Computer Keyboards Transmitting More Than Words:

A Knowledge Synthesis of Computer Keyboards in Hospitals as a Reservoir for Methicillin-resistant *Staphylococcus aureus* Infection

Saarah Hussain, BScH

Master of Public Health Candidate

University of Guelph

March 18th, 2018

Summary

- Methicillin-resistant *Staphylococcus aureus* (MRSA) is a pathogen that leads to a severe staph skin infection and is an emerging public health threat as it is multi-drug resistant
- MRSA is often a nosocomial or hospital-acquired infection and is prominent around the world; community-acquired infections are also of concern
- With electronic patient records, computers are frequently used in the hospital and potentially serve as fomites for transmission of pathogens
- Some hospitals around the world have identified pathogen contamination of their computer keyboards
- Hands are the main source of pathogen transmission, as cross-contamination occurs from healthcare providers when interacting between patients and computers
- The results of this review highlight the need for additional research on the role of computer keyboard MRSA contamination in Canadian hospitals, policy changes for hand washing and cleaning practices, and increased surveillance of MRSA infections, using molecular typing of the isolates and establishing a temporal sequence between object contamination and infection rates

Introduction

With the rise of modern medicine, nosocomial (hospital-acquired) infections have become increasingly prominent as a cause of morbidity and mortality within a hospital setting (1, 2,3). These infections result in severe health and financial challenges for patients and healthcare systems around the world (4). For example, over two million patients acquire nosocomial

infections resulting in 90,000 deaths in the United States each year, which leads to a financial burden exceeding $4.5 billion (1). Within a hospital environment there are a number of important nosocomial pathogens (5). For example, methicillin-resistant *Staphylococcus aureus* (MRSA) can cause severe skin infections as well as infections in other sites (6). MRSA poses a heightened international public health threat due to its widespread and multi-drug resistant nature (6).

Over the years the hospital environment has become filled with new technology and equipment. The role of the hospital environment with regard to increased nosocomial infection rates has been a controversial debate (7). The inanimate environment of the hospital can harbour pathogens on surfaces (1). Common contaminated inanimate surfaces, also referred to as fomites, include chair backs, stethoscopes, and hand rails, and have gathered attention for their potential role in disease transmission (8,9). The advent of modern medicine has paved the way for electronic patient records, thus there has been a drastic increase in computer use in hospital wards, operating rooms (OR), and intensive care units (ICU) (10,11). Cross-contamination of microorganisms occurs by the hands of healthcare providers as they go back and forth between interacting with patients and recording information on the computer (7). There is good evidence that hands are the main source of pathogen transmission in the hospital environment (12,13). MRSA contamination on computer keyboards is dangerous for two main reasons; firstly, the survival time of this pathogen on surfaces is anywhere from 7 days to over 12 months (14) and secondly many strains of MRSA are antibiotic resistant (15).

Prevention and precaution should be taken. There has been a push for hand hygiene policies and promotion in the hospital setting (16,17). There is a lack of evidence for the effectiveness of disinfecting and cleaning procedures in the control of microorganisms such as

MRSA (18). Though, regular disinfecting and cleaning of computer keyboards is advised to control pathogen transmission and spread in the enclosed hospital environment (19,20). In light of recent findings on the role of the inanimate hospital environment and nosocomial infections, this environmental health evidence review seeks to examine the current evidence surrounding computer keyboards as reservoirs for MRSA infection in hospital settings and highlight gaps in both knowledge and policy.

Methods

A literature review was conducted using the electronic database, Google Scholar. The main literature search was restricted to articles from peer-reviewed journals published in English between 2000-2018. The database was searched using the following keywords: “MRSA infection”, “computer keyboard”, and “ICU hospital”. From the search of keywords 817 articles were retrieved from the database, the article titles were screened for relevance to the topic of MRSA and computer keyboards. Abstracts of 115 articles with relevant titles were then reviewed to determine the level of appropriateness for this evidence review; 30 articles were read and examined in entirety.

