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Prevention of Hospital-Acquired Infections

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Patients in hospitals and clinics throughout the United States are subject and susceptible to various hospital-acquired infections (HAIs) that cause idiopathic diseases. In fact, these infections can lead to adverse events such as severe patient trauma and even death. This is no small issue, as the Centers for Disease Control and Prevention estimate that there are approximately 1.7 million cases of HAIs that occur in the United States annually. Furthermore, 99,000 of these cases result in death. Such diseases may be a result of poor aseptic techniques, direct contact transfers, viruses, bacteria, and fungi. Doctors and nurses see countless patients throughout their standard work day and, inevitably, some of the patients that hospital staff come into contact with are infected with communicable diseases. Some doctors utilize hygienic procedures, such as handwashing in between patients, to prevent the spread of these diseases, however; they only put a gown and glove on if the patient has a known infection. Otherwise, they treat them without these protective garments. Additionally, a doctor who is on a tight schedule may not take the time to properly wash their hands since they may be pressed for time (Park, 2013). If health care workers are not wearing the proper garments or utilizing proper hygienic techniques before seeing every patient, they serve as vessels for bacteria and viruses from patient to patient (Ott et al). A patient may even be infected with a communicable disease in the incubation period which makes it difficult for the doctor to know whether to be more cautious when handling the patient, as they are asymptomatic. All these factors are reasons why infections such as Methicillin-resistant Staphlycoccus aureus (MRSA) and Vancomycin-resistant Enterococcus (VRE) are spread throughout hospitals. These bacteria and viruses that escape a hospital's aseptic practices or resist antibiotics may cause ventilator-associated pneumonia (VAP), catheter-related bloodstream infections (CRBSI), and catheter-associated urinary tract infections (CAUTI), all of which are common types of HAIs. (Lobdell, Stamou, & Sanchez,

2012). Moreover, the economic implications of HAIs are rather drastic as well. The overall annual direct costs incurred in order to treat HAIs range from $28.4 to $33.8 billion dollars (Douglas, 2009). MRSA and VRE are the most commonly acquired hospital pathogens and contribute to more than $4 billion in health care costs for treating the skin lesions, respiratory symptoms and sepsis that the bacteria cause (Park, 2013). Sadly, these infections are inadvertently acquired and are largely preventable. Therefore, prevention of hospital-acquired infections is crucial and adequate prevention measures are essential to any hospital or clinic environment to insure patient safety and prevent financial losses. Such prevention measures that have been utilized by hospitals in an effort to cut down on HAIs include universal gloving, educational interventions, and antibiotic stewardship programs. This systematic review will critically address and analyze studies that have reported the efficacy of several different forms of intervention measures in preventing HAIs on patients in ICU environments in order to determine the best prevention technique in reducing rates HAIs.

Methods

This systematic review incorporated articles from PubMed as well as CINAHL. The clinical question, that asks which HAI prevention technique is the most effective in an ICU setting, was addressed through the means of a thorough keyword search. The keyword search was conducted through the previously mentioned databases. The keyword terms searched encompassed *hospital acquired infection*, *reduction*, *ICU*, and *prevention.*

The primary article search only using the keywords resulted in an overwhelming 356 articles; 210 from PubMed and 146 from CINAHL. In an effort to narrow down this selection the 356 articles were subjected to the inclusion and exclusion criteria. Inclusion criteria included

only the peer reviewed journal articles and articles only written in English, since this is the primary language spoken by the researcher. Exclusion criteria omitted articles that were not published in the last fifteen years, as their findings may be obsolete. Another exclusion criterion that was applied to this systematic review was based on the clinical environment in which the included studies were conducted. Studies that were not conducted in an ICU were excluded. This was done since patients in the ICU have a higher risk of developing a hospital-acquired infection than those who are not (Stubblefield, 2014), thus findings have a better chance of being significant and more applicable. Studies that did not include before and after rates of hospital-acquired infections were also excluded, as there is no way to measure the proposed intervention's effectiveness. After applying the inclusion and exclusion criteria, the remaining articles underwent a title review by the researcher and those without pertinent relevance to the research question were excluded. After the title review, the abstracts of the outstanding articles were read thoroughly by the researcher and those with the most pertinence to the research question were utilized in the systematic review.

