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Hospital Footwear as a Vector for Organism Transmission

David J. Frederick
University of Central Florida

HOSPITAL FOOTWEAR AS A VECTOR FOR ORGANISM TRANSMISSION

by

DAVID FREDERICK
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Abstract

In the United States healthcare system, nearly one in 31 patients contract a nosocomial infection. Footwear worn in these hospital settings are a factor that should be considered when determining contributing agents and methods for organism transmission. The purpose of this review is to synthesize the current research on hospital footwear as a vector for organism transmission. Eight studies were included in this review to examine the impact of wearable interventions on footwear-related contamination in the hospital setting and organism transfer as it relates to footwear and hospital environments. The link between the organism load and diversity on hospital worn footwear and the hospital environment may be subject to a preventative intervention. After reviewing the selected research, it can be concluded that hospital footwear serves as a vector of organism transmission. In addition, the intervention of shoe covers appeared to be ineffective in lowering organism transmission. This synthesis will include a discussion based on the results of eight studies.

Dedication

I would like to dedicate this review to my family, peers, and mentors. The influence and support you have invested in me has instilled the sense of purpose that has inspired this thesis and my passion for humanity. Thank you all.

Acknowledgements

Without hesitation, it is only proper to elucidate the influence and enrichment I have received from my chair, Dr. Brian Peach. Going beyond the lessons into research and nursing, you have shared your priceless insights to professionalism, charity, and creed. In addition, to my committee member, Mrs. Charlotte Neubauer, both of you have made every step of this process a learning opportunity that will be more valuable than words can describe.

For my family, whose unwavering care and support has been a constant source of empowerment and comfort, through all my endeavors. Whether under a shared roof or overseas, your steadfast dedication to see me grow and thrive has set the example of the same values and morals I credit to my successes. Family is forever.

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To Savanna, it is because of you I have remained focused, confident, and passionate throughout this process. Your clear, calming voice overcame the noise of frustration and distraction I faced at times during this project. Thank you for your love, support, and reminders to celebrate my hard work. You are my chosen family with resolute love.

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Background

Hospitals provide services and care to individuals that are often more susceptible to contracting illnesses and diseases due to their already compromised immune systems. These health care facilities are contaminated with various microorganisms that may be pathogenic in nature. With exposure to these pathogens, vulnerable patients are more likely to develop a nosocomial infection. Patients receiving care in higher acuity hospital units are uniquely susceptible to nosocomial infections due to their critical conditions. Organisms found in health care settings such as *Methicillin-resistant Staphylococcus Aureus (MRSA)* and *Vancomycin-resistant Enterococcus (VRE)* cause grave or lethal infections, and can colonize surfaces, leaving shoes and other forms of footwear as potential vectors (Ali et al., 2014).

According to the Centers for Disease Control and Prevention (CDC), approximately 687,000 patients contracted a nosocomial infection in a United States (U.S.) hospital in 2015, a rate of one out of 31 patients (CDC, 2018). Any person that enters a health care facility contributes to the ongoing contamination cycle. According to Rashid et al. (2016), nearly 40% of shoes in a community setting contain traces of toxigenic *Clostridium difficile*, a commonly contracted microorganism found in hospital environments. Hospitals have made a concerted effort to combat nosocomial infections and 2011-2015 U.S. data show a 16% decrease of nosocomial infection occurrences (CDC, 2018).

Clothing of healthcare professionals and others inside healthcare facilities are subject to contamination by pathogens. The use of universal precautions such as gloving and strategic hand washing have been successful in limiting some transfer of foreign pathogens (Kanwar et al., 2019). However, though these practices are used by clinicians, cross-contamination still occurs. Pathogens that cause nosocomial infections mainly contaminate healthcare professionals when providing care to patients (Kanwar et al., 2019).

Personal protective equipment (PPE) are known to deter the spread of pathogens (Macdonald, 2015). Policies and use of PPE however vary amongst health systems nationally and internationally. In the United Kingdom, for example, most hospital operating rooms lack a comprehensive cleaning or contamination prevention intervention for staff members' shoes (Agarwal, Stewart & Dixon, 2002). In contrast, according to the Association of Surgical Technologists, in the United States it is standard for health care workers in surgical settings to wear shoe covers with contact precautions from bodily fluids (Association of Surgical Technologists, 2008).