Excluded from this search were patents and citations. Additionally, articles in books, systematic reviews, dissertations, websites, and articles not available through the University of Guelph library via. Google Scholar were excluded. Articles pertaining solely to other pathogens and nosocomial infections, and other inanimate objects were not included. Articles were selected based on their relevance to and testing of the MRSA pathogen and MRSA infection with regard to computer keyboards in hospital settings around the world. Articles discussing hand hygiene in the cross-contamination of MRSA to computers, as well as relevant policy, prevention, and

cleaning of computer surfaces in the hospital, specifically in the OR, ICU, and hospital wards were included. Please refer to Appendix A for a flow chart of literature search results and Appendix B for article summaries.

Results and Discussion

There were 16 articles from the database that met inclusion criteria and were included in this literature review. Computer keyboard surfaces were tested for contamination of pathogens in various studies from the following countries: Canada, United States of America, United Kingdom, Iran, Thailand, Taiwan, Italy, Germany, India, Republic of Korea, Republic of South Africa, and Japan. Modern medicine and computer technology has been adopted around the world in the recording of patient information (10,11). MRSA was found globally, suggesting that computer contamination by MRSA is a widespread public health issue (21). Out of the 16 articles reviewed only 1 study was unable to designate computer keyboards as reservoirs for microorganisms in the OR and ICU (10). All 16 articles showed that there was some degree of pathogen contamination on computer keyboards sampled in hospital settings. Eleven identified MRSA as a source of contamination (1,2,4,5,8,11,12,13,16,17,19), while the remaining five articles reported contamination of computer surfaces, but the organisms identified were unspecified (3,7,10,20,21). In Canada, samples from environmental surfaces within hospital wards were collected and 11.8% were contaminated with MRSA (8). Logistic regression modelling indicated that surfaces such as chair backs and hand rails were at increased odds of being contaminated with MRSA compared to computer keyboards; however, computer keyboards should not be disregarded (8). Colonization rates for computer keyboards are greater than many other user interfaces in the ICU (7). Studies have shown that 92% to 98.5% of

computers are colonized with pathogens such as *Bacillus sp.*, *Micrococcus*, *Escherichia coli*, and *Enterobacter sp.*; with 1.8% to 15% of computers specifically contaminated by MRSA (17,19). Many of the articles focused on research in the ICU, as environmental contamination in the ICU can be riskier as patients are in a vulnerable state and transmission can occur with increased interactions between patient and healthcare providers (22). Patients in the ICU can have additional factors leading to increased susceptibility of nosocomial infections, including being at an increased risk for infections, very young or very old, victims of trauma, immunocompromised, or immunosuppressed (23).

The hospital environment as a reservoir of nosocomial pathogens is controversial and with the introduction of computers in the ICU, OR, and hospital wards healthcare providers are interacting both with patients and this technology on a regular basis (11). Computer keyboards are commonly classified as "high touch" surfaces based on frequency of contact, as they are frequently directly touched (22). It is undisputed that hands are the main source of pathogen contamination of computer keyboards (7). ICU staff were aware that keyboards are an important source of nosocomial infections and furthermore 82% of doctors and 40.3% of nurses admitted to never washing their hands before or after computer use (4). Hand washing policies should be implemented and enforced, although efforts need to be taken to promote and raise awareness of the importance in infection control; as even with implementation of hand washing policies there is variance in compliance. This was observed in the United Kingdom with two hospitals having the same hand washing policies, but hospital B had increased hand washing compliance and 44% higher rate of paper towel usage per hospital bed than hospital A (16). It is recommended to wash hands and change gloves before and after interacting with a patient and wash hands prior to using

the computer (12). With good hand hygiene compliance of 74%, there was low (1.1%) contamination rates of MRSA on computers (13). Therefore, hand hygiene is of utmost importance in controlling pathogen transmission.

