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Effects of Chlorhexidine Products on Nosocomial Infections: A Benchmark Study

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Contents

Acknowledgments

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Executive Summary

Healthcare associated infections (HAI) are more than a burden as they can result in subsequent complications, prolonged patient stays in the hospital, as well as additional antibiotic treatment. The evidence-based change project will focus on ensuring that patients with any form of a central line who are admitted to the intensive care unit (ICU), receive a bath using chlorhexidine gluconate (CHG) products once daily as well as the use of antimicrobial intravenous (IV) caps.

A literature synthesis is provided to discuss the current evidence-based practice (EBP) findings related to the PICOT question. Twelve articles ranging from the highest level of evidence to the lowest are placed into an evaluation table for easy interpretation and conclusion of outcomes. The studies included are those that examine CHG bathing products, with a variety in concentrations, packaging, and some evaluating CHG antimicrobial caps for IV tubing. A few of the articles discuss a multifaceted approach, while others examine a single based approach in relation to infection rates. Overall, there is a common finding between the studies which demonstrate a reduction in central line associated blood stream infection (CLABSI) rates, as well as other nosocomial infections.

A list of the active and passive stakeholders for this project is included, as well as the steps to recreate the implementation phase. A detailed step by step layout is given for the project recreation, as well as a flowchart to summarize the steps. The appropriate data collecting methods include quantitative Excel spreadsheets analyzing the HAI results between two participating units and the qualitative data that will be evaluated through discussions with the active stakeholders to examine the overall staff compliance and their views on the additional EBP education. Patient preferences and ethics are an important aspect of this project as it is deals

with personal hygiene, so it is of utmost importance to consider each patients desire to participate or not, as well as weighing the risks versus benefits. For the project to take place, there should be utilization of a certain leadership style to promote change. This leadership style would ideally be the authentic leader as this would have qualities that foster a healthy EBP environment and display the qualities a leader should have. Success of the chlorhexidine product change project would occur if there were a reduction in HAI rates, including CLABSI.

Effects of Chlorhexidine Products on Nosocomial Infections: A Benchmark Study

The use of evidence-based practice interventions in healthcare remains the gold standard for providing the best patient care in all settings of practice. As a current registered nurse and future advanced practice registered nurse, it is our responsibility as providers to keep up with the latest interventions relating to these standards of best patient care outcomes. Of major importance and relevance, is the prevention of HAIs, as it could affect any patient admitted to the hospital with lasting effects on physical and mental health, as well as financial strains.

Rationale for the Project

When reviewing the trends in HAIs, an alarming 47% increase in CLABSI rates was noted at the national level across all healthcare facilities (CDC, 2022). These findings correlate to previous bedside nursing experience in critical care units, where CLABSI incidence and other HAI rates were rarely zero. Paying attention to these statistics and witnessing firsthand is what sparked an interest in the topic of prevention practices aimed at HAIs. The topic of interest that will be discussed is the effects of chlorhexidine products on hospital acquired infections, along with coexisting interventions that are being proven to be effective.

Patients admitted to critical care units are generally more vulnerable or prone to infection, due to the addition of several invasive lines that are placed for measures such as life support, medication delivery, or accessibility to numerous blood sampling. Examples of such devices include standard intravenous access, peripherally inserted central lines (PICC), central venous catheters (CVC), urinary catheters, rectal tubes, tracheostomy access, and mechanical ventilation tubes. Although these devices have many purposes, they also provide another mode of entry for potentially harmful bacteria to be introduced to the patient. A few examples of the harmful infections that can result from this extra mode of entry include CLABSI, catheter associated urinary tract infections (CAUTI), or ventilator associated pneumonia (VAP).

HAIs are responsible for increased mortality and morbidity rates, along with lengthened number of days a patient is admitted to the hospital; subsequently causing hospital costs to rise for not only the individual institution, but for the patient as well (Zhu et al., 2019). CLABSI are one example of an HAI, that carries an additional burden for patients, with the average mortality rate ranging between 12 and 15 percent (Toor et al., 2022). The price tag associated with one incidence of CLABSI is steep, averaging over $48,000 for a single case (Agency for Healthcare Research and Quality, 2017).

This project focuses on CLABSI due to the relevance in everyday care for patients admitted to the critical care unit and topic of interest when I was last employed as a critical care nurse. Nosocomial infections are considered a burden and a “never event”. In other words, these should never happen, and we must do everything we can to prevent this from happening to our patients. In the ICU we had a protocol for daily soap and water baths for all patients, regardless of if they had a central line placed or not. For patients that did have a central line, nurses were responsible for also providing a chlorhexidine gluconate bath to prevent nosocomial infections such as CLABSI, CAUTI, and others. The CHG bath was to be performed daily and then subsequently charted into the electronic medical record. Other CHG interventions that began to take place shortly before my absence, included the use of CHG caps on IV tubing. Despite our efforts including the use of CHG products, CLABSI and other HAIs still occurred. According to Chapman et al. (2021), there is a heightened focus on patient care and hygiene, but one in twenty-five patients who are hospitalized still deal with the aftereffects of an HAI.

Literature Synthesis

A synthesis of the literature was conducted on the remaining twelve articles to discuss the similarities and differences in findings related to the use of chlorhexidine products and their relationship with HAIs. See Appendix A for the Evaluation Table containing the twelve articles. The level of evidence should be considered when deciding to either support or disagree with research findings. Five articles that were explored are level one evidence as either a systematic review or meta-analysis that support the use of chlorhexidine products in the reduction of CLABSI (Frost et al., 2018; Afonso et al., 2016; Gillis et al., 2023; Muguruza et al., 2019; Fan et al., 2019). Noto et al. (2015) and Pallotto et al. (2019) are also considered the highest level of evidence because both studies conducted randomized control trials. However, the data in one of these articles did not support the use of chlorhexidine products to reduce CLABSI rates due to their study findings which tallied the same number of CLABSI occurrences during the CHG bathing period and the control period (Noto et al., 2015).