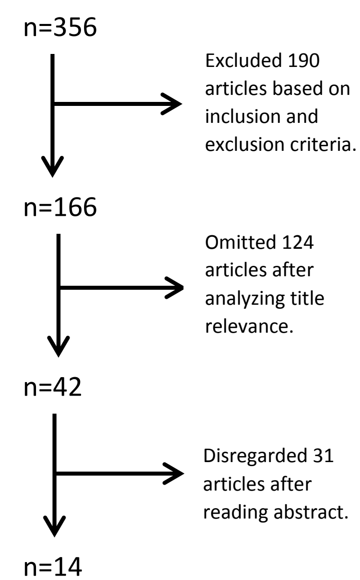

Figure 1.

n= number of articles

Once the articles were fully read, the scoring for the hierarchy of evidence on the final14 articles was based on studies with the lowest risk of bias and a high applicability. Articles that scored the lowest and met the criteria were selected. Randomized control trials received a score of one since they contain the least amount of bias. The evidence obtained from well-designed control trials without randomization and quasi-experimental studies received a score of two.

Cohort and case-control studies received a score of three. By selecting articles with lower scores the amount of bias in this systematic review was greatly reduced. Figure 1 displays a flow diagram of articles excluded for this systematic review by the researcher.

In an effort to answer the research question, the researcher will extract data from the numerous selected studies and analyze variables such as the type of intervention used, the types of infection to which the intervention was applied to, as well as the outcome variable which is the rates of HAIs.

Results

This section includes three tables that display the main findings for each observed intervention. Table 1 presents the findings obtained from studies that used universal gloving as a hospital-acquired infection prevention method in an ICU setting. Out of the four articles that were analyzed only one study, conducted by Yin *et al* (2013), resulted in statistically significant findings of lower rates of HAIs. Although the other three studies showed no statistically significant decrease in the rate of HAIs for the patients in the ICU, the study conducted by Harris *et al* (2013) did show a slight reduction in MRSA and VRE acquisition based on surveillance cultures collected on admission and discharge from the ICU.

Table 1: Studies Measuring the Effectiveness of Universal Gloving Against HAIs

Author(s)	Design	Setting	Primary Outcome	Conclusion
Bearman *et al* (2007)	One group pretest- post-test	Medical ICU	Prevalence of MRSA or VRE	No differences in the proportion of patients acquiring VRE or MRSA
Bearman *et al* (2010)	One group pretest- post-test	Surgical ICU	Prevalence of MRSA or VRE	No statistically significant reduction in MRSA and VRE infections

Table 1: Studies Measuring the Effectiveness of Universal Gloving Against HAIs

Author(s)	Design	Setting	Primary Outcome	Conclusions
Harris (2013)	Cluster-randomized trial	Medical & surgical ICU	Acquisition of MRSA or VRE	No statistically significant reduction in VRE and MRSA acquisition
Yin *et al* (2013)	Retrospective cohort study	PICU	Incidence of HAIs	The risk of any HAI was 25% lower during mandatory gloving periods compared with during nongloving periods (relative risk [RR]: 0.75; 95% confidence interval [CI]: 0.69-0.93; P = .01)

Table 2 displays the results from studies that determined the effect of educational strategies used on healthcare providers for reducing hospital-acquired infections. The prevailing types of educational interventions that were used for the studies analyzed were lectures or classes, posters, video presentations, self-study module, questionnaires and fact sheets, and practical demonstrations. All the studies that were analyzed in this systematic review using educational intervention measures resulted in a statistically significant lower rate of hospital-acquired infections. Educational interventions aimed at the prevention of HAIs resulted in a reduced prevalence of overall hospital-acquired infections. Ventilator-associated pneumonia infections and catheter-related bloodstream infections were the most common types of HAIs.

Table 2: Studies Measuring the Effectiveness of Educational Interventions Against HAIs

Author(s)	Design	Setting	Primary Outcome	Conclusion
Babcock et al (2004)	Pre-intervention and post-intervention observational study	ICU	Overall ventilator-associated pneumonia infections	Reduction in VAP from 8.75 infections per 1000 ventilator days to 4.74 infections per 1000 ventilator days. RR= 0.54. p< 0.001
Coopersmith et al (2002)	Pre-intervention and post-intervention observational study	SICU	Overall catheter-related bloodstream infections	Reduction in CRBSI from 10.8 BSI per 1000 catheter days to 3.7 BSI per 1000 catheter days. RR= 0.34. p< 0.0001
Salahuddin *et al* (2004)	Pre-intervention and post-intervention observational study	ICU	Overall ventilator-associated pneumonia infections	Reduction in VAP from 13.2 infections per 1000 ventilator days to 6.5 infections per 1000 ventilator days. RR= 0.52. p= 0.02
Warren *et al* (2004)	Pre-intervention and post-intervention observational study	ICU	Overall catheter-related bloodstream infections	Reduction in CRBSI from 9.4 BSI per 1000 catheter days to 5.5 BSI per 1000 catheter days. RR=0.58. p= 0.019
Won *et al* (2004)	Pre-intervention and post-intervention observational study	NICU	Overall HAIs	Reduction in HAIs from 15.13 per 1000 patient days to 10.69 per 1000 patient days. RR= 0.71. p= 0.003