Regular cleaning and disinfecting of computer keyboards proves to be effective in controlling pathogen contamination (24,25). However, questionnaire results from healthcare providers concluded that 97% of respondents were not aware of an official policy for computer equipment cleaning (4). With enhanced cleaning in hospital wards there was a 26.6% reduction in MRSA contamination, though if not routinely cleaned, MRSA clusters were identified 2 to 4 weeks post cleaning (2). Disinfectants are also very effective, ethanol removed upwards of 93% to 100% of pathogens in different hospitals (19,20). It is recommended to clean and disinfect computer keyboards regularly and routinely, as well as if there is visible dirtiness (3). Other unique forms of controlling pathogen contamination on computer keyboards are the use of plastic covers, flat silicone-coated surface keyboards that prevent pathogen adherence on the surface, or an alarm system that sets reminders to clean the computer after use (3,11). A novel technology that is being investigated for efficacy is the use of UV lamps to decontaminate computer keyboards, it is promising as there is minimal interruption and requires only low UV exposure; however, further research is required to evaluate its effectiveness and feasibility (26). Although further research is required at this time, hand hygiene compliance and regular cleaning and disinfecting have the potential to save hospitals money and save patients undue suffering (2).

Several limitations were encountered while conducting this knowledge synthesis and limitation themes were identified from the articles reviewed. A major limitation and reason behind the lack of consensus regarding the hospital environment's role in nosocomial

microorganism transmission is the challenge in demonstrating that environmental surface contamination directly results in pathogen transmission and furthermore patient infection (1). There was a lack of information in published research on the exact time sequences between MRSA computer keyboard colonization, patient MRSA infection rates, and patient outcomes (1); the variable survival time of MRSA poses another challenge in establishing a time component (14). Molecular typing of the isolates from patients with MRSA infection (if any), healthcare providers' hands samples, and computer contamination samples could shed light on the course and extent of transmission within the hospital environment, although this is beyond the scope of this review (5,8). There is an extensive amount of evidence on hand washing and several of the articles examining hand washing compliance may be biased by the Hawthorne effect, which could have modified behaviour, increasing compliance results (2). Another limitation is there are differences between the hospitals and countries included in this review. The collection of samples was not standardized and there are differences in culture and policy that were not accounted for in this review; therefore, findings may not be generalizable on a global scale (4). Finally, there are a number of other factors influencing MRSA contamination and MRSA infection rates, numerous other pathogens, and many environmental surfaces within the hospital setting, making it difficult to isolate the role of computer keyboards and MRSA specifically. Other factors potentially influencing MRSA contamination of computer keyboards which were not mentioned in the articles, include the duration of contact with computers (long versus short), number of users coming into contact with the computer of interest, and number of times contact was made in a given time period (17).

