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Using a Systems Engineering Initiative for Patient Safety to Evaluate a Hospital-Wide Daily Chlorhexidine Bathing Intervention

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Abstract

We undertook a systems engineering approach to evaluate housewide implementation of daily chlorhexidine bathing. We performed direct observations of the bathing process and conducted provider and patient surveys. The main outcome was compliance with bathing using a checklist. Fifty-seven percent of baths had full compliance with the chlorhexidine bathing protocol. Additional time was the main barrier. Institutions undertaking daily chlorhexidine bathing should perform a rigorous assessment of implementation to optimize the benefits of this intervention.

Keywords

chlorhexidine bathing; infection control; quality improvement; SEIPS; systems engineering

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A proven intervention for reducing healthcare-associated infections (HAIs) is daily bathing with chlorhexidine gluconate (CHG) for ICU patients, for which numerous studies,[1–10] including a recent meta-analysis,[11] have found reductions in bloodstream infections and colonization by multidrug resistant organisms (MDROs). Although some studies have conducted a limited assessment of compliance with this intervention, data regarding the facilitators and barriers to CHG bathing in the real world of health care in and beyond the ICU are limited. The objective of this study was to evaluate the housewide implementation of daily CHG bathing in an academic teaching hospital. The Systems Engineering Initiative for Patient Safety (SEIPS) model[12] was used to characterize the various elements of the CHG bathing process.

METHODS

We used direct observations of bathing process and conducted provider and patient surveys to assess the implementation of daily CHG bathing.

Setting

Adult inpatient units of a large academic medical center (566 beds) began performing daily CHG bathing housewide using liquid 4% chlorhexidine 6 months prior to this study. The observations and surveys were developed using the SEIPS model to analyze the entire work system.

The SEIPS model

The SEIPS model was used as the overall framework for this study.[12,13] Briefly, the model incorporates both the human and engineering aspects of systems in patient safety by considering how a multitude of factors affects patient safety individually and in combination.[12] The SEIPS model focuses on 5 interacting elements of the work system: person, tasks, tools and technologies, physical environment, and organizational conditions. Interaction of these elements affects processes, resulting into patient outcomes such as quality of care and patient safety, and organizational outcomes such as more productivity and decreased errors.

Registered nurses (RNs), nursing assistants (NAs), and hospital patients were the *persons* involved in our analysis. Patients were divided into 3 categories: 1) patients who did not take an active role in their bathing (washing no parts of their body except the face) were considered to be "fully assisted;" 2) patients who washed part but not all of their bodies during bathing or showering were considered "partially assisted;" and 3) patients who showered or bathed completely without help from nursing staff were considered "independent."

Tasks performed were the individual components of the CHG bathing protocol. Some of these included gathering necessary supplies, providing patient education, and maintaining proper hand hygiene. A complete outline of all the components of the CHG bathing process is shown in Table 1.

The supplies necessary for daily CHG bathing constituted the *tools and technologies* used. These supplies included CHG soap (Hibiclens® 4%), a large sealable plastic bag, 10–15 washcloths, several large towels for drying, non-antimicrobial foam soap (Aloe Vesta®), and CHG-compatible lotion. Adequate supply of these tools was evaluated. The *physical environmental* features considered were lighting conditions, room temperature, and use of the space for preparing and using CHG bathing supplies.

The required CHG bathing education provided to nursing staff by the hospital was part of the *organization* of the work system. The ICU and non-ICU units were considered to be 2 functionally different organizations, given the major differences in study populations and bathing process. Compliance with CHG bathing was compared between these 2 types of *organizational units*.

Outcomes

Compliance with CHG bathing was the main process measure. Using the SEIPS framework, a checklist was developed and used during patient bathing observations to record compliance with each step of the protocol, deviations from the protocol, and the order in which the steps of the bathing process happened. Compliance was assessed in 3 ways: 1) direct observations, 2) from the electronic medical records, 3) and supply usage data. Specific observable components in the CHG bathing protocol were defined as critical for its intended outcome. These components included gathering the necessary supplies (points=4), performing hand hygiene (points=1), wearing gloves (points=1), applying at least 2 pumps of CHG soap to each washcloth (point=1), using 1 CHG washcloth per body part (point=1), rinsing each CHG-bathed area with a new washcloth (points=1), and applying a CHG-compatible lotion (points= 1) to keep the patient's skin moist. Compliance was defined as: 9–10 points= full compliance; 6–8 points=partial compliance and less than 6 points=non-compliance on a 10 point scale.