Floors of hospital facilities are reservoirs for pathogens. Koganti, Alhmidi, Tomas, Cadnum, Jencson, and Donskey (2016), reported, "hospital floors are often heavily contaminated but are not considered an important source for pathogen dissemination because they are rarely touched. However, floors are frequently contacted by objects that are subsequently touched by hands (e.g., shoes, socks, slippers). In addition, it is not uncommon for high-touch objects such as call buttons and blood pressure cuffs to be in contact with the floor" (p. 1374). One study that measured the organism load on an Australian surgical unit identified the following measurements of pathogens on various sites of floors: 1,854 colony forming units (CFU) in the main corridor, 2,598 CFU found on bathroom floors, and 1,074 CFU on patient room floors (Galvin et al., 2016). The researchers attributed this finding to shoe contamination, as well as a lack of standard practices for cleaning and personal protective equipment to prevent transmission. The role that shoes have in transmitting pathogens that cause nosocomial infections should be better understood.

Significance

According to the CDC, an estimated 10% of patients (n= 72,000) who contracted a nosocomial infection in 2015 died from that infection (2018). Floors are a major reservoir for microorganisms and play a role in the transfer of them. Gupta et al. (2007), reported aerated bacteria found in intensive care settings are re-dispersed back into the air from being colonized on the floor with foot traffic. Another report confirmed the same disbursement of bacteria occurs in operating rooms (Paduszyńska, Rucińska, & Pomorski, 2015). Cleaning and disinfecting methods only provide limited solutions for delaying this microbiome from developing (Sharma, Kaur, & Jitender, 2018). A recent study tested the hypothesis that clothes worn by health care professionals serve as vectors of pathogens (Kanwar et al., 2019). Approximately 20% (n=8) of the 41 participants were found to have clothing contamination, with MRSA being the most prevalent microorganism found in cultures. Evidence of MRSA nasal contamination was found in 33% of the physicians in a sample of MRSA positive healthcare workers (Kanwar et al., 2019). This study found that clothing of healthcare workers contribute to the organism load of hospitals as vectors. Findings like these reinforce the importance of investigating further innovations to reduce the rate of nosocomial infections. A focus on how shoes may act as vectors is important to study.

Problem Statement

The purpose of this literature review is to synthesize the current evidence on hospital footwear as a vector for organism transmission.

Methodology

A literature review of peer-reviewed articles, from January 2000 to January 2020, pertaining to footwear contamination in hospitals was completed. Exclusion criteria were: (a) articles not published in English; (b) literature reviews; (c) studies conducted outside of hospitals (d) studies with data older than 20 years; (e) studies conducted on animals; and (f) studies other than quantitative design. Databases utilized for articles included in this review were CINAHL Plus, MEDLINE, PubMED, Google Scholar, and Cochrane Database of Systematic Reviews. The search for articles took place from October 2019 to February 2020. The University of Central Florida College of Nursing librarian assisted with picking search terms. Search terms included hospital acquired infection* OR nosocomial infection*, shoe* OR foot* OR boot* OR protective footwear, hospital* OR healthcare facilit* OR unit* OR theat*, and infection* OR infection rate*. A review of articles' reference lists was completed to identify additional articles not captured by the search terms. The University of Central Florida library database program, EndNote, was used to keep track of articles, and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses was implemented to document search methods (see Figure 1). The National Institutes of Health (NIH) Quality Assessment Tool for Observational Cohorts and Cross-Sectional Studies was used by two investigators to appraise the quality of the articles and can be found in "Table 1". Articles were appraised using the 7 criteria included in the tool. Investigators decided whether criteria were met (=yes), not met (=no), were unclear (= not clear), or not applicable.

Results

After 350 initial full-text articles were screened, and inclusion and exclusion criteria were applied, eight studies met criteria for this review. The countries of origin for these studies included two studies from India, two studies from the United Kingdom, one from Pakistan, one from the United States of America, one from Poland, and one from Australia. The National Institutes of Health (NIH) Quality Assessment Tool for Observational Cohorts and Cross-Sectional Studies was utilized to evaluate the reliability of the included articles and the results can be found in Table 1. Outlined contents for each study can be found in Table 2.