There are several different nosocomial infections that exist and can ultimately cause complications for those in the intensive care units or other areas of the inpatient setting. Regarding the PICOT question, the rates of CLABSI specifically were examined in seven out of twelve articles (Afonso et al., 2016; Frost et al., 2018; Gillis et al., 2023; Noto et al., 2015; Pallotto et al., 2019; Reynolds et al., 202; Tien et al., 2020). Other studies examined the CHG products and their relation to HAIs as a whole and bloodstream infections in general (Chapman et al., 2021; Muguruza et al., 2019). When discussing nosocomial bloodstream infections, it is important to understand the pathogenesis so that the articles that do not mention CLABSI specifically are not left out. With this in mind, two studies by Sarani et al. (2017) & Fan et al. (2019) demonstrate findings that support the use of CHG products by the reduction of skin colonization rates through examination of microorganism cultures and specifically *A. baumannii*, a common bacterium responsible for the development of CLABSI, respectively. Decreasing the amount of skin colonization rates concomitantly decreases the rates of HAIs and bloodstream infections specifically.

All twelve articles included examine an intervention or involve a discussion regarding the use of chlorhexidine products and HAIs. A single article by Gillis et al. (2023), a level one systematic review and meta-analysis, conducted a different type of intervention that involved the use of CHG antiseptic barrier caps and examined those findings in relation to CLABSI. Researchers in six of the articles performed the daily CHG bathing, without regard to the specifics of the concentrations of CHG (Denny & Munro, 2017; Fan et al., Frost et al., 2018; Musuuza et al., 2019; Noto et al., 2015; Sarani et al., 2017). Two articles by Afonso et al. (2016) and Tien et al. (2020) each had interventions that involved daily bathing with a two percent CHG product. Pallotto et al. (2019), examined the effect of daily bathing with a four percent CHG product followed by rinsing with plain water. Researchers from two articles not only included a CHG intervention, but they combined this step with other efforts to create either a standardized or tailored and multifaceted implementation program (Chapman et al., 2021; Reynolds et al., 2021). The findings from these two studies demonstrated that the use of a standardized CHG bathing process or a combination of educational and implementational programs help to reduce variability in HAI rates, while also helping to increase CHG bathing compliance, knowledge, and perceptions by staff performing the baths.

When considering a change in practice that affects patients directly, we must consider all possible risks involved. The application of CHG washcloths used during the daily bathing intervention has few associated risks, making this care procedure highly favored. Minimal side effects that were noted consisted of contact dermatitis like reactions, including local skin irritation, dryness, pruritus, rash, and stickiness (Chapman et al., 2021; Denny & Munro, 2017; Musuuza et al., 2019). Of equal importance to influence patient care, are the limitations of the studies. Several researchers were unable to measure adherence to the bathing process or did not have a CHG bathing compliance measurement tool in place, therefor creating a high likelihood of mixed trends in the HAI rates (Afonso et al., 2016; Noto et al., 2015; Reynolds et al., 2021). Three researchers identified a different type of limitation to their study findings, including a likely variation in the CHG bathing process where some were using prepackaged CHG washcloths and others were mixing the product at the bedside (Fan et al., 2019; Frost et al., 2018; Musuuza et al., 2019).

Despite the limitations and variability in the CHG application processes between individual studies, the findings are indisputable. We must strongly consider the level of evidence of the articles and the overall effect that CHG has on the reduction of nosocomial infections. Five studies total are considered level one evidence because they contain systematic reviews and meta-analyses, all of which concluded in their findings that there is a reduction in the total number of positive skin colonization cultures or bloodstream infections rates, with some identifying a dramatic 40 percent reduction (Afonso et al., 2016; Fan et al., 2019; Frost et al., 2018; Gillis et al., 2023; Musuuza et al., 2019).

Project Stakeholders

For implementation, this project would ideally take place in a hospital critical care inpatient setting in which there are numerous patients that have one of the forms of a central line or other invasive equipment in place. The active stakeholders include hospital and facility administrators, the nursing staff and patient care technicians who will be performing the baths, all patients participating, laboratory staff, and possibly phlebotomists. Passive stakeholders include chief nursing officers, unit managers, education staff, and the financial department.

Permission will need to be granted from all active and passive stakeholders. Gatekeepers of this change project include those who will be directly involved with carrying out the intervention including charge nurses, nursing staff, and medical assistants. Change champions may include charge nurses and highly motivated nursing staff to ensure the implementation is being carried out. It would be beneficial for the charge nurses and unit managers to be involved since this project could possibly lead to decreased rates of infection among the unit and overall improved patient outcomes.

Ethics should be considered in this project due to the vulnerability of the patients when performing an intervention such as bathing an individual. Autonomy is the acknowledgement that the patient has the right to make their own decisions regarding their health (Melnyk & Fineout-Overholt, 2015). Although the use of CHG products are showing promising evidence in their use, the patient ultimately has the right to choose whether or not they would like to participate. The patient should be fully informed of the risks and benefits involved. Privacy must also be provided for patients who receive a CHG bath in order to protect their dignity while maintaining respect and holistic care.

Implementation Plan

The chlorhexidine products evidence-based change project would ideally take place in a hospital or outpatient setting in which there are numerous patients that have some type of central line (peripherally inserted central catheter, central venous catheter, femoral, or subclavian catheters). For this project, the patient population should be identified, and the appropriate 50 adult intensive care patients selected, only including those with some form of central line. Data that will need to be accessed include CMS information or infection statistics that would include all HAIs and CLABSI for the designated site of change to identify the relevant issue. Permission will need to be granted to review the EMR for participating patients to evaluate the blood culture results. Active stakeholders affected by this proposed change include hospital/facility administrators, the nursing staff and patient care technicians who will be providing the interventions, the patients, and their family members. Passive stakeholders include chief nursing officers, unit managers, education staff, and the financial department.

