Feature Article

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Multisite Evaluation of Toothbrushes and Microbial Growth in the Hospital Setting

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Design:
This observational, descriptive study was conducted to determine the prevalence of microbial growth on toothbrushes found in hospital patient rooms.

Methods:
Toothbrush sampling was conducted in 136 acute care hospitals and medical centers from November 2018 through February 2022. Inclusion criteria for the units and patient rooms sampled were as follows: general adult medical-surgical units or critical care units; rooms occupied by adults 18 years or older who were capable of (1) mobilizing to the bathroom; (2) using a standard manual, bristled toothbrush; and (3) room did not have signage indicating isolation procedures.

Results:
A total of 5340 patient rooms were surveyed. Of the rooms included, 46% (2455) of patients did not have a toothbrush available or had not used a toothbrush (still in package and/or toothpaste not opened). Of the used toothbrushes collected (n = 1817): 48% (872/1817) had at least 1 organism; 14% (251/1817) of the toothbrushes were positive for 3 or more organisms.

Conclusions:
These results identify the lack of availability of toothbrushes for patients and support the need for hospitals to incorporate a rigorous, consistent, and comprehensive oral care program to address the evident risk of microbe exposure in the oral cavity.

KEY WORDS:
hospital-acquired infections, nonventilator hospital-acquired pneumonia, oral care

Historically, attention has been focused on ventilator-associated pneumonia (VAP) in the critical care setting. However, the literature supports an immediate need to focus on nonventilator hospital-acquired pneumonia (NV-HAP) throughout the hospital, including both critical care and non–critical care settings.[1,2] Clinical nurse specialists (CNSs) are at the forefront making evidence-based improvements to prevent VAP and NV-HAP. In a point prevalence study including 199 hospitals across 10 states, pneumonia was the number one hospital-acquired infection (HAI) and accounted for 25.8% of all HAIs.[3] Pneumonia was more prevalent than other HAIs that are frequently cited and publicly reported such as gastrointestinal infections, surgical site infections, catheter-associated bloodstream infections, and catheter-associated urinary tract infections. Nonventilator hospital-acquired pneumonia accounted for 65% of pneumonia infections, whereas 35% were attributed to VAP.[3]

Nonventilator hospital-acquired pneumonia is defined as pneumonia developing 48 hours or more after admission that was not present (by clinical findings or symptoms) at time of admission and is linked to increased morbidity and mortality and is the leading cause of death from HAIs.[4,5] Nonventilator hospital-acquired pneumonia has a mortality rate as high as 15% to 30%, occurs at an incidence of 1.22 to 8.9 cases per 1000 patient-days, and extends hospital length

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of stay by up to 15 days.[5–9] Several recently published articles demand greater focus on NV-HAP. The most recent article was in 2022, the Society for Healthcare Epidemiology, along with the Infectious Diseases Society of America and the Association for Professionals in Infection Control and Epidemiology (APIC), published updated recommendations for acute care facilities to implement in order to reduce the incidence of both VAP and NV-HAP in hospitals.[10] For NV-HAP, recommendations with little risk of harm to patients included provide regular oral care, diagnose and manage dysphagia, provide early ambulation, and implement multimodal interventions to prevent viral infections. In 2019, APIC published a Practice Position Statement on NV-HAP.[11] This document highlighted the importance of understanding NV-HAP, provided an overview of the current evidence and encouraged actions that lead to prevention. In 2020, a group of healthcare experts and organizations formed the National Organization to Prevent Hospital-Acquired Pneumonia and published a call to action to underscore the importance of NV-HAP and outline research needs.[1] This organization included stakeholders from the Centers for Disease Control and Prevention, The Joint Commission, the American Dental Association, and the Patient Safety Movement Foundation, as well as clinical experts and researchers in NV-HAP. Together, they developed the "Nonventilator Hospital-Acquired Pneumonia: A Call to Action," which outlined the importance of research needs in this area.[1] Following this publication, The Joint Commission issued a Quick Safety Topic on Preventing Nonventilator Hospital-Acquired Pneumonia.[12] This document challenged healthcare systems to implement and support NV-HAP prevention and add NV-HAP prevention measures to education for patients, healthcare professionals, and students. The Emergency Care Research Institute published the Top 10 Patient Safety Concerns 2022, which identifies imminent patient safety challenges for healthcare organizations. Nonventilator healthcare-associated pneumonia was number 6 on the list.[13] In 2022, Health Affairs Forefront published an article regarding NV-HAP and the threat to patient safety, and the Society for Healthcare Epidemiology/Infectious Diseases Society of America/APIC published the updated strategies to prevent NV-HAP.[10,14] All of these organizations/coalitions discussed the overwhelming concern for morbidity and mortality related to NV-HAP and cite the importance of basic oral care to prevent this HAI.