Conclusions

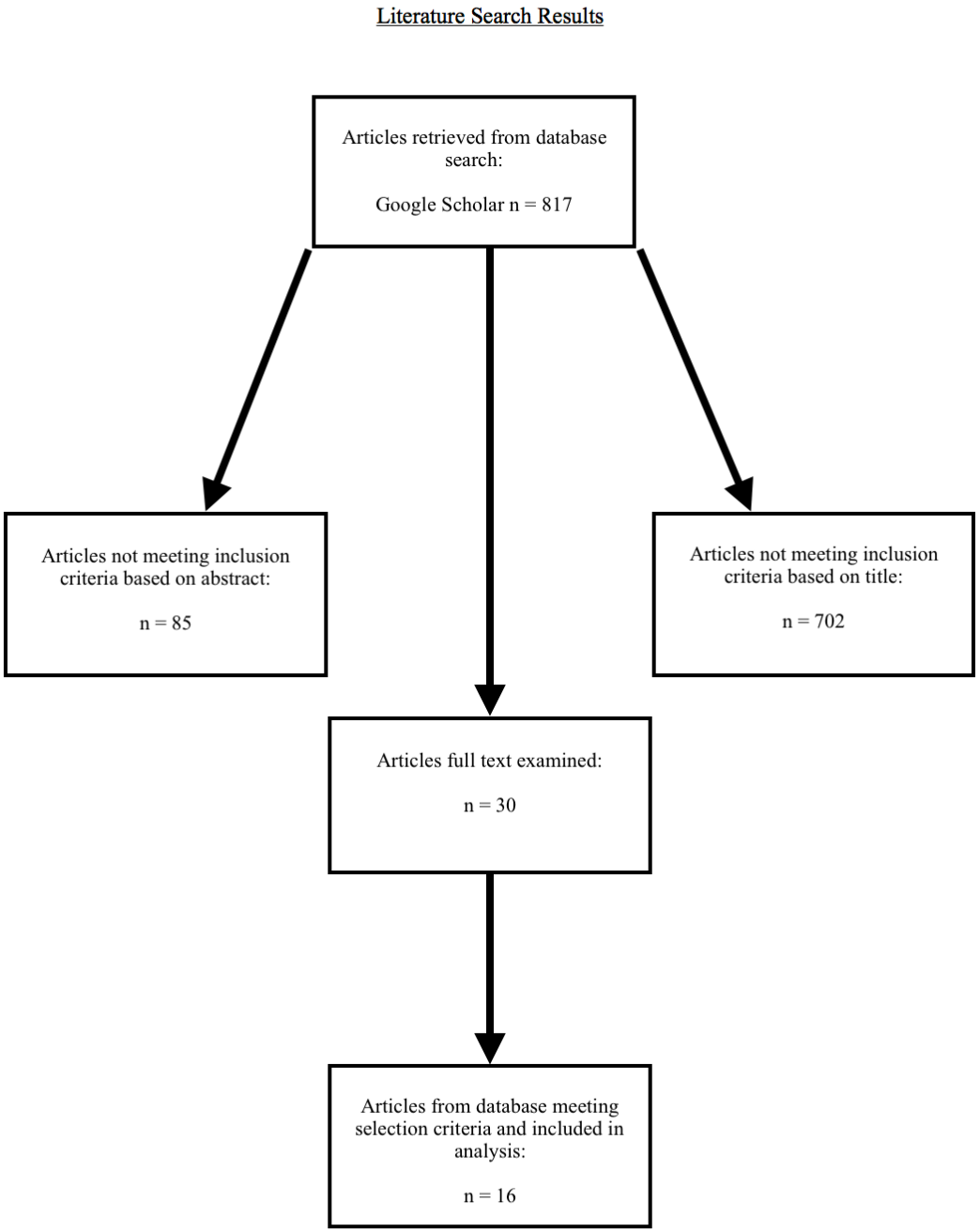
It is evident that the scientific and public health community around the world view nosocomial infections as an emerging threat posed by numerous pathogens in the hospital environment, including the multi-drug resistant MRSA. Modern medicine has transitioned to electronic patient records and the routine use of computers in the OR, ICU, and hospital wards. Followed by research on a number of other inanimate objects in the hospital environment, computer keyboards are gaining attention as a plausible reservoir for pathogens. Numerous primary research studies from hospitals globally have identified pathogen contamination of computer keyboards, many identifying MRSA as the culprit. Healthcare providers must be aware of cross-contamination of pathogens when going back and forth between patients and computers. Good hand hygiene is the most important prevention measure to reduce cross-contamination, followed by regular cleaning and disinfecting practices; policy makers may want to revamp hand hygiene policies and consider implementing computer cleaning policies. In light of the evidence presented in this knowledge synthesis, the implications of computer keyboard contamination must be considered in regard to patient health. There is a need for additional research on computer keyboard MRSA contamination in Canadian hospitals and increased surveillance of MRSA infections, using molecular typing of the isolates to establish a temporal sequence to identify if computer keyboard contamination is the source of MRSA infection. Awareness of computer keyboard pathogen contamination is imperative as this is a preventable public health issue that needs to be acted upon now, if disregarded it can result in life-ending consequences.