Permission will need to be granted from all active and passive stakeholders. It would be beneficial at this point to provide the latest EBP evidence articles regarding the use of CHG products and their potential positive impact on reducing rates of HAIs for patients in their situation. Gatekeepers of this change project include those who will be directly involved with carrying out the interventions including hospital providers such as physicians and nurse practitioners, unit directors, charge nurses, nursing staff, and medical assistants. Change champions may include charge nurses and highly motivated nursing staff to ensure the implementation is being carried out. It would be beneficial for the charge nurses and unit managers to be involved since this project could possibly lead to decreased rates of infection among the unit and overall improved patient outcomes.

Barriers to the project may include resistance from patients or nursing staff to participate due to inadequate knowledge about EBP or little belief in the process. Other barriers may include inadequate nursing staff or patient care technicians to carry out the interventions or high acuity versus available nursing staff, thus creating time constraints. Ideas to minimize this potential resistance include education strategies such as posterboards or short presentations on the benefits and minimal risks and time it would take for undertaking CHG bathing and CHG IV caps.

Resources that will be needed to enact the change include the purchasing of CHG products or ensuring they are already readily available on the unit. The nursing staff will need to be informed of proper techniques of CHG bathing and switching to CHG IV caps, as well as providing reinforced education to staff surrounding CHG benefits. Software that will need to be accessed include the data on CLABSI and other HAI rates generated from the participating patient's blood culture results and the patient's blood culture results who are not receiving care on the unit directly involved with the project.

Timetable/Flowchart

Step one of the implementation plans includes week one and two. First, identify the facility where the project will be relevant, present the current EBP data regarding the use of CHG products and associated rates of HAIs. Gain approval for EBP change project and proceed to identify the active and passive stakeholders of the project.

Step two includes weeks three and four. Create and meet with the implementation team to present the literature and EBP knowledge over the PICOT question. Explain the relevance of the project to the facility and how it could potentially benefit their patients. Make time for the team to ask questions and clarify any uncertainties. Connect with the team to identify their experiences and strengths, followed by assigning team roles. There should be patient care techs or nurses responsible for the interventions. Only patients who agree to participate and have form of central line should be included. If the patient is unable to speak for themselves due to mechanical ventilation or is requiring some other form of life support, it would be necessary to speak with their designated healthcare proxy to gain approval for their participation in the project. It would be ideal for the charge nurse to monitor for compliance and a change champion/ elected individual to keep the team motivated throughout the process. There will need to be nurses or phlebotomy staff to draw the blood cultures and then the laboratory staff included to evaluate the blood culture results.

Step Three includes weeks five and six. Formulate a detailed plan for exactly how the change project will proceed in the facility. Utilizing one unit with patients that match the description requirements for the interventions and one unit with the same characteristics for the usual care group would be necessary for adequate comparison. Identify the project purpose for the facility, data sources (products should already be available in the facility) and define what will be measured for a successful project. There should be access to the electronic medical record (EMR) to be able to evaluate the results of the blood cultures from patients participating in the project and for those on the other unit, who did not participate. Examine the results of other common HAIs during this project as well. Finalize the remaining approvals before proceeding with the project with the team and other stakeholders.

Step four includes weeks seven and eight. Meet with the implementation team to discuss the details of the finalized plan, resources, and plan specifics. Provide handouts with steps detailing how to use the CHG products. Identify any additional resources, facilitators, or barriers to the project at this point. Speak with the stakeholders regarding the beginning date of the project.

Step five includes weeks nine and ten. Begin the EBP implementation phase of the project using the CHG products on the participating unit. The charge nurse should round on the intervention unit to monitor the compliance rates and the EBP change champion should answer any questions the staff may have.

Step six includes week eleven. Meet with all stakeholders to discuss the data gathered so far. Identify if there have been any successes, barriers, or concerns. This includes speaking with the staff who is performing the interventions and the patients receiving the interventions. This step also includes speaking with the charge nurse, change champion, and others who are involved in the implementation phase.

Step seven includes the final week twelve. Gather the generated data from the project results and present those to the team, stakeholders, and respective agency. Data should include the HAI rates that occurred during the implementation phase of the participating unit and HAI rates from the unit who did not receive any additional CHG intervention care measures. Refer to Appendix B for a flowchart on the seven steps.

Data Collection Methods

The data that will be collected during the change project should reflect the intervention outcomes and demonstrate if there was success in relation to the PICOT question. Demographic data will be collected from the patient records. Different methods to collect the data include computing the results of the blood cultures collected from patients in the intervention unit and the unit that is not participating. This data could be entered into an Excel spreadsheet to make it easier for reviewing the overall statistics. Spreadsheet data incorporating the blood culture results, central line specificity, other CHG measures used, and compliance should be accounted for. Outcomes between the participating unit and the nonparticipating unit would be compared to determine if there was an overall reduction in the number of HAIs, including bloodstream infections which would ultimately equate to a successful intervention.

Furthermore, it would be beneficial to include various HAI results including CLABSI, CAUTI, or VAP to determine the effects of CHG products on each category to perform a secondary analysis on HAIs that are also potentially affected by the intervention. The statistics for the secondary analysis could be computed into a separate excel spreadsheet to demonstrate effectiveness of CHG products. This chart would also need to include the same type of data including the type of central line and if there is other invasive equipment being used by the patient such as a urinary catheter or mechanical ventilator.

Evaluation

Data that will need to be gathered to reflect the outcomes to determine if the change was successful would include gathering the quantitative results from the electronic medical record (EMR) of HAI rates during the implementation phase for the intervention unit in comparison to the non-intervention unit. There should be a notation of any adverse reactions to the CHG products, patient complaints, or difficulties experienced by the staff carrying out the change. Additional data to be included is which type of interventions were used, what type of central line the patient had, any existing comorbidities of the patient, and the number of days the patient was involved in the project. The quantitative results could be compared to another unit within the same hospital where there will be access to HAI statistics who did not undergo the project and who did not receive the additional education over CHG products and CLABSI relation. An overall reduction in the incidence rate would indicate a successful intervention, one that utilizes CHG products.