Footwear and Contamination

The Ali et al. (2014) cross-sectional study was conducted on a medical-surgical intensive care unit in Shifa International Hospital, Islamabad over a six-month period. The aim of this study was to compare how hospital acquired infections and duration of patient care are influenced by shoe cover implementation in the ICU. Their researchers focused on three pathogens they identified to be common for the ICU setting: *Acinetobacter*, *MRSA*, and *VRE*. Samples to determine the presence of these pathogens were measured from the blood, urine, sputum**,** and other miscellaneous body fluids from the admitted population from two units over the six-month time frame. The first three-month period (pre-intervention phase) served as a baseline period, where no shoe covers were worn on the units, relying on usual cleaning and sanitization methods only for pathogen control. The second three-month period served as the intervention phase where shoe covers were mandatory for all people to wear while on the units. Aside from cultures for the three outlined organisms, data included in this study included the rate of nosocomial infections in the unit over each three month period. Mortality rates were recorded from each three month period and included in the results. The researchers also recorded the average length of stay for all patients as an additional parameter for the results section. A total of 1151 patients participated in this study, with 55.4% (n=638) in the pre-intervention phase and 44.6% (n=513) in the intervention phase. The ratio of patients in the MICU compared to the SICU was approximately 52% to 48%. In total, 6.6% (n=76 patients) were positive for Acinetobacter, MRSA, and VRE: 2.6% (n=30) patients during the pre-intervention phase and 4.0% (n=46) patients during the shoe cover intervention phase. In total, 10.6% of participants (n=122) died during the pre-intervention phase compared to 10.1% (n=116) during the intervention phase (p value- 0.04). Length of stay was broken down into three separate durations: 1-3 days, 4-6 days, and greater than 6 days. The authors examined length of stay in the 638 in the pre-intervention phase and compared it to the 513 patients in the intervention phase. The differences in the lengths of stay for patients in the pre-intervention phase versus the intervention phase were the following: (a) Days 1-3 (65% v. 57.7%), (b) Days 4-6 (19.3% v. 23%), and (c) >6 days (15.7% v. 19.3%) (p= 0.038). The findings from both phases result with a length of stay P value- 0.038 (Ali et al., 2014).

An observational study conducted by Galvin et al. (2016) evaluated bacteria transference from the floor onto bedsheets in surgical units in a Sydney, Australia teaching hospital. In this study, the researchers used a total of 40 shoe covers worn for different time durations in patient rooms, bathrooms, and corridors of the surgical unit, over a course of 5 days. The worn shoe covers were then exposed to sterile bed sheet material with calculated agitation movements in order to mimic patient activity and transmission of pathogens while on a surgical sheet. Colony forming units (CFU) was the measurement selected for the results of the cultured samples from the surfaces of the shoe covers and the bedsheets. Samples in the corridor collected 1,854 CFU and transferred 5.7% of pathogens to the bedsheets. Bathroom samples collected 2,598 CFU and transferred 0.48% of pathogens to the sheets. Patient room shoe covers collected 226 CFU over five minutes of exposure and transferred 1.25% of pathogens onto sheets. Over ten minutes of patient room exposure, the CFU increased to 1,074 and the 1.12% of pathogens transferred to the sheets. The top pathogens that were transferred and cultured was *Staphylococcus aureus* with a transfer rate of 15.08±0.66% and *Staphylococcus epidermidis* with a transfer rate of 17.74±0.53% (Galvin et al., 2016). Standard daily cleaning and sanitization methods were continued during the five-day period, so as not to bias results (Galvin et al., 2016).

In 2018, Kanwar et al. conducted a cross-sectional study aimed to evaluate the clothing and shoes of hospital workers as potential vectors for pathogens, while focusing on the transfer of pathogens to the community. Cultures were obtained from the hands, clothing, and shoes of physicians and nurses at a Cleveland, Ohio, hospital at the end of each work shift. A total of 41 staff members participated in this study over a period of 5 months. Samples from these participants were taken at the end of every shift. The participants included 25 nurses and 16 physicians. The site of the most contamination recorded by the researchers was found on the sole surface of shoes. Shoes were contaminated with one or more pathogens in 29% of the workers (Kanwar et al., 2019). The pathogens cultured from shoes included *MRSA, Carbapenem-resistant gram-negative bacilli*, and *C. diff* (Kanwar et al., 2019).