References

1. Bures S, Fishbain JT, Uyehara CF, Parker JM, Berg BW. Computer keyboards and faucet handles as reservoirs of nosocomial pathogens in the intensive care unit. American journal of infection control. 2000;28(6):465-71.
2. Dancer SJ, White LF, Lamb J, Girvan EK, Robertson C. Measuring the effect of enhanced cleaning in a UK hospital: a prospective cross-over study. BMC medicine. 2009;7(1):28.
3. Waghorn DJ, Wan WY, Greaves C, Whittome N, Bosley HC, Cantrill S. Contamination of computer keyboards in clinical areas: potential reservoir for nosocomial spread of organisms. British Journal of Infection Control. 2005;6(3):22-4.
4. Anastasiades P, Pratt TL, Rousseau LH, Steinberg WH, Joubert G. Staphylococcus aureus on computer mice and keyboards in intensive care units of the Universitas Academic Hospital, Bloemfontein, and ICU staff's knowledge of its hazards and cleaning practices. Southern African Journal of Epidemiology and Infection. 2009;24(2):22-6.
5. Visalachy S, Palraj KK, Kopula SS, Sekar U. Carriage of multidrug resistant bacteria on frequently contacted surfaces and hands of health care workers. Journal of clinical and diagnostic research: JCDR. 2016;10(5):18.
6. Halcomb EJ, Griffiths R, Fernandez R. Role of MRSA reservoirs in the acute care setting. International Journal of Evidence-Based Healthcare. 2008;6(1):50-77.
7. Hartmann B, Benson M, Junger A, Quinzio L, Röhrig R, Fengler B, Färber UW, Wille B, Hempelmann G. Computer keyboard and mouse as a reservoir of pathogens in an intensive care unit. Journal of clinical monitoring and computing. 2004;18(1):7-12.
8. Faires MC, Pearl DL, Ciccotelli WA, Straus K, Zinken G, Berke O, Reid-Smith RJ, Weese JS. A prospective study to examine the epidemiology of methicillin-resistant Staphylococcus aureus and Clostridium difficile contamination in the general environment of three community hospitals in southern Ontario, Canada. BMC infectious diseases. 2012;12(1):290.
9. McDonald M, Ness SM. Infection control. Health. 2014.
10. Quinzio L, Blazek M, Hartmann B, Röhrig R, Wille B, Junger A, Hempelmann G. Computers in anesthesia and intensive care: lack of evidence that the central unit serves as reservoir of pathogens. International journal of hygiene and environmental health. 2005;208(4):299-304.
11. Wilson AP, Ostro P, Magnussen M, Cooper B. Laboratory and in-use assessment of methicillin-resistant Staphylococcus aureus contamination of ergonomic computer keyboards for ward use. American journal of infection control. 2008;36(10):19-25.
12. Fukada T, Iwakiri H, Ozaki M. Anaesthetists' role in computer keyboard contamination in an operating room. Journal of Hospital Infection. 2008;70(2):148-53.
13. Lu PL, Siu LK, Chen TC, Ma L, Chiang WG, Chen YH, Lin SF, Chen TP. Methicillin-resistant Staphylococcus aureus and Acinetobacter baumannii on computer interface surfaces of hospital wards and association with clinical isolates. BMC infectious diseases. 2009;9(1): 164.

