 April 2022

Accepted 1 June 2022

Available online 6 June 2022

Keywords:

Nosocomial bacteria (NB)
Radiology department (RD)
Staphylococcus epidermidis
Staphylococcus aureus
Bacillus spp.
Escherichia coli

ABSTRACT

The not infrequent area for nosocomial bacterial (NB) contamination became the surface of radiology Department (RD) gadgets. The aim of the current study was to identify NB inside the RD devices as vectors. Affecting the inpatients fitness and public health. Questionnaire trial was used, after each sample collection for NB isolation and identity. approximately 93 % of RD technicians were participated, 87% worked with inpatients, 63% used sterile plastic sheet, 87% changed plastic sheet between inpatient, 60% modified each day, and 93% sterilized the devices after inpatient. The sterilization each day changed into 90%, NB infection had inpatients transmitted (44%), transferred to technicians (38%), moreover 80% of technicians were expected the NB infection from RD gadgets. The NB isolated from x-ray system cassette were 73%, couch (60%), and chest stand 50%, (25, 30 and 27%) for (key board, lead apron and tube head cope with). The NB isolated from ultrasound machines were; 30% probe, both 24% probe holder, for (gel and key board) as (15 and 14%). The x-ray system as 41.83% became higher than the ultrasound machines 19.75% isolated NB have been Staphylococcus epidermidis 22%, Staphylococcus aureus 19%, Bacillus spp. 19%; Escherichia coli 12%. in conclusion, the NB detected in RD gadgets may serve as vectors that affect the inpatient and public health. It is highly recommended the “Hospitals Hygiene strategy; simply, use the recent anti NB gel. gadgets modernization and regularity sterilization; ought to refresh guides “fitness schooling” and “Hospitals Hygiene strategy”.

© 2022 The Author(s). Published by Elsevier B.V. on behalf of King Saud University. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

* Corresponding author.

E-mail address: abashir@gudgk.edu.pk (M.A. Bashir).

Peer review under responsibility of King Saud University.



Production and hosting by Elsevier

1. Introduction

Adhesive tape in RD as radiographic markers attended as a NB vector (Abramowicz Basseal 2020). The surface of RD devices are a common source of NB infection (Aguirre-Dávila et al., 2021). The NB contamination of RD gadgets observed with the aid of present of Staphylococci and Bacilli, NB also provided on lead aprons

<https://doi.org/10.1016/j.jksus.2022.102154>

1018-3647/© 2022 The Author(s). Published by Elsevier B.V. on behalf of King Saud University.

This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

as 92% (Balogun, 2021). The RD gadgets manipulate pieces and working shows had NB infection by 22.6% that from the ultrasound gadget probes 9 (Biscayart et al., 2020). Transportable x-ray equipment showed NB infection(Duggan et al., 2020), transportable RD gadgets had NB on surfaces because the radiographer; cassette behind the returned of inpatient, the cassette, transportable radiographic gadgets, and radiographer’s arms, confirmed irritated NB infection (Gordon et al, 2013). The NB linked to distinct RD gadgets; the ultrasound system probes established Staphylococcus (epidermidis and hominis), MRSA, Acinetobacter baumannii, Pseudomonas aeruginosa and Klebsiella pneumoniae(Hartato et al., 2018). The x-ray equipment tubes had NB as 41.7%, manage panels, imaging plates had 91.7%, and cassettes had 8%. The NB 86% isolated, from x-ray equipment and add-ons covered 77% for Staphylococcus aureus, 48% for Pseudomonas aeruginosa, 15% for Proteus spp., 9% for Streptococcus, and 44% for Coliform spp.. The supply of NB contamination changed into from ultrasound machines gel. The extraordinary parts of ultrasound machines and gel had NB, which gel had been closely NB contaminated that blanketed Enterococcus faecalis and Staphylococcus aureus(Ilyas et al., 2019). The NB got here the ultrasound gadget probes that turned into 48.38% Staphylococcus epidermidis 22.6% Staphylococcus aureus and nine.7% Pseudomonas aeruginosa, additionally had Escherichia coli, Citrobacter and Enterobacter (Lopez-Gigosos et al., 20182019). NB 30% isolated from the ultrasound machines contained Klebsiella spp. and Pseudomonas spp.(Magiorakos et al., 2017). All through the search for what was the proper with the research, the aim of the studies became directed after questionnaire period to prove that the RD gadgets of all kinds and the important role in diagnosing inpatients. which could as feasible vectors of NB that affected the inpatients fitness, technician’s health and public health, which conducted as a health threat in RD.Graph 1.Graph 2.Graph 3..