The process of change will be qualitatively evaluated by speaking with the team and determining the compliance rates with CHG bathing and their views on the additional education provided for this procedure. Data may be quantitative through results of CLABSI rates and qualitative through discussion with team members. If the change project could not be enacted for any reason, steps that could provide a positive impact on this topic include providing the data from EBP articles that are relevant to the issue. This can be accomplished using educational posters, presentations, or brief educational meetings on the unit regarding the use of daily chlorhexidine bathing and other CHG products for patients with a central line.

Cost/Benefit Analysis

The average cost of one CLABSI has been estimated at over $48,000 (Agency for Healthcare Research and Quality, 2017). In addition, CLABSI has been associated with increased length of stay, higher mortality rates, and additional hospital costs (Zhu et al., 2019). In the United States, the five major HAIs are estimated to cost the healthcare system a total of $9.8 billion each year (Zimlachman et al., 2013). To compare associated costs, the average cost for bathing patients with CHG cloths is under five dollars, demonstrating a tremendous savings for the hospitals overall (Shah et al., 2016). CHG antibacterial caps also present another potential savings for hospitals. In a recent systematic review and meta-analysis by Gillis et al. (2022), the researchers examined six studies that evaluated the expense of antibacterial caps. Altogether, the studies demonstrated a total cost savings of $41,000 per 1,000 catheter days which was calculated by annual costs and catheter days (Gillis et al., 2022). It is apparent that a successful intervention would equal substantial savings for the hospitals who partake in the CHG project.

Discussion of Results

The actual implementation of the interventions for the chlorhexidine products on hospital acquired infections project did not happen, as this was a benchmark project. It was unreasonable to implement this project in the setting where current access to patients is, which is in the family care practice outpatient setting. This project would need to take place in a critical care setting to evaluate the results of patients with invasive lines such as central venous catheters, urinary catheters, and mechanical ventilators. With the discussed intervention in place for the project, it would be expected to learn whether or not the current evidence supports continuing to use CHG products for patients admitted to a critical care unit.

Challenges to implementation could include nursing staff shortages, patient care technician shortages, and high acuity with increased nurse to patient ratio. Providing a CHG bath and placing CHG caps on IV tubing takes minimal time, however if the nursing staff is faced with time constraints or staff shortages, this could pose a barrier. Variable bathing practices and belief in importance could also play a role in carrying out the use of CHG products.

Solutions to address the possible challenges to implementation could include providing education through handouts, posters, or unit meetings over the findings associated between CHG products and prevention of CLABSI and other nosocomial infections. There is a possible gap in knowledge over current evidence-based practice findings and this could be a strategy to close the gap and keep staff up to date. Holding competitions between the different ICUs could provide additional incentive (extra day of paid time off or gift cards) for the nurses and patient technicians. Each unit would need to have the appropriate staffing nurse to patient ratios for fair competition.

The use of authentic leadership style is ideal for myself during this project as a future Family Nurse Practitioner. According to Melnyk & Fineout-Overholt (2015), this type of leader is described as being in tune with their own personal values and beliefs, are very self-aware, and have a strong focus on having ethics as a priority. Additionally, these types of individuals understand the importance of having strong relationships while incorporating a transparent and optimistic attitude with their team members that eventually leads to the development of those around them in a positive, optimistic environment (Melnyk & Fineout-Overholt, 2015). I couldn’t think of a better way to get people to be motivated about evidence-based practice (EBP) than by first making sure you are showing your team that you are helping to provide a positive environment that is supportive of learning, but also considers others individual strengths and opinions. This type of leadership style is reflected in my personal strengths that were identified on the CliftonStrengths survey which include: belief, focus, responsibility, developer, and consistency.

The variety of HAIs are the focus of this change project and examining how our chlorhexidine products are affecting these rates. This idea was first adopted after analyzing which areas in the critical care units could use attention. HAIs are one of the most common adverse events which can lead to increased length of stay in the hospital, disability, and mortality/morbidity (Lewis et al., 2019). During my time as a critical care nurse, HAIs were a topic which was discussed daily, along with the interventions we were doing to help minimize their occurrences. CLABSI, CAUTI, and others would still occur occasionally despite our best efforts with the CHG products. During Covid especially, we saw an increase in various HAIs which was also possibly due to the high acuity and staff shortages. According to the 2021 annual CDC HAI highlight report, there was a 10% increase across critical care units in CLABSI in 2020 and 2021, along with an increase in CAUTI (overall 9% increase in ICUs). It is out of necessity and not necessarily a stretch, that these interventions and implementations were explored further due to the rates of HAIs in our own ICUs.

For the implementation of the project to succeed and sustain, an essential first step is to identify the latest evidence-based practice (EBP) findings to guide and incorporate into practice. According to Melnyk & Fineout-Overholt (2015), there are several interventions that are necessary for EBP to remain implemented, including EBP education and skill building, mentorship and support, a supportive EBP environment, leaders and managers who support EBP, and strategies to overcome system barriers. In my change project, there are steps that include presenting the latest EBP knowledge to the hospital staff involved and giving education using handouts on the correct sequence of CHG product use. My project also incorporates answering staff questions and clearing up any uncertainties, as well as providing a team supporter who gives positive feedback and is a resource to those during the implementation phase. Ways to minimize barriers to the change and make it sustainable are also addressed via a transparent leadership style, providing a supportive and resourceful environment, along with incentives.

Barrow et al. (2022), discusses an ideal theory, that appears to be more like steppingstones for the change management process, known as Lippitt's "Phases of Change Theory". This theory involves specific strategies to get the change problem identified, sets goals and action plans, but also discusses the need for staff acceptance of change and overall relationship with the system. Using strategies and tools like this would be beneficial to keep in the "toolbox" to manage the change process, along with Kotter's Eight Step Change Model to also remove barriers, provide wins, and make the EBP change more sustainable (Barrow et al., 2022).