14. Otter JA, Yezli S, French GL. The role of contaminated surfaces in the transmission of nosocomial pathogens. Use of biocidal surfaces for reduction of healthcare acquired infections. 2014;27-58.
15. Po JL, Burke R, Sulis C, Carling PC. Dangerous cows: an analysis of disinfection cleaning of computer keyboards on wheels. American journal of infection control. 2009;37(9):778-80.
16. Devine J, Cooke RP, Wright EP. Is methicillin-resistant Staphylococcus aureus (MRSA) contamination of ward-based computer terminals a surrogate marker for nococomial MRSA transmission and handwashing compliance?. Journal of Hospital Infection. 2001;48(1):72-5.
17. Hong DY, Park SO, Lee KR, Baek KJ, Moon HW, Han SB, Shin DH. Bacterial contamination of computer and hand hygiene compliance in the emergency department. Hong Kong Journal of Emergency Medicine. 2012;19(6):387-93.
18. Dancer SJ. The role of environmental cleaning in the control of hospital-acquired infection. Journal of hospital Infection. 2009;73(4):378-85.
19. Karbasizade V, mohammadi Sichani M, Parsafar S. Bacterial contamination of computer keyboards in hospitals in Isfahan in Iran. International Journal of Biosciences (IJB). 2014;4(1):320-4.
20. Messina G, Ceriale E, Burgassi S, Russo C, Defranceschi C, Mariani L, Taddei L, Lenzi D, Manzi P. Impact of a disinfecting technique on microbial contamination of computer keyboards and telephone handsets. Journal of Hospital Administration. 2013;2(4):1.
21. Keerasuntonpong A, Kesornsuk S, Trakulsomboon S, Thamlikitkul V. Colonization of Nosocomial Pathogens on Computer Keyboards in Patient Care Areas. Siriraj Medical Journal. 2017;57(9):380-1.
22. Huslage K, Rutala WA, Sickbert-Bennett E, Weber DJ. A quantitative approach to defining "high-touch" surfaces in hospitals. Infection Control & Hospital Epidemiology. 2010;31(8): 850-3.
23. Neely AN, Sittig DF. Basic microbiologic and infection control information to reduce the potential transmission of pathogens to patients via computer hardware. Journal of the American Medical Informatics Association. 2002;9(5):500-8.
24. Amini R, Heidari Moghadam R, Soleimani S, Madihi SV, Jahani H, Pakzad I, Heidarzadi K, Karami N, Karimi Z, Hematian A, Mohammadi J. Disinfection and general cleaning practices used in health care centers and hospitals. Journal of Basic Research in Medical Sciences. 2014.
25. Rutala WA, White MS, Gergen MF, Weber DJ. Bacterial contamination of keyboards: efficacy and functional impact of disinfectants. Infection Control & Hospital Epidemiology. 2006;27(4):372-7.
26. Gostine A, Gostine D, Donohue C, Carlstrom L. Evaluating the effectiveness of ultraviolet-C lamps for reducing keyboard contamination in the intensive care unit: a longitudinal analysis. American journal of infection control. 2016;44(10):1089-94.

Appendix A


Literature Search Results
Articles retrieved from database search:
Google Scholar n = 817
Articles not meeting inclusion criteria based on abstract:
n = 85
Articles not meeting inclusion criteria based on title:
n = 702
Articles full text examined:
n = 30
Articles from database meeting selection criteria and included in analysis:
n = 16

Appendix B

Reference	Country	Findings
Anastasiades P, Pratt TL, Rousseau LH, Steinberg WH, Joubert G. Staphylococcus aureus on computer mice and keyboards in intensive care units of the Universitas Academic Hospital, Bloemfontein, and ICU staff's knowledge of its hazards and cleaning practices. Southern African Journal of Epidemiology and Infection. 2009;24(2):22-6.	Republic of South Africa	• Results from an anonymous questionnaire completed by ICU staff show that 72% of respondents stated that they believe keyboards and mice are an important source of nosocomial infections • 82% of doctors and 40.3% of nurses admitted they never wash their hands before or after using the computer • 97% of respondents were not aware of an official cleaning policy for computer equipment • Swab results of 14 computer mice and keyboards in the ICU isolated *Staphylococcus aureus* from one computer mouse and 2 keyboards and 6 months later 5 computer mice
Bures S, Fishbain JT, Uyehara CF, Parker JM, Berg BW. Computer keyboards and faucet handles as reservoirs of nosocomial pathogens in the intensive care unit. American journal of infection control. 2000;28(6):465-71.	United States of America	• 144 samples were obtained including 80 keyboards and 64 faucet handles, which yielded 33 isolates in the ICU • Colonization rate for keyboards was 24% to 26% in the rooms • MRSA represented 49% of isolates • An associated pattern of environmental contamination and patient infection • Keyboards may serve as reservoirs of nosocomial pathogens and vectors for cross-contamination in the ICU
Dancer SJ, White LF, Lamb J, Girvan EK, Robertson C. Measuring the effect of enhanced cleaning in a UK hospital: a prospective cross-over study. BMC medicine. 2009;7(1):28.	United Kingdom	• When hospital wards received enhanced cleaning there was a 32.5% reduction in levels of microbial contamination at hand-touch sites • Near patient sites were more frequently contaminated with MRSA than sites further from the patient • Wards receiving extra cleaning had a 26.6% reduction in new MRSA infections • After the cleaner left the wards, clusters of new MRSA infections were identified within 2 to 4 weeks • Enhanced cleaning saved the hospital money
Devine J, Cooke RP, Wright EP. Is methicillin-resistant Staphylococcus aureus (MRSA) contamination of ward-based computer terminals a surrogate marker for nococomial MRSA transmission and handwashing compliance?. Journal of Hospital Infection. 2001;48(1):72-5.	United Kingdom	• 25 computer terminals between two hospitals were examined, MRSA was identified in 6 (24%) • 5 MRSA positive terminals were from hospital A, which had a higher rate of MRSA transmission and only 1 MRSA positive terminal from hospital B • MRSA containment and hand washing policies were similar at both hospitals, however hospital B had better hand washing compliance and 44% higher rate of paper towel usage per hospital bed • MRSA cross-contamination from ward-based computer terminals poses a low risk