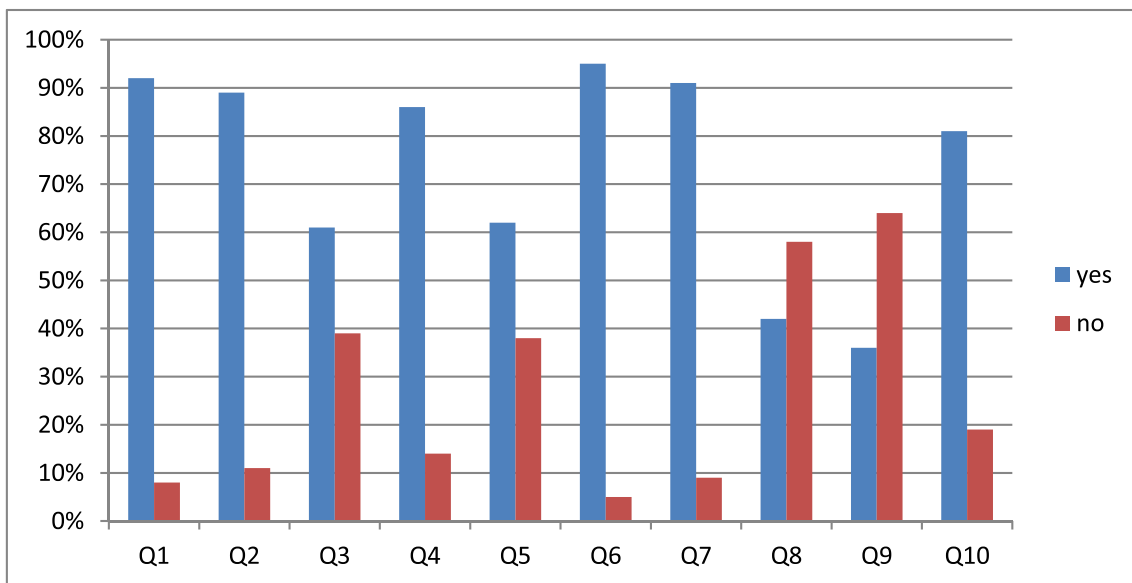
2. Methodology

- A “Cross-sectional Study” was done using questionnaire trial (Matthiesen et al., 2021), the survey was equipped (Table 1, (Mullins et al., 2020), then it was added in network transmission(Nyirenda et al., 2019), so survey data were composed (Oshoma et al., 2019), then were using “Simple Excel” transferred the ethics(Pan et al., 2018).