A cross-sectional study by Paduszyńska et al. (2015), was conducted on a General and Oncological surgical unit in a Polish medical university hospital (2015). Their objective was to evaluate how physicians contribute to the organism transmission during rounds on the surgical unit. Swabs taken from shoes of physicians were compared to those taken from the hands and stethoscopes before and after rounds. Bacteria were categorized by the researchers, and concerning species are presented in Table 2. The research concluded that concerning bacteria such as *E. Coli* and *Enterococcus faecalis* contaminated 56% (n=14) of physicians' soles before rounds, compared to 65% (n=16) after rounds (Paduszyńska et al., 2015). Swabs from the providers' hands found 16% (n=4) before rounds and 28% (n=7) after rounds. Stethoscope testing found 12% (n=3) occurrence in both before and after rounds (Paduszyńska et al., 2015).

Another cross-sectional study sought to analyze the relationship between footwear and organism transmission in the operating room. The Agarwal et al. study (2002), was based the Bradford Royal Infirmary in the United Kingdom. In this study, they measured blood and bacteria via swabs from the upper surface of shoes and soles of shoes worn in four different operating rooms (2002). The recording of specimen collection took place at the end of the shift for the participants, respectively. A total of 54 pairs of shoes worn in the operating rooms by healthcare staff and visitors were included in the data collection. Included shoes belonged to individual staffers of specific specialty or were for general use among the units. The results from this study concluded that the majority of the CFU's on the healthcare workers' and visitors' shoes were on the soles. Of the 54 pairs of shoes included in the study, 237 total CFUs were found on the upper portion of shoes. The soles of shoes accounted for 843 CFUs. Blood was found on 44% of the shoes worn (Agarwal et al., 2002). Blood was present on 63% (n=10) of surgeons, 31% (n=4) of anesthetists. Nurses and operating room assistants both had shoe blood contamination rates of 43% (n=3) each. Visitors resulted with 36% (n=4) blood contamination of boots (Agarwal et al., 2002).

Using a cross-sectional design, Amirfeyz, Tasker, Ali, Bowker, and Blom (2007) compared the level of contamination between shoes originating from outside an operating room to shoes exclusive to the operating room. Both groups of shoes were used in the elective orthopedic surgery operating room, and their level of contamination was measured at the beginning of a shift and at the end of a shift. A total of 100 shoes were utilized, evenly selected from outside and inside of the operating room. When measuring the contamination of shoes that originated outside, 88% (n=44) of them were contaminated by 2 or more bacteria species, and only one pair of shoes did not have any bacterial growth of the screened bacteria species (*Staphylococcus*, *Coliform*, *Bacillus*, *Diphtheroid*, *Neisseria*, and *Micrococcus* species) (Amirfeyz et al., 2007). The swabbing of these outside shoes took place inside all the areas of the surgical facility, except the operating room itself. For the shoes worn in the operating room, the majority of the shoes had one bacterium species, at the beginning and end of the shift. Beginning of the shift results were 32% (n=16) pairs of shoes with no growth, 48% (n=24) with one bacterial species, and 20% (n=10) with 2 or more bacterial species. The end of the shift results of the same shoes were 44% (n=22) with no growth, 50% (n=25) with one bacterial species, and 6% (n=3) with 2 or more bacteria species (Amirfeyz et al., 2007).

A cross-sectional study was conducted in a pediatric intensive care unit and a neonatal intensive care unit found in Adesh Medical College and Hospital located in India (Sharma et al., 2018). The aim of this study was focused on the effect of shoe covers on the bacterial contamination of the selected units. The NICU staff was instructed to wear their everyday shoes in the unit and the PICU staff were directed to wear shoe covers while in the unit. Their methods included 98 swabs of unit floors, 49 floor swabs from each unit, done on a weekly basis at the same time. The PICU and NICU samples were reported to have had no significant difference in contamination ($p>0.05$). Bacteria samples of *E. Coli* and *MRSA* equally colonized 2.04% of shoes, which equaled 1 swabbing sample each during this study (Sharma et al., 2018).