Conclusions/Recommendations

Based on the literature synthesis, the level of evidence, and clinical expertise, it is recommended to continue and reinforce the implementation of daily chlorhexidine bathing for critical care patients requiring a central line to ultimately improve patient outcomes. Additionally, it would be beneficial to continue to reinforce efforts against HAIs by applying antibacterial CHG caps. Thus, the best outcomes will be obtained by utilizing a multifaceted CHG program where more than one form of CHG product is consistently implemented and sustained. The literature synthesis illustrates that CLABSI, and other HAI rates can be reduced in hospitalized and critical care patients with the use of daily CHG bathing and CHG caps. 2%- 4% CHG cloths or solution and antimicrobial IV caps were analyzed among the twelve studies, and all produced similar outcomes, demonstrating the anti-microbial superiority of CHG over plain soap and water baths.

The recommendation for utilizing the CHG interventions is based off the evidence provided in the twelve articles and thus supports the PICOT question. The use of these antimicrobial products has minimal risks, are not time consuming, and can provide substantial savings for the healthcare system and patients. It is recommended to utilize strategies to create an environment where such EBP is accepted, supported, and reinforced using positive actions and rewards. By reducing the rates of CLABSI and other HAIs we can help to reduce hospital length of stay, patient mortality and morbidity, and improve patient outcomes.

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Appendix A

Evaluation Table

Citation: (i.e., author(s), date of publication, & title)	Conceptual Framework	Design/ Method	Sample/ Setting	Major Variables Studied and Their Definitions	Measurement of Major Variables	Data Analysis	Study Findings	Strength of the Evidence (i.e., level of evidence + quality [study strengths and weaknesses])
1. Afonso E, et al., 2016, Prevention of hospital acquired blood stream infections through chlorhexidine impregnated washcloth bathing in intensive care units	N/A	SR& MA Systematic literature search across Medline, EMBASE,Cochrane, & Web of Science databases	N= 4 RCT's out of 291 potential studies Setting: 22,850 Pts 15 adult & 10 ped ICU's D CHG bath Excluded trials: no CHG intervention or not RCT Attrition: NR	IV1: D bath with 2%CHG washcloth IV2: control bath DV1: PO HABSI (all hospital acquired BSI) DV2: CLABSI (subgroup analysis) (p.1)	Total HABSI rates calculated per 1,000 pt days as PO (p.2) Subgroup analysis of CLABSI per 1,000 pt days (p.5) P= 0.002 for HABSI P= 0.01 for CLABSI (p.1) Cochrane Risk of Bias Assessment Tool (p.2)	OR (p.2)	PO for HABSI: (OR: 0.74; 95% CI): 0.60-0.90; p= 0.002) Subgroup analysis for CLABSI: (OR: 0.50; 95% CI: 0.35-0.71; p=0.01) (p.1)	-LOE: Level I -Strengths: Use of systematic search & RCT's. Random effects MA with subgroup analysis of HABSI & pathogen subtypes, low statistical heterogeneity, & sensitivity analysis of high-risk bias studies (p.9) -Limitations: Non-blinding to the intervention, lack of compliance measurements, lack of reporting baseline hygienic practices. (p.9) -Feasibility: D bath with 2%CHG washcloths is feasible in ICU. -Possible Risk: None discussed. -Recommendation: This article is the highest LOE and should be considered in tx of ICU pts. Provides evidence that use of CHG washcloths prevent HABSI in ICU's primarily due to prevention of CLABSI. (p.9)
2. Chapman et al., 2021, Chlorhexidine gluconate bathing program to reduce health care-associated infections in both critically ill and non-critically ill patients	N/A	Observation Study (p.7)	N= 57,453 Pt days total Setting: 1 Medical-Surgical ICU & 1 Telemetry Unit Pts in same hospital Standardized CHG bathing protocol	IV1= CHG protocol intervention IV2= no CHG protocol intervention DV1= HAI rates pre CHG intervention in ICU	IR: # of HAIs per 1,000 Pt days Pre & Post CHG protocol intervention Collected complete monthly infection counts & # of pt days before & after protocol intervention (p.3)	IR (p.4) Poisson distribution (p.7)	DV1= 61 infections X 9339 Pt days; *IR= 6.5* per 1,000 Pt days (95%CI: 5.9-7.2) DV2= 150 infections X 48,114 Pt days; *IR= 3.1* per 1,000 Pt days (95%CI: 2.8-3.4) DV1 & DV2 (95%CI: 1.6-3; P<0.001) (p.4)	-LOE: Level IV -Strengths: Reduce disparity by creating standardized CHG bathing protocol. Demonstrates CHG effectiveness in ICU setting. -Limitations: Findings based on observational study using data that is unadjusted. (p.7) -Feasibility: It is feasible to implement a standardized method to the CHG bathing. -Possible Risk: Pt complaints of product making skin feel sticky. -Recommendation: Infection reduction rates cannot be directly linked to the CHG usage due to the level of evidence. However, the results are significant and should be strongly considered.