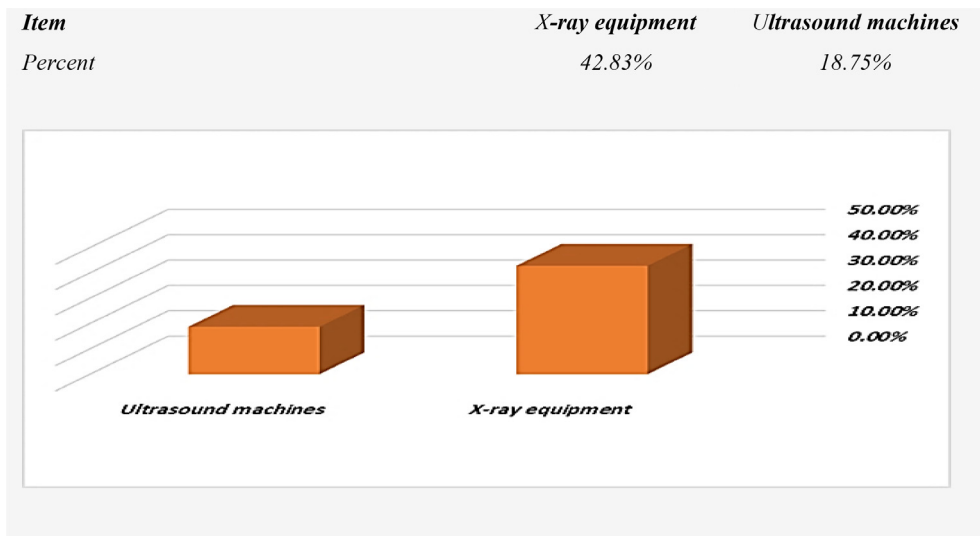
- **Samples collection:** This potential research was focused in Al-Kharj, Saudi Arabia private hospital, for RD devices. The x-ray equipment and ultrasound machines swab samples were colated at diverse days during week and at different times to confirm a variety of NB present. The ultrasound machines swab samples were collected from the probe, probe holder, keyboard and gel. The samplings were achieved with the “Health Measures”, and then were elated directly to the laboratory for dispensation.
- **NB isolation and identification:** Cultures were performed on blood agar and MacConkey agar at 37 °C for 24 h. The isolated NB were identified by standard microbiological techniques (Pillay & Lyall, 2020), then were confirmed by “Micro-Scan” (Pravin et al., 2020)
- **Data analysis:** The data was examined and then analysed using “Simple Excel”.

3. Results and discussion

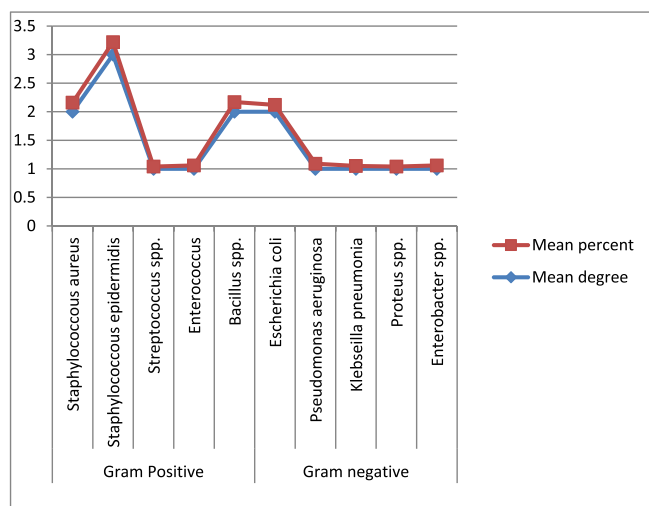
Table 2 and graph 1 that presented x-ray equipment and ultrasound machines questionnaire answer, about 93% of technicians, more than four-fifths, participated in the questionnaire. The second question was about 87% of the technicians working with inpatients, about four-fifths. The third question was 63% who used sterile plastic sheet for devices, more than half of them. The fourth question, 87%, was the change of plastic sheeting between each inpatient, that was, more than three quarters. The fifth question, 60% change every day, about two-thirds. The sixth question, 93% sterilize the devices after each inpatient, close to the total. The seventh question does the sterilization every day, only 90%, also close to the total. The eighth question, the NB infection had transmitted among the inpatients, 44% was nearly half, and this high risk. The ninth question: the NB infection transferred to the technicians 38%, more than a third, here is the risk to the working staff, and the NB infection rate may increase. The tenth question, about 80% of the technicians expected that the source of infection be from the devices, meaning that the source was about four-fifths, which causes the NB infection and spreads easily, and this was the result of dealing with RD devices affected public health (Abramowicz and Basseal, 2020; Aguirre-Dávila et al., 2021; Balogun, 2021; Biscayart et al., 2020; Duggan et al., 2020; Guyatt et al., 2013). After did the



Graph 1. X-ray equipment and ultrasound machines questionnaire answer.