Nonventilator hospital-acquired pneumonia predominantly starts in the oral cavity.[5] Research provides supportive evidence that bacteria colonize in the oropharyngeal area within dental plaque and can be aspirated into the lungs, potentially leading to the development of NV-HAP.[15,16] Dental plaque provides a rich microhabitat, and microbes can replicate 5 times in 24 hours.[17,18] To remove dental plaque and the associated microbial load, comprehensive oral care should be part of an overall daily strategy to reduce NV-HAP in the clinical setting. Providing complete and comprehensive oral care for every patient includes the right equipment, protocols, and education of both providers and patients.[19] Several reports have demonstrated a decrease in NV-HAP when an oral hygiene protocol was implemented.[19–22]

An essential piece of equipment for effective oral care is the toothbrush. When used appropriately, toothbrushing provides mechanical removal of plaque and debris in the oral cavity. In hospitalized patients, it is unknown how the type of toothbrush, care, storage, and replacement of toothbrushes may impact oral care and prevent NV-HAP. Currently, there are scant data to quantify if toothbrushes harbor microbes and the amount or type of microbes residing on toothbrushes used by hospitalized patients. Messina et al[23] and Rabakowska et al[24] demonstrated bacterial contamination on many hospital surfaces including counters, toilets, beds and bedding, monitors, devices, and computer keyboards. Toothbrushes were not included, although patient's personal hygiene supplies such as toothbrushes may also be reservoirs for bacterial growth. Both studies found that the devices tested were possible reservoirs of bacteria, which may lead to HAIs. In 2012, Frazelle and Munro[25] reviewed the literature on toothbrush contamination and found that microbial contamination was present on toothbrushes of both healthy and oral diseased adults. The contamination was associated with dental plaque, toothbrush (bristle) design, method of storage, and environmental factors.[25] The authors noted this contamination may increase the risk of infection and mortality in vulnerable populations such as critically ill adults.[25] They also recommend additional descriptive studies to examine toothbrush contamination in the hospital setting and the need to develop evidence-based oral care guidelines for adults that minimize risks related to toothbrush contamination.[25]

Only 1 study was found addressing disinfectants for contaminated toothbrushes. A study in India investigated the use of disinfectants with contaminated toothbrushes from children who brushed their teeth for 5 days. The authors found the use of disinfectants such as chlorhexidine gluconate and sodium hypochlorite reduced the growth of microorganisms on toothbrushes.[26]

Thus, as beginning work in improving comprehensive oral care, it is important to determine if toothbrushes are available in patients' rooms and to quantify the amount and type of microbial growth on these toothbrushes. These data will help guide the development of specific aspects of a comprehensive oral care protocol to help prevent NV-HAP.

PURPOSE

Toothbrushing is recommended 4 times per day with an American Dental Association–endorsed soft-bristled toothbrush for mechanical removal of plaque.[19,21,27] However, for hospitalized patients, there is no standard practice for

toothbrush type (hospital provided or patient's own), storage of the toothbrush, routine of oral care, or the duration of toothbrush usage prior to replacement. In order to first address this question, it is important to identify current practice and possible contamination of toothbrushes. The purpose of this study was to determine the incidence of microbial growth on toothbrushes sampled from hospitalized patients.