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			Attrition: NR (p.2)	DV2= HAI rates post CHG intervention in ICU (p.3)				
3. Denny & Munro, 2017, Chlorhexidine bathing effects on health-care-associated infections	N/A	Literature Review Systematic literature search across PubMed & CINAHL (p.1)	N= 23 out of 134 potential articles Setting: English language & published in peer-reviewed journals EX CHG bathing & HAIs Attrition: NR (p.2)	IV1= CHG bathing DV= CLABSI (p.1)	Literature review discussing findings from diff studies on CLABSI & other HAIs after CHG use (p.10)	Various findings from the literature	Some studies did not show large reduction in CLABSI rate Many other studies did show a reduction in CLABSI & other HAIs with use of CHG bath products (p.10)	-LOE: Level VII -Strengths: Provides easy to interpret and relevant findings on multiple studies. Provides findings on specific HAIs, including CLABSI. -Limitations: Level 7 evidence. -Feasibility: The use of CHG bath products is feasible. -Possible Risk: Local skin irritation or contact dermatitis. Possible decreased susceptibility to CHG. (p.11) -Recommendation: This review of literature demonstrates most studies have found CHG products to be effective. Future research must provide evidence to support recommendations.
4. Fan et al., 2019, Effect of chlorhexidine bathing on colonization or infection with *Acinetobacter baumannii:* a systematic review and meta-analysis	N/A	SR & MA Systematic literature search across PubMed, EMBASE, Web of Science, & CINAHL 13 studies (1 RCT, 7 Interrupted time series, 5 pre-post comparison studies) (p.3)	N= 13 out of 113 potential studies in SR (p. 3) Setting: Variety of different ICUs CHG bathing Attrition: NR	IV1= CHG arm (8,069 Pts) IV2= Control arm (9,051 Pts) DV= colonization rates of *A. baumannii* (p.1 & 4)	DerSimonian & Laird method (p.3)	RR (p.2) Pooled RR using random-effects model in Pts tx w/ CHG vs control arm (p.1)	CHG arm: (RR, 0.66; 95%CI: 0.57-0.77; P<0.001) (p.1) 34% reduction in colonization rate of *A. baumannii* in IV1 group vs IV2 group (p.5)	-LOE: Level I -Strengths: Use of comprehensive search across databases. Examines effect of *A. baumannii* colonization rates (common cause of CLABSI). First MA to show effect of CHG on this bacteria. -Limitations: High heterogeneity. Variable frequency & medium application of CHG. Possible inherent trend bias due to pre-post studies. (p.7) -Feasibility: It is feasible to use CHG products to prevent *A. baumannii* skin colonization. -Possible Risk: Low risk vs. benefit -Recommendation: This MA demonstrates a 35% reduction of colonization rate for one of the possible bacteria responsible for CLABSI. Recommended to use CHG products for prevention based on LOE & findings.

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Citation: (i.e., author(s), date of publication, & title)	Conceptual Framework	Design/ Method	Sample/ Setting	Major Variables Studied and Their Definitions	Measurement of Major Variables	Data Analysis	Study Findings	Strength of the Evidence (i.e., level of evidence + quality [study strengths and weaknesses])
5. Frost S, et al, 2018, Evidence for effectiveness of CHG bathing & health care associated infections among adult intensive care patients	N/A	Trial Sequential MA Systematic literature search across MEDLINE, EMBASE, & Cochrane Library 5 RCT's from ICU's included in final analysis (p.2)	N= 5 out of 164 potential studies (p.3) Setting: Adult ICU Only RCT's assessed effect to reduce HAI in adult ICU included Excluded trials w/ CHG combined w/ other intervention Attrition: NR (p.2,3)	IV= D bath with CHG DV1= BSI (4 RCTs; 18,290 pts) DV2= CLABSI (3 RCTs; 17,540 pts) DV3= MDRO (2 RCTs; 17,152 pts) DV4= VAP (4 RCTs; 10,564 pts) DV5= CAUTI (3 RCTs; 9,983 pts) (p.3-6)	BSI, CLABSI, MDRO, VAP, CAUTI all assessed in ICU setting pts in relation to D CHG bath	IRR (p.3)	Reduced CLABSI in ICU by approximately 40% (IRR = 0.60, 95% CI 0.34, 1.04) (p.1) P= 0.33 for CLABSI (p.3-6)	LOE: Level I -Strengths: Use of only RCT's. Use of TSA to avoid confusion of effectiveness of CHG bathing. -Limitations: One of the studies included didn't use prepacked CHG cloths, the staff prepared CHG wash cloths at bedside. Differing time periods between trials. Potential of missing unpublished trials & potential individual trial heterogeneity (p.7) -Feasibility: D bathing with CHG is feasible in the practice of critical care units. -Possible Risk: None determined. -Recommendation: Because this is based using the highest LOE, D bathing with CHG should be used in the ICU setting for those who have a central line.
6. Gillis et al., 2023, Antiseptic barrier caps to prevent central line-associated bloodstream infections: A systematic review and meta-analysis	N/A	SR & MA Systematic literature search using Medline, EMBASE, Cochrane, & CINAHL (p.1) 15 studies included in MA (3 RCTs & 12 non-random) (p.3)	N= 16 out of 3,599 potential studies in SR & 15 in MA Setting: 5 ICU, 5 non-ICU, 6 mixed 10 EX Curos Cap & 6 EX SwabCap Adult & pedi Pts Attrition: NR	IV= ABC IV2= no ABC DV= CLABSI (p.3)	Total CLABSI rate per 1000 cath days calculated for intervention & standard care group as PO Risk of Bias for randomized trials tool & Risk of Bias for Nonrandomized Studies of Interventions Tool (p.3)	IRR & RR (p.3) Mantel-Haenszel method w/ random effect model (p.3)	PO for intervention group: (391 CLABSI/273,993 cath days; IRR 1.43/1,000 cath days) PO for standard care group: (620 CLABSI/284,912 cath days; IRR 2.18/1,000 cath days) RR= 0.65 (95% Cl 0.55-0.76; P <.00001) (p.1)	-LOE: Level 1 -Strengths: Recent data w/ comprehensive literature search. Uses some RCTs. Authors contacted for more info if necessary. -Weaknesses: Risk of bias in non-randomized studies. Only 3 RCTs available. Variety in patient populations. -Feasibility: Use of ABCs is feasible in ICU settings. -Possible Risk: no risk or safety concerns -Recommendation: ABC with CHG can be used in Pts with CVC/ central lines to prevent CLABSI/HAI