In the absence of published validated instruments for assessing compliance with CHG bathing, the factors we included were chosen based on pre-study observations we performed of the bathing process. Points were decided based on the clinical expertise of the infection control team that developed the intervention at our facility. They were agreed upon before direct observations were undertaken and focused on the tasks likely to be the most clinically important in the bathing process.

For the charting purposes, compliance to the CHG bathing process was considered present if patients received a CHG bath as noted in the EMR. In addition, the hospital-wide cost of transitioning to CHG bathing protocol was compared to the previous, non-CHG bathing protocol.

Observation and survey methods

Observations were completed and surveys were distributed between May 27, 2014 and June 27, 2014. Observations were done on weekdays during the day shift (7:00am to 3:00pm), as most bathing in inpatient units occurs during this time. A single, trained observer performed direct observations in all the 17 adult inpatient units that performed daily CHG bathing. This same individual randomly distributed written surveys to a sample of nursing staff and administered a survey to a random sample of patients on the same days as they were doing observations. Only nursing staff who had performed at least 1 CHG bath took the survey, and only patients who had received 1 bath or shower since arriving at the hospital were asked to complete the survey. Survey questions addressed components of CHG bathing education and procedure, and satisfaction about the process. Both of these can plausibly affect compliance to the bathing process. Surveys were conducted after the observations.

Statistical analysis

IBM SPSS Statistics, Version 22.0 (Armonk, NY) was used for statistical analysis. Two-tailed Fisher's exact test and Student's *t*-test was used to assess differences in proportions and continuous variables respectively. A P value of $< .05$ was considered statistically significant.

RESULTS

Twenty-eight CHG baths performed by performed by RNs and NAs were observed in 17 adult inpatient units (4 ICU and 13 non ICU). Overall, 105 nursing surveys and 86 patient surveys were completed.

Observation results

Overall 3 RNs and 31 NAs were observed. Most of the baths observed (27/28) were bed baths, and only 1 was a shower. Of these baths, 57% (16/28) were fully compliant, 36% (10/28) were partially compliant, and 7% (2/28) were non-compliant. There were no statistically significant differences in compliance between ICU and non-ICU units or between fully-assisted versus partially-assisted bathing (Table 2).

Specific steps of bathing protocol

All nursing staff performed hand hygiene, wore gloves, and changed gloves appropriately during observations. Comparisons of completion rates of tasks performed in ICU versus non-ICU units and in fully versus partially-assisted baths are shown in Table 1. None of the differences between unit types or levels of bathing assistance were statistically significant.

In 89% of baths, all necessary bathing supplies were collected. An appropriate amount of CHG soap was used for each washcloth in 93% of baths observed. Each body part was washed with 1 CHG dipped washcloth in 71% of baths observed. Each area washed with CHG was rinsed with a new washcloth (or in the shower) in 68% of observed baths. Compared to non-ICU patients, a higher proportion of ICU patients had a lotion applied to all areas washed with CHG soap (24% vs. 43%, respectively).

Times of different aspects of CHG bathing recording are shown in Table 1. There were no statistically significant differences in average times between unit types or levels of bathing assistance. The average length of time bathing occurred (excluding any other care activities) was 12 minutes and 34 seconds (9 minutes and 14 seconds on ICU units and 13 minutes and

40 seconds in non-ICU units; 13 minutes and 6 seconds for fully assisted baths and 11 minutes and 51 seconds for partially assisted baths).

Environmental notes

For the majority of baths, nursing staff set up all supplies on the patient side table for easier access. However, for 5 of the 28 baths, bathing supplies were kept near the sink away from the patient, increasing the time spent between bathing steps.

Nursing survey results

Sixty-two percent (64/104) were RNs and the rest were NAs. Survey questions addressed components of CHG bathing education and procedure. Compared to ICU nurses, a higher proportion of non-ICU nurses reported reading about the CHG bathing process available on the intrahospital website (46% of ICU staff and 70% of non-ICU staff, p=.049). Even though all staff were instructed to give information sheets about CHG bathing to patients, only 6% of nursing staff did so; this did not differ between ICU and non-ICU nurses.

Process satisfaction questions—Seventy-six percent (79/104) of nursing staff in all units agreed or strongly agreed that they can accomplish bathing in a timely manner (13% disagreed or strongly disagreed). Across all units, 32% of nursing staff agreed that CHG soap causes skin reactions in patients (30% disagreed or strongly disagreed), and 14% agreed or strongly agreed that CHG soap causes skin breakdown in patients over time (49% disagreed or strongly disagreed).