The final cross-sectional study included in this synthesis was conducted by Gupta, Anand, Chumber, Sashindran, and Patrikar (2007) in a tertiary hospital's ICU in India. The aim of their study was to evaluate the implementation of shoe covers as it affects floor and air contamination. Floor swabs and air samples were collected in various areas of the unit during periods before and after shoe cover intervention. The study took place over a course of four weeks. In the first two week phase, all staff and visitors wore shoes covers. In the remaining two weeks, no shoe covers were used on the unit, and any footwear was permitted. Floor swabs and air samples were collected at the same scheduled times during the study and cultured in the same conditions. In each phase, 192 floor samples and 96 air samples were collected. This resulted in a total of 384 floor samples and 192 air samples between both phases. Cultures of floor samples when shoe covers were used resulted in 9521 CFUs, and there were 9971 CFUs found on the floors when shoe covers were not used. A total of 262 CFUs were found in the air when shoe covers were worn, compared to 220 CFUs when they were not worn (Gupta et al., 2007). No significant impact between the two phases on floor contamination were reported ($p>0.05$).

Table 1. The National Institutes of Health (NIH) Quality Assessment Tool for Observational Cohorts and Cross-Sectional Studies

Authors	1. Was the research question or objective in this paper clearly stated?	2. Was the study population clearly specified and defined?	3. Was the participation rate of eligible persons at least 50%?	4. Were all the subjects selected or recruited from the same or similar populations (including the same time period)? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?	5. Was a sample size justification, power description, or variance and effect estimates provided?	6. For the analyses in this paper, were the exposure(s) of interest measured prior to the outcome(s) being measured?	7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?
Ali et al. (2014)	Yes	Yes	Yes	Yes	Yes	No	Yes
Gupta et al. (2007)	Yes	Yes	N/A	Yes	Yes	No	Yes
Amirfeyz et al. (2002)	Yes	Yes	Not clear	Yes	Yes	No	Yes

Sharma et al. (2018)	No	Yes	Not clear	Yes	No	No	Not clear
Kanwar et al. (2019)	Yes	Yes	Yes	Yes	No	No	Yes
Galvin et al. (2016)	Yes	Yes	N/A	Yes	No	No	Yes
Agarwal et al. (2002)	Yes	Yes	Not clear	Yes	No	No	Not clear
Paduszy'nska et al. (2014)	Yes	Yes	Not clear	Yes	No	No	Yes

Table 2. Studies outline

Authors	Location	Study Type	Unit/ Facility	Samples	Methods	Organisms	Results
Ali *et al.* (2014)	Pakistan	Observational study	Hospital (ICU)	1151	Blood, urine, sputum culture from patients before and after shoe cover implementation.	*Acinetobacter*, *MRSA*, *VRE*	Before shoe covers HAI rates were 2.6%. After shoe cover implementation, rates were 4.0%.
Gupta *et al.* (2007)	India	Observational study	Hospital (ICU)	384 floor, 192 air	Floor swabs and air samples were collected in various areas during periods before and after shoe cover intervention.	Bacteria in general, colony forming units. Fungal colonies collected but not typed.	192 floor samples with shoe covers result with a CFU of 9521, without shoe covers another 192 samples had 9971 CFU. With 192 air samples total, 96 with shoe covers had a CFU of 262, and without: 220 CFU. *MRSA* was most prominent

							finding. (CFU-colony forming units per m^3.)
Amirfeyz *et al*. (2002)	UK	Observational study	Hospital (OR)	100	Samples taken from shoes only worn in the OR and shoes worn outside and brought into the OR.	*Staphylococcus, Coliforms, Bacillus spp., Diptheroid spp., Neisseria spp., Micrococcus spp.*	The shoes worn outside had 88% of those sampled contaminated with 2 or more bacteria species. The shoes exclusive to the OR had 48% of those sampled contaminated by 1 or more bacteria species.
Sharma *et al.* (2018)	India	Observational study	Hospital (PICU/ NICU)	98	Floor swabs were sampled in a unit that allowed everyday worn shoes as well as a unit that did not allow everyday worn shoes.	Bacteria in general, fungal and viral samples not collected. *E. Coli*, *MRSA*, *Kleibsella*, *Enterobacter*, and *Pseudomonas* were cultured.	The PICU samples, that included no footwear intervention and the NICU samples that included footwear intervention had no significant difference in contamination.