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7. Musuuza et al., 2019, The impact of chlorhexidine bathing on hospital-acquired bloodstream infections: a systematic review and meta-analysis	N/A	SR & MA Systematic search across Medline, EMBASE, CINAHL, Scopus, Cochrane 26 studies (8 RCT or CRT & 18 non-random) (p.4)	N= 26 out of 788 potential articles in MA (p.4) Setting: 19 ICUs & 7 various settings CHG bathing Attrition: NR	IV= CHG products used IV2= control group DV1= BSI (p.3)	IRR of HABSIs calculated as ratio between IR (# of BSI per 1,000 Pt days) in pts tx with CHG vs control group DerSimonian & Laird method	IRR & IR (p.3) Random-effects logistic regression model (p.3)	5,259 BSI in 861,546 Pt days CHG products: IR= 4.4 (95%CI: 4.2-4.6) Control group: IR= 7.5 (95%CI: 7.3-7.8) Random effects IRR for IV1: 0.59 (95% CI: 0.52-0.68) (p.5)	-LOE: Level I -Strengths: Use of 8 RCTs. Included only studies with CHG as primary intervention. Adults were main focus of study. -Limitations: High degree of heterogeneity in studies. Likely variation in CHG bathing process. Lack of definition for CLABSI across studies. Lack of site of origin for BSI results. -Feasibility: Use of CHG products is feasible in ICU settings. -Possible Risk: skin rashes, skin dryness, pruritus (p.6) -Recommendation: This MA demonstrates BSI was reduced by approximately 40% using CHG. It is recommended to provide consistent CHG bathing to reduce BSI & HAI risk.
8. Noto M, et al, 2015, Chlorhexidine bathing and health care associated infections	N/A	RCT Pragmatic cluster random crossover study (p.1)	N= 9,340 Setting: 5 adult ICU's Each unit alternated CHG bath & control bath depending on random generated # (p.2) Attrition: 0.13% due to exclusion of pts admitted during washout periods	IV1= D bath with CHG (intervention) IV2= D comfort bath (control) DV1= CLABSI DV2= CAUTI DV3= VAP DV4= C. Diff (p.2-3)	CLABSI, CAUTI, VAP, & C. Diff infections rates calculated together per 1000 pts days for the primary outcome (p.3)	RR (p.6)	Primary outcome: RR= −0.04 (−1.10 to 1.01) P=0.95 (p.5) CLABSI: RR= 0.02 (−0.26 to 0.30) P= 0.91 (p.5) 4 CLABSI occurred during CHG bathing & 4 CLABSI occurred during control bathing (p.1)	LOE: Level II -Strengths: Personnel responsible for adjudicating infections were blinded to the treatment. Large sample size with multiple ICU's. Multiple crossover events. (p.9) -Limitations: Longer intervention may have ecological consequences that reduce infectious outcomes. Inability to blind staff administering baths to the treatment group. Single center study. Bathing adherence was not assessed. (p.9) -Feasibility: D bath with CHG agent would be feasible in critical care setting. -Possible Risk: None discussed. Recommendations: Based on LOE, although there was no reduction of CLABSI rates in this RCT, there were multiple trial weaknesses that should be Add to be able to definitively say if D CHG bathing had no effect. Longer intervention time may be needed to adequately assess outcomes on HAI. More trials may be needed at various acute care hospitals to address transferability.
9. Pallotto C., et al 2019, Daily bathing with 4%	N/A	RCT (p.1)	N= 449 pts Setting: PC-ICU & ICU	IV1= D bath w/ 4% CHGwr (intervention)	VAP, CAUTI, CLABSI, BSI, UTI incidence rates calculated	IR (p.1)	-PO intervention group IR= 23.2 (95% CI, 17-31.3)	-LOE: Level II -Strengths: High LOE & RCT. Persons responsible for diagnosing infections blinded to intervention. Uses computer generated

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chlorhexidine gluconate in intensive care settings: a randomized controlled trial		Single blind monocentric study (p.6)	pts in a single hospital in Italy Randomized CHG arm received D 4% CHGwr tx & control arm received D bath with soap & water Attrition: none excluded (p.1)	IV2= D bath w/ standard soap & water DV1= PO (all HAI calculated together) DV2= VAP DV3= CAUTI DV4= CLABSI DV5= BSI DV6=UTI (p.1)	together per 1000 pt days for PO intervention & control group. (p.1) P=0.008 CLABSI; P= 0.204 CLABSI & BSI; P=0.027 (p.4)		-PO control group IR= 40.9 (95% CI, 32-52.2) -P=0.034 -CLABSI intervention group IR= 3.8 (95% CI, 1.6-8.1) -CLABSI control group IR= 9.4 (95% CI, 5.5-15.9) -P= 0.204 -CLABSI & BSI intervention group IR= 9.2 (95% CI, 5.5-14.9) -CLABSI & BSI control group IR= 22.6 (16.2-31.6) -P=0.027 (p.4)	randomization. Demonstrates a 40.4% less frequent IR of HAI in intervention arm. -Limitations: Performed at hospital in Italy. Transferability questionable. Single blind study. Pts & nurses performing baths not blinded to intervention. -Feasibility: D bath with 4%CHGwr is feasible in ICU setting. -Possible Risk: None discussed. -Conclusion: -Based on the findings from the RCT, D bath with 4%CHGwr has benefits to ICU pts with reductions in HAI rates. -Recommendation: Based on LOE, D bath with 4%CHGwr should be utilized in ICU settings. Could be useful to compare 4%CHGwr and 2% CHG. More trials may be needed in US to add. transferability.
10. Reynolds S, et al, 2021, Results of the CHG bathing implementation intervention to improve evidence-based nursing practices for prevention of CLABSI Study (CHanGing BathS): a stepped wedge cluster randomized trial	N/A	Stepped Wedge Cluster Randomized Trial Multicenter, pragmatic cluster randomized, stepped wedged cross-sectional study (p.3)	N= 1,640 Setting: 2 hospitals in US (9 adult ICUs, 3 ped ICUs, 1 ped bone marrow transplant unit, 1 adult hematology/ oncology) Units included had at least 1 CLABSI event in past 12 months (p.3) Attrition: NR	IV= tailored, multifaceted implementation program DV1= CHG bathing process compliance DV2= CHG bathing EHR documentation compliance DV3= CLABSI rates (p.8)	DV1= 424 process audits with implementation strategy (b=6.97, p=.009) (p.8) DV2= 298 documentation audits with intervention by CAI score (b=6.81, p=.15) (p.8) DV3= CLABSI rates during intervention (b=1.22, p=.56) (p.11)	Compliance Rate for DV1 & DV2 (p.6) Incidence Rate for DV3 (p.11)	Implementation program on CHG bathing compliance 6.97% higher after intervention than before (b=6.97, p=.009) (p.8) Implementation program on EHR documentation compliance 6.81% (b=6.81, p=.15) (p.8) Implementation program on CLABSI rates decreased 27.4% at 12 months post intervention (from 2.59 to 1.88) (b= -0.16, p=.009, intercept =1.97, p<.001) (p.11)	LOE: Level II -Strengths: Demonstrates how a multi-tailored CHG educational & implementation program can increase compliance of CHG bathing, staff knowledge, and perceptions of CHG bathing. Clinically significant 27.4% decrease in CLABSI. -Limitations: Self-reported measures may contain bias. Measuring CHG bathing process compliance through observation audits challenging to obtain. Hawthorne effect may affect results. -Feasibility: Education outreach visits, audits, feedback, and CLABSI rate recordings are feasible for the ICU population of interest. -Possible Risk: None discussed. -Recommendations: The intervention techniques in this study should be studied & implemented. Providers should keep the LOE in mind, but be aware that his study has shown a decrease in CLABSI rates with an increase in CHG bathing compliance.