Table 3 illustrates the results from studies utilizing antibiotic stewardship programs in order to reduce the prevalence of hospital-acquired infections. An antibiotic stewardship program (ASP) is a coordinated program that promotes appropriate antibiotic use in order to improve patient outcomes, reduce microbial resistance, and decrease the spread of infections. Overuse and misuse of antibiotics is a large public health issue, as infectious organisms adapt to antibiotics and develop a resistance (Antimicrobial Stewardship). An ASP seeks to increase the susceptibility of microbials to antibiotics through the appropriate and careful administration of the antibiotics themselves. Although the study conducted by Geissler et al(2003) did not result in a statistically significant reduction in the total number of HAIs, a significant reduction of hospital-acquired infections from 37% to 15%, was identified due to antimicrobial resistant microorganisms and was attributed to the stewardship program. The reduction was significant for MRSA (from 61% to 13%, p<10-3) and for Enterobacteriaceae resistant to ceftriaxone (37% to 13%, p<10-4). The study conducted by Murni (2015) not only resulted in an overall reduction of hospital-acquired infections, but also a decrease in irrational antibiotic use from 43% to 20.6%. According to the WHO, rational antibiotic use is defined as "patients receive medications appropriate to their clinical needs, in doses that meet their own individual requirements, for an adequate period of time, and at the lowest cost to them and their community", therefore; as per the WHO, irrational or non-rational use of antibiotics is the use of antibiotics in a way that is not compliant with rational use as defined previously (Brahma *et al*, 2012). Similarly, research done by Elligsen (2012) showed that an ASP resulted in an overall antibiotic use decrease from 1,134 days of therapy per 1,000 patient-days in the pre-intervention period to 985 days of therapy per 1,000 patient-days in the post-intervention period (P= 0.003). Although the study conducted by Meyer *et al* (2007) did not yield any significant primary outcomes, the research team did note

that the intervention was associated with a significant decrease in total antibiotic use density from 949.8 before to 626.7 DDD (daily defined doses)/1000 pd (patient days) after the intervention. Similarly, to total antibiotic use, total antibiotic costs/pd showed a significant change (30% reduction in antibiotic costs) after the intervention. Correspondingly, the study conducted by Blanc (2000) did not yield any significant findings in regards to infection rates, however; the study showed that through the implementation of an ASP a decrease in 22% of the expenses for antibiotics resulted.

Table 3: Studies Measuring the Effectiveness of Antibiotic Stewardship Programs Against HAIs

Author(s)	Design	Setting	Primary Outcome	Conclusion
Blanc (2000)	Comparative study with a retrospective and a prospective part	ICU	Incidence of HAIs	No significant difference was found in rates of HAIs
Elligsen (2012)	Prospective, controlled interrupted time series	ICU	Monthly hospital-acquired *C. difficile* infections	*C. difficile* infections decreased by 31%, from 16 cases during the pre-intervention period to 11 cases in paired calendar months
Geissler *et al* (2003)	Comparative study before and after policy implementation	ICU	Total Number of HAIs.	No significant reduction in total number of HAIs
Meyer *et al* (2007)	Pre-intervention and post-intervention observational study.	Neurosurgical ICU	Device-associated infection rates	No significant change in device-associated infection rates before or after intervention

Table 3: Studies Measuring the Effectiveness of Antibiotic Stewardship Programs Against HAIs

Author(s)	Design	Setting	Primary Outcome	Conclusion
Murni (2015)	Before-and-after study	PICU	Total Number of HAIs	Reduction in HAIs from 22.6% (277/1227) to 8.6% (123/1419) RR= 0.38

Discussion

Through the extensive analysis of the 14 articles presented in this systematic review, it can be conclusively determined that the best way to prevent and reduce hospital-acquired infection rates is through an educational program. There are numerous preventive measures presently established to reduce and prevent hospital-acquired infection rates, so each study that was incorporated into this systematic review addressed and analyzed one of the three proposed interventions (universal gloving, educational program, or antibiotic stewardship program) to ultimately determine the most effective means to decrease rates of HAIs, which was the primary outcome of this study.