Graph 2. Mean nosocomial bacterial isolated from x-ray equipment and ultrasound machines.



Graph 3. Mean nosocomial bacterial identified from x-ray equipment and ultrasound machines.

Table 1 X-ray equipment and ultrasound machines questionnaire.

No.	Question	Answer	
		Yes	No
1	You are a technician of x-ray and ultrasound devices	93%	7%
2	You work on the mentioned devices for inpatients	87%	13%
3	Use plastic covers for the mentioned devices during work	63%	37%
4	Change the plastic covers for mentioned devices after each inpatient	87%	13%
5	Change plastic covers every day for mentioned devices	60%	40%
6	Sterilizes the mentioned devices after each inpatient	93%	7%
7	Sterilizes the mentioned devices every day	90%	10%
8	Infection was transferred from inpatient to another inpatient after mentioned devices using	44%	56%
9	You infected from the inpatients after using the mentioned devices	38%	62%
10	Expect mentioned devices is a vectors or carrier of nosocomial bacteria	80%	20%

questioner these results indicated a great sense of responsibility towards public health, and despite all the efforts made the rate of NB transmission remains high. More than one-third of the

Table 2 X-ray equipment and ultrasound machines questionnaire answer.

Question	Description	Yes	No
Q1	You are a technician of x-ray and ultrasound devices	93%	7%
Q2	You work on the mentioned devices for inpatients	87%	13%
Q3	Use plastic covers for the mentioned devices during work	63%	37%
Q4	Change the plastic covers for mentioned devices after each inpatient	87%	13%
Q5	Change plastic covers every day for mentioned devices	60%	40%
Q6	Sterilizes the mentioned devices after each inpatient	93%	7%
Q7	Sterilizes the mentioned devices every day	90%	10%
Q8	Infection was transferred from inpatient to another inpatient after mentioned devices using	44%	56%
Q9	You infected from the inpatients after using the mentioned devices	38%	62%
Q10	Expect mentioned devices is a vectors or carrier of nosocomial bacteria	80%	20%

inpatients had NB infection and more than a quarter of the technicians had NB infection through work. These confirmed that the RD devices were an important factor in transmitting of NB infection (Ross et al., 2021). The rate of NB infections remained within these few limits were not a cause for concern, especially in light of effective health strategies capable of containing the NB infection. It must ensure that technicians must use personal protective equipment correctly and disinfect RD devices properly, and must follow “Hospitals Hygiene Strategy” Saliou(et al, 2016). The RD technicians must follow “Hospitals Hygiene Strategy” to maintain the safety of them and inpatient, the results indicated the extent of great NB commitment to follow “Hospitals Hygiene Strategy”, requiring the sterilization of the RD devices daily and after each patient. Whether by changing the plastic sheeting or the sterilization processes used and available in hospitals and care centers. The effect of portable RD devices on reducing NB infection, especially since these devices are almost devoid of monitoring and follow-up, which must clean and sterilized after each use (Sartoretti et al, 2017). The ultrasound machine probes need high-level disinfection required after completing the procedure (Sartoretti et al, 2017). That confirmed by technicians considered the RD devices important vector in NB transmitting infection, which requires the application of “Hospitals Hygiene Strategy” to combat NB infection(Wang and Yang, 2021).

Table 3 that presented mean NB isolated from x-ray equipment, the results were evident through the highest NB isolation resulted of hospital bacterial infections, from cassette were 73%, indicated to the most used and the fastest moving from one place to another. It followed by 60% from x-ray equipment couch as used by all inpatients. Then the chest stand result was 50% and it used every time for inpatients. The rest ranged from (25, 30 and 27%) for (key board, lead apron and tube head handle) respectively. It was clear that the cassette tray in the x-ray equipment contains the highest average classification percentage of isolated NB, followed by the patient's couch and was ranked third in the chest support and it was noticeable that the movable tube head forms one of the parts that are least exposed to the presence of NB (Westerway et al., 2017).