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11. Sarani et al., 2017, Evaluation of the daily chlorhexidine bath effect on skin colonization of the intensive care unit patients	N/A	Quasi-experimental study (p.1)	N= 80 Pts Setting: Single ICU in Iran; 20-60yo Pts; 5-day time frame CHG bathing Attrition: NR (p.2)	IV1= 40 Pts received CHG product bath IV2= 40 Pts received no CHG intervention DV= positive microorganism cultures (p.3)	Frequency %	Frequency % Descriptive statistics, Chi-Square test, & Fisher's exact test (p.4)	7.5% Frequency= 3 out of 40 Pts + for microorganism cultures after CHG; P<0.0001 100% Frequency= 40 out of 40 Pts + for microorganism cultures; P<0.0001 (p.4)	-LOE: Level III -Strengths: This study demonstrates a significant finding and supports the practice. Only includes Pts admitted for the time frame of the test. Setting is ICU and adults. -Limitations: Impossibility of simultaneous evaluation of intervention & control groups. Subjects were not blinded. (p.6) -Feasibility: It is feasible to use CHG products. -Possible Risk: No risk discussed. -Recommendation: There was a 92.5% reduction in positive cultures with the use of CHG products. Recommended to use these for prevention of susceptible skin colonization bacteria.
12. Tien K., et al, 2020, Chlorhexidine bathing to prevent central line–associated bloodstream infections in hematology units: a prospective, controlled cohort study	N/A	Controlled Cohort Study (p.2)	N= 893 pts Setting: Hematologic tx center 2,300 bed hospital in Taiwan Pts >20yo hospitalized to receive IV cytotoxic chemotherapy (p.2) Attrition: NR	IV1= 2% D bath with CHG IV2= usual care group DV1= PO (group A strep BSI, skin-flora related BSI, & CLABSI) DV2= NCO (gut-origin bacteremia) (p.1)	IR calculated per 1000 pt days for PO (results) in the CHG group & usual-care group. (p.3) P= <0.001 for PO in CHG group (p.3) P= 0.781 for PO in usual-care group (p.3)	IR & HR (p.1)	Reduced IR in PO CHG group by 60% PO in CHG group: -IR = 3.4 per 1000 pt days -HR= 0.4; (95% CI, 0.2-0.6; P < 0.001) PO in usual-care group: -IR= 8.4 per 1000 pt days -HR= 1.1; (95% CI, 0.6-2.1; P= 0.781) (p.1&3)	-LOE: Level IV -Strengths: Study demonstrates a 60% lower HR for gram + cocci related BSI, skin-flora related BSI, or CLABSI. (p.5) Both groups (bedridden & ambulatory) used same CHG, 2%. Provided a NCO group that assessed for gut origin bacteremia; showed results that displayed CHG had no effect, thus supporting that the effect is genuine, rather than result of confounding by Pt characteristics. (p.5) Accounts for multivariability analysis, represents pts with a CVC, and factors in time to detect change in evidence (p.3,6) -Limitations: Study is performed in Taiwan in noncritical care units. (p.1) Lack of blinding pts or researchers & lack of randomization. -Feasibility: D bath with 2% CHG would be feasible for pts in both noncritical & critical care settings, in the presence of a central line. -Possible Risk: None discussed. -Recommendations: 2% D CHG bathing can be a simple, safe, & effective intervention to prevent BSI & CLABSI. Further RCTs to confirm the protective effect of CHG is warranted based on LOE. (p.7) More trials may be needed in the US to Add. transferability.

Legend: ABC=antiseptic barrier caps; Add= addressed; BSI= blood stream infection; CAUTI= catheter associated urinary tract infection; CDC= Centers for Disease Control; CHG= chlorhexidine; CLABSI= central line associated bloodstream infection; CLB= Central Line Bundle; D= daily; DT= determine; EX= examine; HAI= Healthcare Associated Infection; HR= Hazards Ratio; ICU= Intensive Care Unit; ID= identify; IRR= incidence rate ratio; LOE= level of evidence; MA= Meta-Analysis; MDRO= multi-drug resistant organism; NCO= Negative Control Outcome; NR= not reported; OBS= Observations; OR= Odds Ratio; PNHSN= Prevention National Healthcare Safety Network; Po= Primary Outcome; Pts = patients; Qual= Qualitative; RCT= Randomized Control Trial; RR= risk ratio; SCF = Socio-Cultural Factors; TSA= trial sequential analysis; TX= treatment; VAP= ventilator associated pneumonia

Appendix B

Flowchart