Patient survey results

Sixty-nine percent (57/83) of all patients agreed or strongly agreed they understood the importance of CHG bathing. No patients surveyed had an adverse reaction to the CHG soap. Overall, most of the patients (68/69) agreed or strongly agreed that they felt clean after bathing with CHG soap

Compliance with CHG based on EMR and CHG usage data

The overall compliance, based on patient records indicating that a patient received CHG bathing, was 72% across all units and slightly higher in the ICU (77%) compared to non-ICU units (70%). This compliance was computed for the period of 1 month after the daily CHG bathing intervention was first implemented to when this study was conducted. The non-compliance due to patient refusal was 8% in the ICU and 18% in the non-ICU units. Based on CHG soap usage data from December 2013 to May 2014 and equating each 16-ounce bottle to 7 complete daily baths, we estimated CHG soap to be used for 56% of patient days.

Cost of CHG bathing supplies

The cost of all bathing supplies from December 2012 through May 2013 (before CHG daily bathing implementation) was $175,580. In the 6-month period from December 2013 through May 2014 in which CHG bathing occurred across the hospital, the total cost of bathing supplies was $213,953 (a 22% increase).

DISCUSSION

This study assessed compliance to CHG bathing protocol mainly through direct observations of CHG baths. These were conducted in most adult inpatient units of a large academic facility. We found that 57% of the baths being undertaken were fully compliant with the CHG bathing protocol, 36% were partially compliant, and 7% were non-compliant. There was no marked difference in compliance rates between ICU and non-ICU units. Given the known efficacy of daily CHG bathing, this is a relatively low adherence to the bathing protocol and merits attention. Our use of a systems engineering approach to examine barriers, facilitators, and adherence to the intervention highlights several factors that should be considered when implementing daily CHG bathing in a health care institution.

While several studies have examined the efficacy of daily CHG bathing, few have delved into the implementation factors that are essential for translating evidence into practice. In a quasi-experimental study using 2% CHG-impregnated cloths, Montecalvo et al[8] reported compliance with bathing of 82%. Compliance was assessed by quantifying the number of CHG baths given per day. The study was conducted in the ICU setting where the patient population is general more homogeneous than in the non ICU setting. In a quasi-experimental study in a non-ICU setting (4 adult general medicine units),[5] the overall rate of compliance with CHG bathing using purchasing records was estimated to be 77% but direct observations were not performed.

A recent pragmatic large cluster-randomized trial conducted in adult ICUs of 43 hospitals, examined CHG bathing and mupirocin decolonization and assessed compliance by directly observing bathing.[4] Compliance was reported to be 85%. The main reason for non-compliance in this study was patient discharge before a scheduled bathing.

Compared to the compliance noted in our study (57%), 2 of the studies mentioned above demonstrated a fairly high level of compliance, Montecalvo[8] et al—82% and Kassakian[5] et al—85%. This fairly high level of compliance may be explained by the fact that CHG bathing was monitored in a 'controlled' setting of a study environment. This is further supported by the fact that a pragmatic trial by Huang et al,[4] conducted under routine clinical practices, reported a lower compliance of 77% (vs. 82% and 85%).

The low compliance found in our study, which was not limited to ICUs, suggests that assessment of implementation is important at multiple stages of an infection prevention intervention. This can be accomplished by examining the various system elements of the intervention as we did in this study with the use of the SEIPS model.

In our study, we examined the entire work system around the bathing process. With regard to the person element of the work system, all nursing staff performed hand hygiene, wore gloves, and changed gloves appropriately. However, patient education about CHG bathing (ie, task in the work system) occurred in only 14% of observed baths, despite 89% of nurses reporting that they were confident educating patients about bathing. Further, when patients were surveyed, only 8% reported receiving an information sheet about CHG bathing from nursing staff. This is an important finding because for an intervention such as CHG bathing, patient buy-in especially in the non ICU setting is important.[14] To our knowledge, previous studies have not examined patient perceptions regarding CHG bathing. Overall, CHG bathing was well tolerated by patients, and none of them experienced any adverse events. This is similar to other studies that have shown that CHG is well tolerated with minimal adverse events.[6,10,15]

The most frequent barrier to CHG bathing mentioned by most nurses was that the bathing process is time consuming, a characteristic of the task element in the work system. The additional time may also be a consequence of the product chosen for bathing (liquid versus CHG-impregnated cloths).[16] Unlike previous reports,[17] in our study lack of supplies was not a barrier to CHG bathing. We observed that the 6-month cost of all bathing supplies went up by $38,372 (22%) after CHG bathing was implemented. Given the overall reduction in HAIs anticipated as a result of this intervention, this would be still be a cost-saving intervention.