METHODS

This observational, descriptive study was conducted to determine the prevalence of microbial growth on toothbrushes found in hospital patient rooms. Sampling was conducted in 136 acute care hospitals and medical centers from November 2018 through February 2022. Hospitals were identified for potential participation, and hospital consent was obtained by a representative of Stryker Sage (Cary, Illinois).

Inclusion criteria for the units and patient rooms sampled were as follows: general adult medical-surgical units or critical care units; rooms occupied by adults 18 years or older who were capable of (1) mobilizing to the bathroom and (2) using a standard manual, bristled toothbrush and (3) did not have isolation precautions.

Only used toothbrushes were sampled for this study. A "used toothbrush" was defined as a toothbrush that was found out of the package and accompanied by an opened toothpaste tube. "Used toothbrushes" included both hospital-issued and personal toothbrushes (electric toothbrushes were excluded). An "unused toothbrush" was defined as a toothbrush that was present and in an unopened package, or an opened toothbrush accompanied by an unopened toothpaste tube.

This study was designed to examine current clinical practice. Because the focus of the study was on the toothbrush and did not involve research on human subjects, it was not submitted to the institutional review board for review. No patient identifiers were included in collection or analysis. Patients were notified of toothbrush collection and replacement by hospital staff as is done in some hospitals following their standard practice protocol. This study was sponsored by Stryker Sage.

If the room was designated as double occupancy and there were 2 patients in the room, 2 toothbrushes were collected. Toothbrushes were collected most frequently from bathroom counters, bedside tables, or inside bedside cabinet drawers. Used toothbrushes were immediately placed in an individual sterile bag using a sterile gloved hand. No identifying information was placed on the bag with the toothbrush, and no patient identifiers were included in any aspect of the data collection. For each unit, data were collected regarding the number of samples and number of rooms where a toothbrush was not found. Following collection of a toothbrush for analysis, the toothbrush was immediately replaced with the same or similar toothbrush, which was provided by Stryker Sage and met specifications of the American Dental Association.[27] Patient toothbrushes were evaluated for gram-negative organisms, Vancomycin-resistant *Enterococcus*, methicillin-resistant *Staphylococcus aureus*, *Enterococcus*, *S aureus*, and multidrug-resistant organisms to determine possible risk of contamination of the lung parenchyma secondary to microaspiration.

All bagged toothbrushes were placed in shipping containers that contained ice packs (to improve the integrity of sample) prior to sending via overnight delivery to one independent laboratory, which is a current Good Manufacturing Process laboratory and is registered with the Food and Drug Administration (Advanced Testing Laboratory, Cincinnati, Ohio). The laboratory is not certified or registered with any other clinical organization or governing body. Appendix A (http://links.lww.com/NUR/A41) describes the steps used by the independent laboratory. Basic screening methods were utilized to identify and confirm organisms. Techniques included Gram stain, catalase test, latex test, and coagulase test. All of the results were based on presumptive typical reactions on selective agars. No results from the toothbrush analyses were used for clinical diagnosis or treatment planning related to patient care.

RESULTS

The 136 hospitals participating in the study were located in 38 states, and 4 hospitals were located in Ontario, British Columbia, and Saskatchewan, Canada. Hospitals included were government or privately owned and had either an academic or community focus. There was the potential for 5340 toothbrushes to be collected.

Of the rooms entered (which included both single and double occupancy), there were a total of 5340 patients; 29% (1549 patients) had no toothbrush present; and 17% (908 patients) had an "unused toothbrush." Given these data, 46% of patients did not have a toothbrush or had an unused toothbrush present (Figure 1). Of the 1817

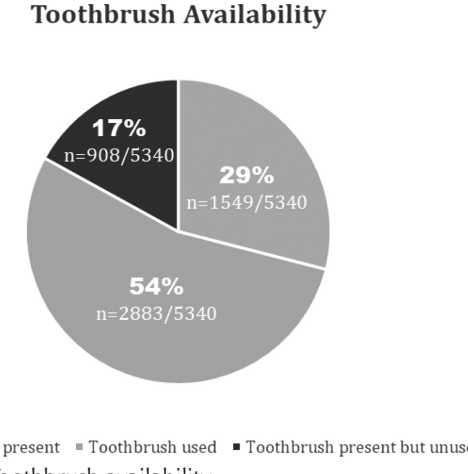

FIGURE 1. Toothbrush availability.