Kanwar *et al.* (2019)	USA	Observational study	Hospital	41	Shoes, as well as hands and clothing, of health care workers were swabbed for samples at the end of their shifts respectively.	*MRSA*, *C. Diff*, *VRE*, and *carbapenem-resistant Gram-negative bacilli* were screened for.	29% of the 41 participants had more than one type of the screened bacteria on their shoes.
Galvin *et al.* (2016)	Australia	Observational study	Hospital (Surgical Unit)	40	Samples from shoe covers and surgical bedsheets were cultured in patient rooms, bathrooms, and corridors on the surgical unit.	*S. aureus*, *Staphylococcus epidermidis*, *E. Coli*, *Pseudomonas aeruginosa*, *Enterococcus faecium*, and *Acinetobacter baumannii*	Samples in the corridor collected 1,854 CFU and transferred 5.7% of pathogens to the bedsheets. Bathroom samples collected 2,598 CFU and transferred 0.48% of pathogens to the sheets. Patient room shoe covers collected 226 CFU over five minutes of exposure and transferred 1.25% of pathogens onto sheets. Over ten

							minutes of patient room exposure, the CFU increased to 1,074 and the 1.12% of pathogens transferred to the sheets.
Agarwal *et al.* (2002)	UK	Observational study	Hospital (OR)	54	Swabbed samples were collected and cultured from the upper portion of shoes and the soles of shoes of surgical staff after use in the OR. Blood traces were also tested for.	*Staphylococcus spp.*, *Streptococcus spp*, *Sarcrina spp.*, *Bacillus spp.*, *S. aureus*, *S. haemolyticus*, *S. epidermidis*, yeast, and blood were isolated.	Significant findings of bacteria were found on most surgical staff boots.
Paduszy'nska *et al.* (2014)	Poland	Observational study	Hospital	11	Samples from the soles of physicians' shoes were collected before and after rounds.	Bacteria in general, including *S. aureus*, *MRSA*, *E. Coli*, *Acinetobacter baumanii*, and *Enterococcus faecalis*.	Alert bacteria, such as *E. Coli* and *Enterococcus faecalis* contaminate 56% of physicians' soles before rounds, compared to 65% after rounds.

Notations	
CFU- colony forming units	*E. Coli- Escherichia coli*
UK- United Kingdom	*VRE- Vancomycin-resistant Enterococci*
ICU- Intensive Care Unit	*S.- Staphylococcus*
USA- United States of America	spp.- multiple species
OR- Operating Room	NICU- Neonatal Intensive Care Unit
PICU- Pediatric Intensive Care Unit	*MRSA- Methicillin-resistant Staphylococcus aureus*

Discussion

The objective of this review was to synthesize literature from the past 20 years pertaining to footwear and organism transmission in hospital environments.

Footwear Contamination

Any footwear exposed to the hospital environment is subject to contamination by the unique organism populations commonly found in these healthcare facilities. Organisms foreign to the hospital environment may be introduced into these settings via footwear contamination. When taken together, the results of the studies included in this review, indicate that footwear serves as a vector for organism transmission in the hospital environment. Studies that detailed the types of organisms cultured and quantities were insightful. Organisms that are pathogenic and resistant to common hygienic measures were highlighted in several studies. Galvin et al., found significant traces of *MRSA* in all areas sampled during their study, for a total average of 306 ± 22 CFU on each shoe cover (2016). *Staphylococcus* species were the organisms most found in the results of all articles that outlined species diversity. A study that tested different forms of footwear in the hospital environment on the organism load found remarkably consistent results between the types of footwear. In this study, *MRSA* and *E. Coli* were found to be equal in their prevalence of samples taken during periods when shoes were worn (2.04%) and when shoe covers were worn (2.04%) (Sharma et al., 2018). Another study that used shoes and shoe covers as independent variables to test this theory resulted in an insignificant difference (p value > 0.05) between both phases of only shoe use and only shoe cover use by all individuals in the selected ICU environment over time (Gupta et al., 2007). Findings like these reinforce the concept that footwear worn in the hospital setting serve as vectors for organism transmission, regardless of whether it is shoes, or shoe covers. This was true, even though the hospital units took part in some form of sanitization of their floors. This factor supports the concept that by excluding footwear from sanitization efforts, potentially pathogenic organism colonies may persist in hospitals.