As seen in Table 2, the five studies that analyzed the implementation of an educational program on HAIs in an ICU setting all resulted in statistically significant lower rates of infections. The educational interventions that were used in the studies analyzed include lectures or classes, posters, self-study module video presentations, questionnaires and fact sheets, and practical demonstrations. The majority of the educational intervention studies that were included in this systematic review analyzed the impact the programs had on ventilator-associated and

catheter-associated rates of HAIs and all resulted in a statistically significant decrease in these infections from the pre-intervention period to the post-intervention period.

Although statistically significant conclusions can be drawn from all the studies cited in Table 2, they are not all without limitations. The specific limitations present in these studies include the fact that the ICU staff in the Coopersmith *et al* (2002) and Warren *et al* (2004) articles were not blinded to either the presence of or the recipients of the intervention. This raises the possibility that the staff may have altered their behavior based upon the widespread knowledge of the measured outcome. Additionally, in the Coopersmith *et al* (2002) study the researchers assumed that improvements in the educational program test score led to a change in behavior patter, which in turn, led to a decrease in the hospital-acquired infection rate. However, since they did not directly monitor bedside practice it is possible that bedside behavior was not altered from the educational program and the decrease in HAIs was independent of the intervention. Another limitation from the Babcock *et al* (2004) study includes the fact that the researchers did not collect baseline data such as the severity of the illness that may have influenced the occurrence of the hospital-acquired infection. However, the inclusion of multiple ICUs makes this less likely. The study conducted by Salahuddin *et al* (2004) had limited results due to the small number of patients and that the study was performed at a single center. Similarly, the study done by Warren *et al* (2004) had the limitation of only being performed in a single ICU, so these results may not be applicable to other hospitals. Despite all these limitations, the conclusive findings of these studies demonstrate significant reductions in the occurrence of HAIs with the implementation of education-based interventions.

Universal gloving was not considered the best prevention measure for hospital-acquired infections since only one of the four articles that were analyzed, conducted by Yin et al (2013),

resulted in statistically significant findings of lower rates of hospital-acquired infections. However, this study was met by numerous limitations which have effected the validity of the findings. One limitation was that the study only included a single center, which makes the findings less applicable to other hospitals and ICUs. An additional limitation is that the study did not include baseline patient data such as demographic details and antibiotic use; thus, residual confounding variables may have effected the analysis. Lastly, the researchers did not monitor glove use, whether health care workers changed gloves appropriately to ensure that they did not transmit organisms from patient to patient when implanting universal gloving remains unclear.

In addition to universal gloving, antibiotic stewardship programs were not regarded as the most effective hospital-acquired infection preventive intervention. Of the five studies analyzed in this systematic review that addressed ASP as an intervention technique, only two studies had statistically significant reductions in hospital-acquired infections. These two studies also had numerous limitations to them, which may have rendered the findings less applicable and valid. The study by Elligsen (2012) was not administered in the context of a randomized controlled trial so therefore could be subject to selection bias or temporal confounding. Another limitation of this study was that it was a single-center study; therefore, it is unclear as to whether the findings from this study could be generalized elsewhere. This study also afforded a small sample size which was underpowered to detect small but meaningfully important improvements. Lastly, the analysis for this study only went on for 12 months after the intervention, so additional, long lasting analysis is needed to monitor that the ongoing benefit is maintained in future years. The study conducted by Murni (2015) may have resulted in a statistically significant reduced rate of HAIs, however; the overall use of antibiotics did not change with the intervention, and thus this decrease in HAI rates has the possibility of being attributed to some other confounding variable.

The studies in Table 2 did account for confounding variables, however; there were still a few aspects that needed to be examined. Although all the education-based intervention studies resulted in lower rates of hospital-acquired infections, it remains unclear as to what type of educational measure is the most effective tool that leads to decreased HAIs. The different types of education-based interventions included lectures or classes, self-study module, posters, video presentations, questionnaires and fact sheets, and practical demonstrations but it remains undetermined as to which of these was the most effective in altering staff behavior in order to cut down on HAIs.

After analyzing all the included articles in this systematic review, it can be ascertained that of the three hospital-acquired infection prevention measures; education-based programs have proved to be the most effective. Prevention of HAIs is of utmost importance since these infections are common causes of excess morbidity and hospital costs among patients requiring intensive care. The economic implications due to HAIs are widespread, so preventing and reducing these infections can save hospitals a tremendous amount of money. It may be helpful for future studies on this topic to differentiate the types of education-based programs to determine the most effective method to employ with their ICU staff to prevent and reduce hospital-acquired infections.

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