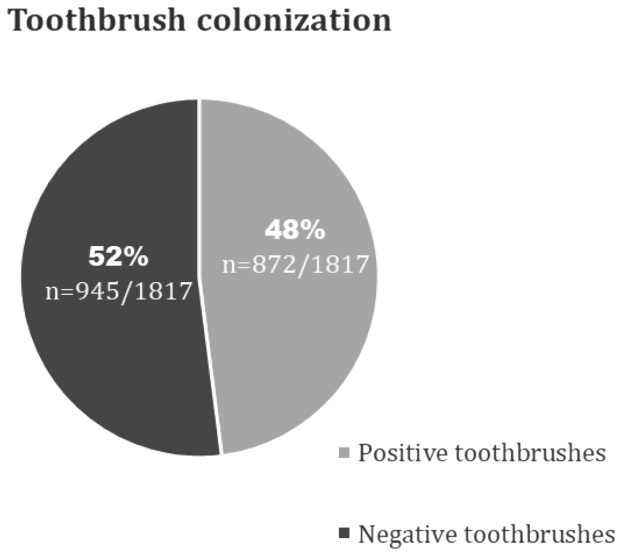

FIGURE 2. Toothbrush colonization, n = 1817.

toothbrushes tested in the laboratory, almost half of all toothbrushes tested were positive for at least one organism (n = 872 [48%]), whereas 945 (52%) tested negative for organisms (Figure 2). Two hundred fifty-one toothbrushes were positive for 3 or more organisms. All hospitals had at least 1 positive toothbrush culture, and 124 of 136 hospitals (91%) had at least 1 positive MDRO found on a toothbrush (Figure 3). The types of organisms identified on the toothbrushes tested in the laboratory included 510 gram-negative organisms (28%), 420 vancomycin-resistant *Enterococcus* (23%), 212 methicillin-resistant *S aureus* (12%), 428 *Enterococcus* (24%), and 229 *S aureus* (13%) (Figure 4).

DISCUSSION

This is the first published research to evaluate the presence and microbial status of toothbrushes in hospitalized patients. Studies have shown that bacterial growth and contamination occur on many hospital surfaces. Unfortunately, these studies have not included patient personal hygiene supplies.[23,24] The primary purpose of the current exploratory study was to sample toothbrushes used by hospitalized patients and determine the incidence of microbial growth present on these toothbrushes. The study started out as a small, exploratory pilot study. However, early on, it was identified that toothbrushes were often absent from a patient's room, and of the toothbrushes sampled, many different bacteria were identified. Given these initial results, the study expanded over time to include 136 hospitals with data collection over a 3-year period.

Of the toothbrushes cultured, nearly half (48%) had some type of microbial growth. This is a concerning finding as there is an identified link of oral hygiene with respiratory disease. In their 2012 study of healthy and oral-diseased individuals, Frazelle and Munro[25] concluded that inconsistencies with care and storage may impact contamination of toothbrushes, and more research is needed. They also described the need for additional descriptive studies to examine toothbrush contamination in the hospital setting and the need to develop evidence-based nursing oral care guidelines for adults that minimize risks related to toothbrush contamination.[25] Our data confirm these conclusions specifically related to toothbrushes.