Recommendations for Shoe Covers in Healthcare

Controlling the spread of infectious organisms is a top priority for the healthcare industry. Sanitization efforts, personal protective equipment, and other measures have been implemented and innovated to promote this aim. Three of the studies included in this review tested a hypothesis of utilizing shoe covers, a form of personal protective equipment, to deter the spread of infectious organisms. In the studies of Sharma et al., (2018) and Gupta et al,. (2007) both concluded there were no significant differences between the data collected before and after periods of shoe cover intervention, respective to organism transmission measures. The study conducted by Ali et al., found a significantly higher rate of infection during the shoe cover intervention phase as opposed to the shoe phase (2014). Based on these three studies, it can be concluded that the incorporation of shoe covers in a hospital facility does not deter the prevalence of organism transmission. In fact, they may make infection transmission worse.

Recommendations for Research

More research adding to the methods conducted in these studies should be done to supplement the findings. Outside of the same aims and methods utilized in these studies, more original research should be conducted as well. Future studies should consider evaluating nosocomial infection rates as it may give better indications of how shoe contamination and related footwear interventions impact patient health. In addition, future studies should consider implementing P-values to reflect their findings. Using this tool may further support and put into relative context their findings. When assessing the results of both the Gupta et al. (2014) and the Ali et al. (2007) studies, which both included an intervention phase of using shoe covers, noteworthy findings occurred. The Gupta et al. (2014) study had a higher incidence of showed a higher CFU of bacteria in the air during the intervention phase. This finding may lead to hypotheses targeting the relationship between shoe covers and their ability to disperse bacteria into the air. We reached the hypothesize that shoe covers aid in redispersion of bacteria into the air. The study conducted by Ali et al. (2007) showed a longer length of stay, on average, of patients during the shoe cover intervention phase. We hypothesize this finding may be attributed an underlying increase of bacterial contamination on staff members' hands as they are more inclined to make contact with their footwear to don and doff the shoe covers. Researchers may hypothesis the correlation between hospitalized patients that are subject to environments with shoe covers implemented and the length of their stay in future studies. Another method that future studies using cultures to reflect the contamination levels of surfaces should consider is baseline sampling. This method ensures a foundation of how to relate any interventions. Lack of baseline data may serve as a limitation to studies. The study conducted by Amirfeyz et al., (2007) compared the bacterial load of shoes worn inside of the operating room to shoes worn in another unit. Included in this study was an interesting result of the baseline samples taken from the shoes designated to the operating room having a higher incidence rate of contamination than the same shoes by the end of the day. We hypothesize these findings are a result of the shoes having some sort of exposure to a chemical cleaning agent while in the operating room. This agent may be related to floor sanitization methods. Research is needed to investigate differences in nosocomial infection rates when staff and visitors use and do not use footwear. Dedicating research to assess interventions to footwear contamination in the hospital setting may lead to innovations in infection control. Identifying areas of hospitals with higher organism loads can be identified through focused research. Research assessing organism transmission through footwear may lead to developments of standards, products, practices, policies, and technologies.

Limitations

Some limitations occurred in this review. The requirement for studies to be in English may have excluded studies in other countries, which limits the generalizability of the findings. This review also did not include any studies focused on other known interventions for footwear in the hospital environment, such as sanitization floor mats. More limitations were seen in this review as none of the studies included data on whether organisms are able to spread through shoe covers and colonize on covered footwear. Only one study included used nosocomial infections as an outcome measure in their results. This outcomes measure, if included in more results, would give a more thorough indication of how this method of organism transfer may impact patient outcomes like inpatient mortality and length of stay. The inconsistency of P-values across the selected studies prohibited the ability of this review to use this measure as a standard of relativity. When conducting the search for studies, this review was limited to select databases and services that may have excluded other existing works that meet the subject criteria outside of these resources.