Table 4, that presented mean NB isolated from ultrasound machines, it was found that the highest percentage was given 30% from probe, either 24% from probe holder, give less than the previous one, but it was still high. It was close together for (gel and key board) as (15 and 14%) respectively. The probe occupied the first place of the NB presence it, followed by the probe holder. While the keyboard was the least in NB, the gel considered an important factor in NB infection transmitting. It was worth noting that ultrasound machines imaging requires a longer physical proximity of the device operator to the inpatient, which required special precautions to prevent NB infection (Westerway et al., 2017).

Table 5 and graph 4 that presented mean NB isolated from x-ray equipment and ultrasound machines; it found that the x-ray equipment as 41.83% was higher than the ultrasound machines as 19.75% that was by more than twice (Abramowicz and Basseal, 2020; Aguirre-Dávila et al., 2021; Balogun, 2021; Biscayart et al., 2020; Duggan et al., 2020; Guyatt et al., 2013). This indicated the danger and the presence of the x-ray equipment large size for easy access to NB and it was one of the largest places contained NB as degreed as health risk [25].

Table 6 and graph 5 that presented mean NB identified from x-ray equipment and ultrasound machines, one of the most isolated NB were *Staphylococcus epidermidis* as 19% they are found on the skin as normal flora and can cause wound and blood sepsis. Then *Staphylococcus aureus* was 20%, it was from the nose and between the fingers and may cause infection of wounds, sepsis, food poisoning, ulcers and boils. The *Bacillus* spp. was 19%; they are present in the soil and may cause contamination of wounds and muscle stiffness. *Escherichia coli* was 12%, it was present in the gastrointestinal tract and causes inflammation of the digestive tract and urinary system, and it may lead to kidney inflammation and damage. The rest of the gram-negative are present in the gastrointestinal tract and soil and causes diarrhea of the digestive and blood system sepsis. As for the *Streptococcus* spp. that are present in the nose, they can cause sore throats and inflammation of the heart. *Enterococcus* is found in the gastrointestinal tract and can cause wound infection and enteritis. It turns out that the NB sources are from the skin, the digestive canal, and the soil, and it had been hill to the device that in turn carries it, causing serious diseases as it transforms from the natural flora to the pathogenic due to change its location (Hartato et al., 2018; Ilyas et al., 2019;

Table 3
Mean nosocomial bacterial isolated from x-ray equipment.

Item	Mean Load degree	Mean Load percent
X-ray couch	6	60%
Chest stand	5	50%
Tube head handle	4	25%
Cassette	7	73%
Key board	4	30%
Lead apron	4	27%

Table 4
Mean nosocomial bacterial isolated from ultrasound machines.

Item	Mean Load degree	Mean Load percent
Probe	4	30%
Probe holder	3	24%
Key board	3	15%
Gel	2	14%

Table 5
Mean nosocomial bacterial isolated from x-ray equipment and ultrasound machines.

Item	X-ray equipment	Ultrasound machines
Percent	42.83%	18.75%

Table 6
Mean nosocomial bacterial identified from x-ray equipment and ultrasound machines.

Item	Mean degree	Mean percent
Gram Positive		
Staphylococcus aureus	3	19%
Staphylococcus epidermidis	2	20%
Streptococcus spp.	2	6%
Enterococcus	1	6%
Bacillus spp.	3	19%
Escherichia coli	2	12%
Gram negative		
Pseudomonas aeruginosa	2	11%
Klebseilla pneumonia	1	5%
Proteus spp.	2	6%
Enterobacter spp.	1	6%