A systematic review of 1551 articles identified 15 articles related to oral care and NV-HAP; 9 of the 15 articles focused on oral care as the main intervention for prevention of NV-HAP.[28] Not only is it important to provide

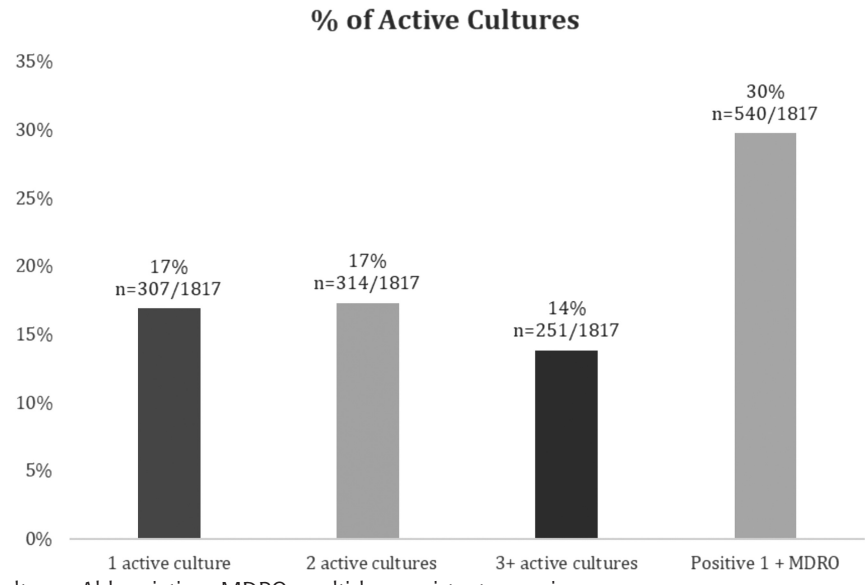

FIGURE 3. Positive cultures. Abbreviation: MDRO, multidrug-resistant organism.

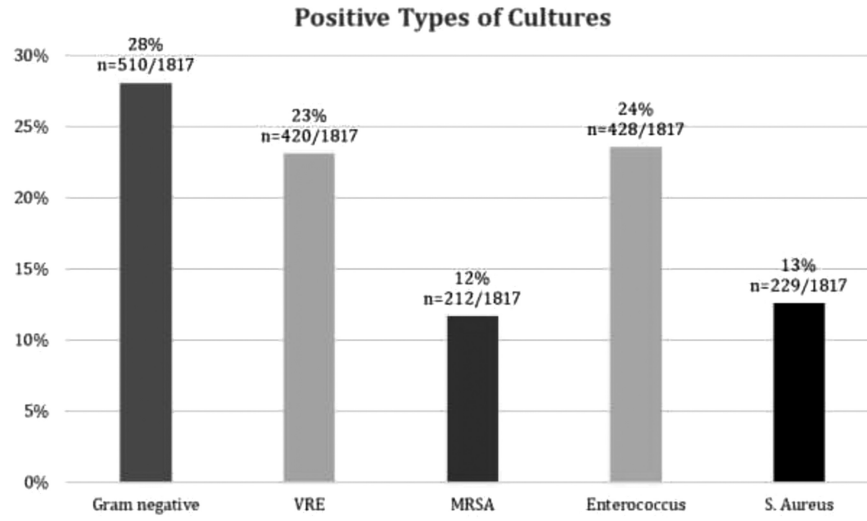

FIGURE 4. Type of organisms and frequency. Abbreviations: MRSA, methicillin-resistant *Staphylococcus aureus*; VRE, vancomycin-resistant *Enterococcus*.

appropriate oral care to clean the mouth and prevent NV-HAP, it is just as important to not introduce additional microbes found on the toothbrush back into the mouth, which would place a patient at a greater risk for pneumonia The organisms found in the current study cultured from toothbrushes were the same as implicated as causative organisms for both NV-HAP and VAP in other studies.[29] Interestingly, although isolation rooms were excluded from this study, many of the organisms found on toothbrushes were organisms that would meet the criteria to place the patient in an isolation protocol.

Lack of availability of a toothbrush is another intriguing finding in this study. Many rooms had no toothbrush available for patient use. Forty-six percent (n = 2457) of patient rooms entered did not have a toothbrush available or had an "unused toothbrush." This raises an important question about access to the essential tools required for proper oral hygiene during hospitalization. Dental plaque serves as a microbial reservoir, and plaque colonization is a specific source of gram-negative nosocomial infection. A key strategy for removal of dental plaque is brushing the teeth. Therefore, a toothbrush is an essential tool for prevention of NV-HAP. The American Dental Association has endorsed a protocol for comprehensive oral care in hospitalized patients.[27] This protocol breaks down by type of patient (independent, dependent, etc) and lists the tools and optimal frequency of oral care. Every hospital should include this protocol in their comprehensive oral care program. How to store a toothbrush in the hospital setting should also be included in this protocol; however, there is little evidence on best practices for storage.