Reference	Country	Findings
Faires MC, Pearl DL, Ciccotelli WA, Straus K, Zinken G, Berke O, Reid-Smith RJ, Weese JS. A prospective study to examine the epidemiology of methicillin-resistant Staphylococcus aureus and Clostridium difficile contamination in the general environment of three community hospitals in southern Ontario, Canada. BMC infectious diseases. 2012;12(1):290.	Canada	• Samples from environmental surfaces in hospital wards were collected with 11.8% of surfaces testing positive for MRSA • Based on molecular typing there were 5 different MRSA strains identified in the hospital environment • Logistic regression modelling indicated that compared to computer keyboards, surfaces such as chair backs, hand rails, isolation cars, and sofas had increased odds of being contaminated with MRSA
Fukada T, Iwakiri H, Ozaki M. Anaesthetists' role in computer keyboard contamination in an operating room. Journal of Hospital Infection. 2008;70(2):148-53.	Japan	• MRSA was found on keyboards used in the OR • Cleaning keyboards with ethyl alcohol reduced bacterial counts • Wet contaminated gloves and keyboards transmitted MRSA more readily than dry contaminated gloves and keyboards • To prevent cross-contamination keyboards should be disinfected once daily or when visibly dirty • Proper hand hygiene is essential and gloves should be removed after each procedure and before using the computer
Hartmann B, Benson M, Junger A, Quinzio L, Röhrig R, Fengler B, Färber UW, Wille B, Hempelmann G. Computer keyboard and mouse as a reservoir of pathogens in an intensive care unit. Journal of clinical monitoring and computing. 2004;18(1):7-12.	Germany	• 26 contaminated samples (5.9%) out of 222 samples from keyboards and mice from 14 patients' rooms • 2 contaminated samples (6.3%) out of 16 samples from physician's computer terminals • Colonization rate for computer keyboard and mouse is greater than other user interfaces in the ICU • May be a reservoir for the transmission of microorganisms and become vectors for cross-contamination of nosocomial infections in the ICU
Hong DY, Park SO, Lee KR, Baek KJ, Moon HW, Han SB, Shin DH. Bacterial contamination of computer and hand hygiene compliance in the emergency department. Hong Kong Journal of Emergency Medicine. 2012;19(6): 387-93.	Republic of Korea	• 103 out of 112 (92%) samples from computer keyboards and mice in the emergency department from 3 hospitals showed growth of microorganisms • MRSA was obtained from 2 keyboards (1.8%) • Hand hygiene compliance was observed 29.9% of the time • Computer equipment in the emergency department may serve as reservoirs for nosocomial infection • Hand hygiene should be performed before and after use of computer equipment in the emergency department