Lopez-Gigosos et al., 2018; 2019; Magiorakos et al., 2017; Matthiesen et al., 2021; Mullins et al., 2020; Nyirenda et al., 2019). The interval between imaging operations must lengthened to allow for cleaning and disinfection, and it was advisable to ensure that protocols for cleaning and disinfection of all RD devices are in place according to the manufacturer's instructions. The ultrasound machine probes should cleaned and disinfected using the high-level disinfection method (Guyatt et al., 2013), need sterilization if appropriate, with "Hospitals Hygiene Strategy" and the use of a sterile hood of the adapter was mandatory [26–27]. The NB know the ways of their access and use "Hospitals Hygiene Strategy" that reduce the likelihood of NB reaching the RD. Reconsidering "Hospitals Hygiene Strategy" followed and considerate RD staff lead to reducing NB infection. The ultrasound machines and x-ray equipment are real important factors in NB transmitting [27]. The results showed the x-ray equipment was an important and effective factor in NB transmitting infection compared to the ultrasound machines scanner, due to the surface area exposed to NB contamination was much greater. That necessitates sterilize all parts, especially the most vulnerable to NB contamination. The NB contamination consideration was an important factor. The most vulnerable parts are the probe. Probe holder, keyboard and gel, which were necessary for NB source and the method of sterilizing it after each use in addition to the quality of the gel, which carry NB [25]. There were difference between the RD devices used externally and used internally, the NB transmitting infection greater, the necessity of conducting on the RD devices used internally, and the types of gel. The injury of RD technicians, must take greater precautions during their work, and due to the long period of imaging and the possible physical closeness during the imaging process [26]. Despite all efforts made to reduce the effects of NB on the RD devices indicated the necessity of reviewing the "Hospitals Hygiene Strategy" in sterilization operations or / and providing

training. That appropriated for RD staff on NB infection prevention and control practices to conduct special courses explaining the importance of sterilization to public safety and to control sterilization operations with special tables for the sterilization process, time and the materials. The appropriate implementation of workflow prevention measures NB infection and its control, to prevent non-staff on RD devices to perform sterilization, disinfection operations and reviewing the effectiveness of sterile wipes. That used to disinfect and sterilize RD devices after use, as well to make sure to replace the plastic covers after each follow-up inpatient's diagnostic process (Wang and Yang, 2021).

4. Conclusion

That concluded the NB was detected in RD devices so that make as vectors of NB that affected inpatient health and public health. That recommended the "Hospitals Hygiene Strategy" must use clearly too combat NB infection to maintain inpatient and public health use the recent anti NB gel. Modernization of equipment and regularity in sterilization. Technician must refresh courses for "Health Education" and "Hospitals Hygiene Strategy".

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The authors extend their appreciation to the Researchers supporting project number (RSP-2021/197), King Saud University, Riyadh, Saudi Arabia.

References

Abramowicz, S., Basseal, M., 2020. World federation for ultrasound in medicine and biology position statement: how to perform a safe ultrasound examination and clean equipment in the context of COVID-19. *Ultrasound in Med. & Biology* 46 (7), 1821–1826.

Aguirre-Dávila, E., Morales-Castillo, M., Moreno-Vásquez, M., 2021. Parenting, autonomy and academic achievement in the adolescence. *Journal of Family Studies* Pp. 1–14.

Balogun, O., 2021. Benefits and limitations of portable chest radiography. *Radiologic Technology* 92 (3), 301–304.

Biscayart, C., Angeleri, P., Lloveras, S., Chaves, T.d.S.S., Schlagenhauf, P., Rodríguez-Morales, A.J., 2020. The next big threat to global health? 2019 novel coronavirus

(2019-nCoV): What advice can we give to travellers?—Interim recommendations January 2020, from the Latin-American society for Travel Medicine (SLAMVI). *Travel Med. and Infect. Dis.* 33.

Duggan, M., Shokoohi, H., Liteplo, S., Huang, C., Goldsmith, J., 2020. Best practice recommendations for point-of-care lung ultrasound in patients with suspected COVID-19. *The J. Emergency Med.* 59 (4), 515–520.