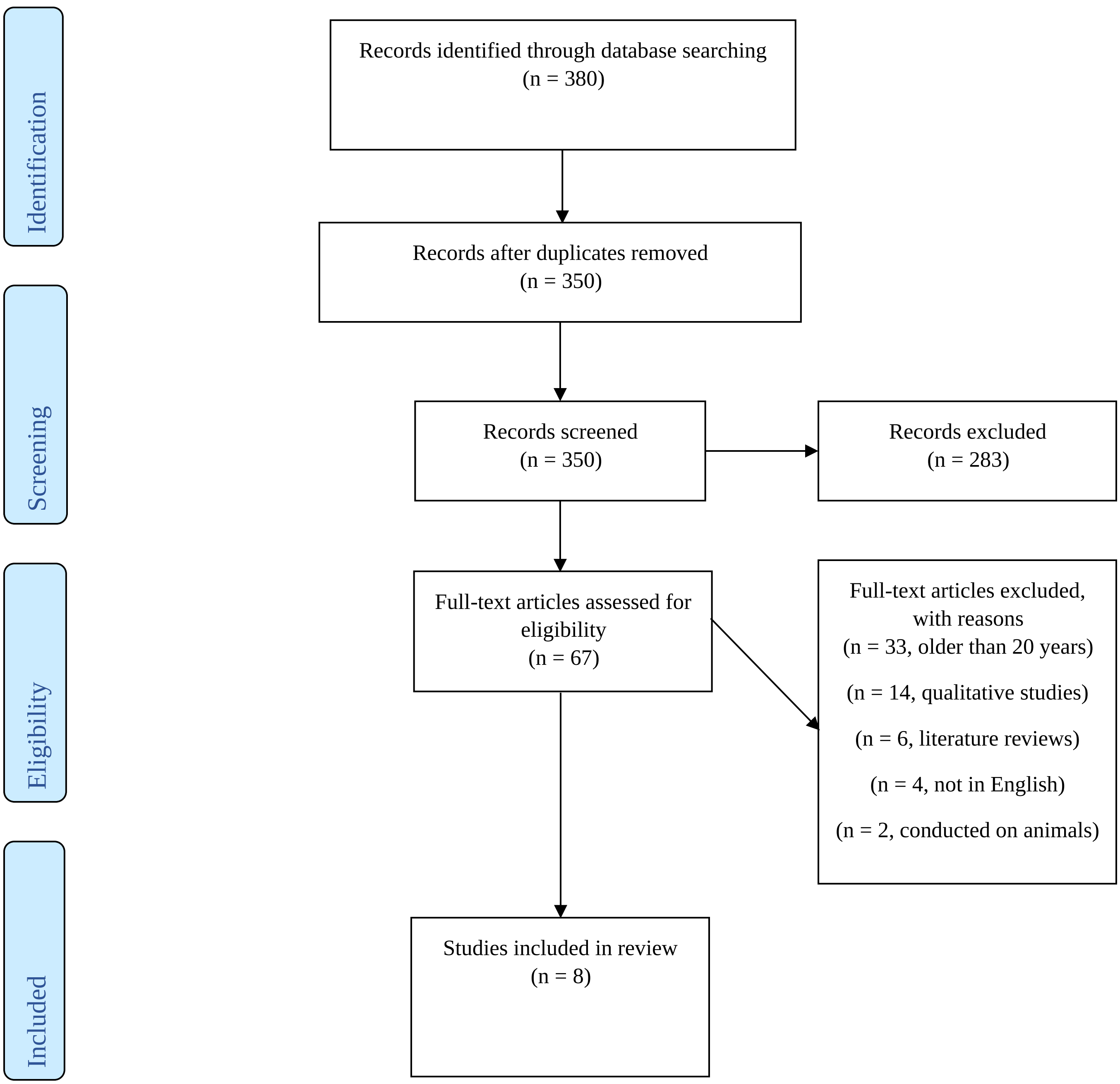
Conclusion

Footwear worn in hospital settings contributes to the organism load as vectors for organism transmission. The organisms that are found on the various surfaces of footwear include potential pathogenic organisms. This review has also highlighted that despite hygienic measures and other interventions implemented in these studies, the presence of nosocomial-causing organisms persisted on footwear. A relationship between organisms transmitting from footwear to surfaces, and vice versa, in the hospital environment was also confirmed.

Nosocomial infections are credited to increases costs, depletion of resources, and lower quality of care in hospitals (Paduszyńska et al., 2015). Keeping factors like these in mind, it is important that the healthcare industry include innovative policies and practices that address this mode of organism transmission. Patients are not the only ones subject to these organisms. Implementing sanitization floor mats, specifically designed to sanitize the soles of shoes, may combat the organism load on all footwear in a hospital environment. Products with this effect, backed with policy and strategic placement, addresses several factors that shoe covers fail to. Since shoe covers can serve as vectors, creating policies targeting the locations and length of time they may be worn should be considered.

Figure 1.

Prisma Diagram



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