Reference	Country	Findings
Karbasizade V, mohammadi Sichani M, Parsafar S. Bacterial contamination of computer keyboards in hospitals in Isfahan in Iran. International Journal of Biosciences (IJB). 2014;4(1): 320-4.	Iran	• Swab samples were collected from 65 keyboards in medical wards from various hospitals • 98.5% of computers were colonized by pathogens; 15% by MRSA • Ethanol removed 93% of test bacteria • Computer keyboards are a source of bacterial contamination in the transmission of nosocomial infections • Computers should be cleaned daily with disinfectants and compliance with hand washing procedures are recommended
Keerasuntonpong A, Kesornsuk S, Trakulsomboon S, Thamlikitkul V. Colonization of Nosocomial Pathogens on Computer Keyboards in Patient Care Areas. Siriraj Medical Journal. 2017;57(9):380-1.	Thailand	• Comparison of 26 computer keyboards from general medical wards and 26 computer keyboards from secretarial offices • Colonization rate of pathogens on the keyboards was 96.2% from patient care areas compared to 92.3% from the offices • Pathogenic organisms were more often found from computer keyboards located in patient care areas • Computer keyboards should be periodically cleaned
Lu PL, Siu LK, Chen TC, Ma L, Chiang WG, Chen YH, Lin SF, Chen TP. Methicillin-resistant Staphylococcus aureus and Acinetobacter baumannii on computer interface surfaces of hospital wards and association with clinical isolates. BMC infectious diseases. 2009;9(1):164.	Taiwan (Republic of China)	• 282 computer interface surfaces from hospital wards tested • Contamination rates of MRSA of hospital ward computers was 1.1% • With good hand hygiene compliance, upwards of 74%, there are low contamination rates of MRSA on ward computer interfaces; thus no further contribution to nosocomial infection
Messina G, Ceriale E, Burgassi S, Russo C, Defranceschi C, Mariani L, Taddei L, Lenzi D, Manzi P. Impact of a disinfecting technique on microbial contamination of computer keyboards and telephone handsets. Journal of Hospital Administration. 2013;2(4):1.	Italy	• An innovative disinfecting technique was effective in disinfecting the sample of 50 computer keyboards from 3 hospitals • Colony-forming units decreased to 0 • Computer keyboards emerged to be originally dirtier with several types of bacteria than telephone handsets • Microbial contamination of keyboards is considerable and can act as a vehicle for health care-associated infections • Disinfection is important
Quinzio L, Blazek M, Hartmann B, Röhrig R, Wille B, Junger A, Hempelmann G. Computers in anesthesia and intensive care: lack of evidence that the central unit serves as reservoir of pathogens. International journal of hygiene and environmental health. 2005;208(4):299-304.	Germany	• 190 sites from computers in the OR and ICU were cultured for bacteria and fungi • Swab analyses did not find any significant number of pathogenic bacteria or fungi • This is attributed to either absence or the low number of pathogens detected on the computer surfaces • Microbial contamination of OR and ICU computers is too low for designating them as a reservoir for microorganisms at this time

Reference	Country	Findings
Visalachy S, Palraj KK, Kopula SS, Sekar U. Carriage of multidrug resistant bacteria on frequently contacted surfaces and hands of health care workers. Journal of clinical and diagnostic research: JCDR. 2016;10(5):18.	India	• Out of the 157 hand swabs collected from health care workers 42.7% of them showed pathogen growth; 1.3% by MRSA • Out of the 30 environmental samples (4 from computer keyboards) from the hospital, 53.3% showed pathogen growth, 3.4% by MRSA • All health care workers should adhere to infection control practices to control for health care-associated infections
Waghorn DJ, Wan WY, Greaves C, Whittome N, Bosley HC, Cantrill S. Contamination of computer keyboards in clinical areas: potential reservoir for nosocomial spread of organisms. British Journal of Infection Control. 2005;6(3):22-4.	United Kingdom	• Swabs were taken from 48 computers from a variety of clinical areas and all 48 computer keyboards were contaminated • 4% were colonized with known bacterial pathogens and 96% with microorganisms that potentially could cause nosocomial infections • Computer keyboards and mice should be cleaned regularly, plastic covers can be used, and most importantly compliance with hand hygiene practices in clinical areas
Wilson AP, Ostro P, Magnussen M, Cooper B. Laboratory and in-use assessment of methicillin-resistant Staphylococcus aureus contamination of ergonomic computer keyboards for ward use. American journal of infection control. 2008;36(10):19-25.	United Kingdom	• Compared flat silicone-coated surface keyboards with standard keyboards • Bacteria such as MRSA were most easily removed from flat keyboards • Total viable count on flat keyboard with an alarm was lower than the standard keyboard • The alarmed flat keyboard was cleaned 87% of the time when the cleaning reminder alarm was triggered • Compliance with hand hygiene prior to touching the standard keyboard was 27%