Lastly, given the lack of toothbrushes available for use, this may be a result of a perceived lack of understanding of the importance of oral care in the nonventilated patient. It is important that healthcare clinicians increase their awareness and understanding of the importance of oral hygiene and prioritize this as a treatment or intervention.

Limitations

Although this study has numerous limitations, the results provide overwhelming evidence regarding the need for improved availability and management of toothbrushes in the clinical setting. Limitations include the following: there was not a clear, discrete process for how units were identified for data collection and if all rooms (except isolation) were included in data collection. Although this could potentially bias the results, it is doubtful that selection of units could dictate the use of toothbrushes or the microbes identified. Other limiting factors are that no data were collected regarding patient demographics, diagnoses, length of hospital stay, potential presence of microbes in the mouth upon admission to hospital, the length of time a patient had been in a room, or the length of time the supplies (toothbrush, toothpaste) had been in use. The positive cultures may have measured patient state before admission as well as oral versus no oral care and environmental contamination. Potentially, an unopened tube of toothpaste could signify the completion of a tube with a replacement. In addition, no data were collected to assess if the organisms cultured were present upon patient arrival or in the environment and placed the patient at risk for new, dangerous organisms after admission.

Clinical Nurse Specialist Implications

The CNS specializes in advancing nursing practice to improve outcomes while working within the 3 spheres of impact, according to the National Association of Clinical Nurse Specialists, which includes the Patient Direct Care

Sphere, the Nurse and Nursing Practice Sphere, and the Organization/Systems Sphere.[30] The CNS role is essential in that CNSs continually identify opportunities to improve patient care, thereby impacting patient outcomes, as well as help spread evidence-based practice across the organization. In this setting, the CNS focus on oral care for prevention of pneumonia is relevant to all 3 spheres of impact. Oral care is a basic necessity not only for comfort but also for prevention of NV-HAP. As a facilitator and leader of continuous quality improvement, it is important for CNSs to have current knowledge about the patient safety risks associated with inconsistent or absence of oral care. This research provides essential information about the current state of oral care in the hospital setting—lack of toothbrush availability and the risk of microbial growth on toothbrushes. A first step for the CNS is to assess oral care products available on the unit and evaluate compliance with oral care practices. In addition, communication to staff regarding the results of this study as well as findings on the unit will help raise the awareness regarding oral care. These beginning steps will potentially result in a significant improvement in oral care and decrease complications of NV-HAP.

Future Research

Several questions are generated from this study that should be explored further with future research. How often should toothbrushes be replaced, and how should they be stored in the hospital setting? Research is needed to determine at what point microbial growth is present on toothbrushes. This could guide clinical care and determine the length of time toothbrushes should be used for hospitalized patients prior to replacement.

Future research, which would require institutional review board approval, should also be conducted to assess patient characteristics, origin of toothbrush (hospital-issued, from home), diagnosis, and length of stay when toothbrushes are cultured. Including patients in isolation would be an interesting addition to the literature as well. It is unknown if the organisms cultured were a result of the patient's own infectious process or if this colonization could lead to infection. A more rigorous research design is required to answer this question.

CONCLUSIONS

The results of this study provide overwhelming evidence regarding the need for improved management and availability of toothbrushes in the clinical setting. Clinical nurse specialists and all clinicians at the bedside need to lead the way in the design and implementation of policies that allow for adequate time, proper oral care supplies, ease of access to supplies, clear procedures, and outcome monitoring ensuring that patients are protected from NV-HAP. These are all aspects of a comprehensive oral care program. The results from this study support the need for improvement in one aspect of comprehensive oral care—the availability, cleaning, and potential replacement of toothbrushes at the bedside.

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