Guyatt, G.H., Thorlund, K., Oxman, A.D., Walter, S.D., Patrick, D., Furukawa, T.A., Johnston, B.C., Karanicolos, P., Akl, E.A., Vist, G., Kunz, R., Brozek, J., Kupper, L.L., Martin, S.L., Meerpohl, J.J., Alonso-Coello, P., Christensen, R., Schunemann, H.J., 2013. GRADE guidelines: 13. Preparing Summary of Findings tables and evidence profiles—continuous outcomes. *GRADE guidelines: 13. Preparing Summary of Findings tables and evidence profiles—continuous outcomes.* 66 (2), 173–183.

Hartato, E., Sitorus, D., Wanto, A., 2018. Analisis jaringan saraf tiruan untuk prediksi luas panen biofarmaka di indonesia. *semanTIK* 4 (1), 49–56.

Ilyas, F., Burbidge, B., Babyn, P., 2019. Health care-associated infections and the radiology department. *Journal of medical imaging and radiation sciences* 50 (4), 596–606.

Lopez-Gigosos, R.M., Mariscal, A., Gutierrez-Bedmar, M., Real, M., Mariscal-López, E., 20182019. Carbapenem resistance in *Acinetobacter baumannii* is associated with enhanced survival on hospital fabrics. *Acta microbiologica et immunologica Hungarica* 66 (1), 143–154.

Magiorakos, A.P., Burns, K., Rodríguez Baño, J., Borg, M., Daikos, G., Dumpis, U., Lucet, J.C., Moro, M.L., Tacconelli, E., Simonsen, G.S., Szilágyi, E., Voss, A., Weber, J.T., 2017. Infection prevention and control measures and tools for the prevention of entry of carbapenem-resistant Enterobacteriaceae into healthcare settings: guidance from the European Centre for Disease Prevention and Control. *Antimicrobial Resist. & Infection Control* 6 (1).

Matthiesen, S., Pietras, L., Bode, H., Cholmakow-Bodechtel, C., Cerwenka, S., Pfister, M., von Räden, U., Steinacker, G., Wiessner, C., Briken, P., Dekker, A., 2021. Methodology of the German National Sex Survey—GeSiD (German Health and Sexuality Survey). *The Journal of Sex Research* 58 (8), 1008–1018.

Mullins, K., Burnham, K., Henricson, K., Cohen, S., Fair, J., Ray, W., 2020. Identification and analysis of bacterial contamination of ultrasound transducers and multiuse ultrasound transmission gel bottle tips before and after the aseptic cleansing technique. *J. Ultrasound in Med.* 39 (10), 1957–1963.

Nyirenda, D., Williams, R., ten Ham-Baloyi, W., 2019. Infection control recommendations for radiology departments in Malawi. *Health SA Gesondheid* 24, 1–6.

Oshoma, E., Ehigiamusoe, O., Olee, E., 2019. Microorganisms associated with usable equipment in the radiological unit of University of Benin Teaching Hospital. *African Scientist* 17 (4), 275–284.

Pan, W., Li, W., Li, G., Li, Y., Zhang, Y., Sun, H., 2018. Simple sample preparation method for direct microbial identification and susceptibility testing from positive blood cultures. *Frontiers in Micro.* 9 (481), 1–9.

Pravin, G., Ramakrishna, P., Sindhu, N., Sampath, S., 2020. Bacteriology of ultrasound probes and the antibacterial efficacy of decontaminants used for probes in a Tertiary Care Hospital. *J. Evid. Based Med. Healthc.* 7 (2), 83–86.

Ross, M., Cherkerzian, S., Mikulis, D., Turner, D., Robinson, J., Inder, E., Matthews, G., 2021. A randomized controlled trial investigating the impact of maternal dietary supplementation with pomegranate juice on brain injury in infants with IUGR. *Scientific reports* 11 (1), 1–15.

Wang, C., Yang, Y., 2021. Complexity and bias in cross-sectional data with binary disease outcome in observational studies. *Statistics in Medicine* 40 (4), 950–962.

Westerway, C., Basseal, M., Brockway, A., Hyett, A., Carter, A., 2017. Potential infection control risks associated with ultrasound equipment—a bacterial perspective. *Ultrasound in medicine & biology* 43 (2), 421–426.