Our study had several strengths. First, to our knowledge this is the first study to apply a systems engineering approach to assess implementation of housewide CHG bathing through direct observations and surveys of health care workers and patients. We complemented this approach with assessment of bathing compliance using EMR documentation and chlorhexidine usage data. Our methods and findings may be used to create a generalizable framework for implementation assessment.

Regarding limitations, it is possible that the Hawthorne effect came into play for health care workers who knew that they were being observed. In that case, the compliance observed in this study could be an overestimation of the true compliance with CHG bathing. Only 28 baths were observed, which might have limited the level of variability in the observed baths. However, observations were performed in all adult inpatient units and are therefore likely to be representative of house wide CHG bathing practices. Another limitation is that we did not conduct a formal budget impact analysis of the intervention. Factors such as price increase might have contributed to the increase of the total cost of 6-months bathing supplies. However the brand did not change. We plan to conduct future studies to address these gaps.

CONCLUSION

In conclusion, low compliance with the CHG bathing protocol was a key finding in this study. Time was the main barrier identified by the nursing staff. Future studies to implement CHG bathing in the ICU or other settings should conduct an assessment of implementation to facilitate adherence and reduce variation.

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Table 1

Completion of tasks of the chlorhexidine bathing protocol

Task and assessment of compliance	All	ICU	Non-ICU	Fully assisted bathing	Partially assisted bathing
Gathered all necessary supplies (Ziploc bag, washcloths, chlorhexidine, compatible lotion)= **4 points**	(25/28) 89%	(7/7) 100%	(18/21) 86%	(14/16) 86%	(11/12) 92%
Gloves **(1 point),**	20/28 (71%)	5/7 (71%)	16/21 (76%)	13/16 (81%)	7/12 (58%)
Hand hygiene **(1 point)**	21/28(75%)	6/7 (86%)	15/21 (71%)	14/16 (88%)	6/12 (50%)
Educated patient about rationale and process	(4/28) 14%	(1/7) 14%	(3/21) 14%	(1/16) 6%	(3/12) 25%
Applied ≥ 2 pumps chlorhexidine soap per washcloth **(1 point)**	(26/28) 93%	(7/7) 100%	(19/21) 91%	(14/16) 88%	(12/12) 100%
Used one washcloth with chlorhexidine per body part **(1 point)**	(20/28) 71%	(4/7) 57%	(16/21) 76%	(12/16) 75%	(8/12) 67%
Rinsed each washed area with a new washcloth (or rinsed in shower) **(1 point)**	(19/28) 67%	(4/7) 57%	(15/21) 71%	(11/16) 69%	(8/12) 67%
Applied lotion to all areas bathed with chlorhexidine soap **(1 point)**	(8/28) 28%	(3/7) 43%	(5/21) 24%	(6/16) 38%	(2/12) 17%
Average length of time chlorhexidine applied to one arm	42 sec	37 sec	44 sec	40 sec	45 sec
Average total time spent observing bath	17 min, 45 sec	14 min, 27 sec	18 min, 51 sec	19 min, 30 sec	15 min, 26 sec
Average time spent bathing	12 min, 34 sec	9 min, 14 sec	13 min, 40 sec	13 min, 6 sec	11 min, 51 sec
Average time spent preparing for the bath (supplies, set up)	6 min	6 min	6 min	6 min	6 min

Note: Steps not listed in this table include performing hand hygiene and wearing gloves.

ICU, intensive care unit.

Table 2

Observation compliance for all units comparing fully versus partially assisted bathing

Level of compliance*	All	ICU	Non-ICU	Fully assisted bathing	Partially assisted bathing
Fully compliant	(16/28) 57%	(4/7) 57%	(12/21) 57%	(9/16) 56%	(7/12) 58%
Partially compliant	(10/28) 36%	(3/7) 43%	(7/21) 33%	(5/16) 31%	(5/12) 42%
Non-compliant	(2/28) 7%	(0/7) 0 %	(2/21) 10%	(2/16) 13%	(0/12) 0%

*9–10 points= full compliance; 6–8 points=partial compliance; and less than 6 points=non-compliance

ICU, intensive care unit