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Major Article

Contemporary stethoscope cleaning practices: What we haven't learned in 150 years

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Background: Stethoscopes can be microorganism reservoirs. The US Centers for Disease Control and Prevention (CDC) has published medical equipment disinfection guidelines to minimize infection transmission risk, but studies of guideline adherence have been predominately survey based, with little direct observation of disinfection practices.

Methods: We performed an observational, cross-sectional, anonymous study of patient-provider interactions, assessing practitioners' frequency and methods of stethoscope and hand disinfection practices.

Results: Stethoscopes were disinfected in 18% of 400 observed interactions, with less than 4% verified as conforming to CDC guidelines. None was disinfected before patient examinations involving open chest or abdominal wounds, as recommended by the CDC. Hands were cleaned before and after encounters 27 times (6.8%) but were not cleaned at all in 231 (58%) encounters, although gloves were worn in 197 (85.3%) of these cases.

Discussion: Stethoscope disinfection is grossly overlooked, possibly jeopardizing patient safety, particularly in acute care interactions. Periodic stethoscope disinfection, although inconvenient, helps reduce bacterial contamination and may reduce health care–associated infections.

Conclusions: Stethoscopes were disinfected per CDC guidelines in less than 4% of encounters and were not disinfected at all in 82% of encounters. Although hands were rarely cleaned (6.8%) per CDC guidelines, gloves were usually worn, but no convenient stethoscope equivalent exists. Stethoscope cleanliness must be addressed.

Health care–associated infections (HAIs) pose a significant danger to hospitalized patients. In 2011, the US Centers for Disease Control and Prevention (CDC) estimated that there were 721,800 HAIs in the United States,[1] contributing to approximately 75,000 inpatient deaths.[2] It has been shown that both stethoscopes and hands share similar contamination levels, even after performance of a single patient physical examination.[3] Approximately 85% of stethoscopes foster bacteria.[4] Although most are considered nonpathogenic (eg, coagulase-negative staphylococci),[4-7] species such as *Pseudomonas aeruginosa*, vancomycin-resistant enterococci, *Clostridium difficile*, respiratory syncytial virus, and methicillin-resistant *Staphylococcus aureus* have also been isolated.[4,6-9] Some studies have reported a negligible risk for stethoscopes as vectors for infection[10,11]; however, others have found significant HAI risk.[6,12] Since described in 1861 by Semmelweis[13] as a means to prevent the spread of puerperal fever, frequent hand cleaning has been one of the primary ways to prevent infection transmission.[14] Although in contemporary practice gloves may serve as barriers to infectious disease transmission, no such routinely available option exists for the stethoscope, and even though some providers may use an additional glove to cover their stethoscopes as a contact precaution, this practice is not widely standardized. Thus, if stethoscopes are contaminated, this "failure of disinfection" may create a substantial risk in the acute care environment.

Because hospitalized patients are more vulnerable to infection owing to their compromised state of health and their continual exposure to pathogenic bacteria,[8] the CDC has recommended that

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disinfection practices be optimized. CDC disinfection guidelines follow the Spaulding classification, categorizing medical equipment based on the level of patient care and the type of contact for which it is used: "critical" equipment for contact with sterile tissue, vasculature, and so forth; "semicritical" for contact with mucous membranes and nonintact skin; and "noncritical" for contact with intact skin, excluding mucous membranes. Because stethoscopes are usually used over intact skin, with the exception of some acute care interactions (eg, trauma and intensive care unit patients), they are frequently classified as noncritical equipment, occasionally overlapping into the semicritical category. The nature of patient interactions, with stethoscope use over intact skin or nonintact skin, determines whether the stethoscope used in that interaction should be classified as noncritical or semicritical, respectively. To simplify description of the scenarios discussed, this study adapted the Spaulding terminology to apply interchangeably to both the stethoscopes and the patient interactions in which they were used (eg, semicritical stethoscopes/interactions).

CDC recommendations for disinfecting noncritical stethoscopes include disinfecting between "each patient or once daily or once weekly," whereas semicritical stethoscopes should be disinfected "before use on each patient."[15] Although the Spaulding-specified high-level disinfection or sterilization for semicritical equipment is not feasible for personal stethoscopes, particular attention should be given to stethoscope disinfection prior to use over and around nonintact skin.

Unfortunately, most research evaluating stethoscope disinfection is based on self-reported surveys. Survey-based research is subject to bias, especially if it is perceived to have clinician-associated negative results, such as assignment of responsibility for infection transmission. Our purpose was to directly observe the frequency and methods of stethoscope disinfection used by health care providers in emergent and acute care interactions. Because hand and stethoscope contamination levels are strongly correlated,[3,16] we also sought to observe the frequency of hand cleaning and glove use.

METHODS

Study design

This was an observational, cross-sectional study of interactions between patients and health care providers in the emergency department (ED), surgical intensive care unit (SICU), and labor and delivery (L&D) unit at a large teaching hospital in Houston, Texas, with a level-1 trauma center. Interactions with patients suffering from open thoracic and/or abdominal wounds, either from trauma (defined for this study as physical violence suffered from motor vehicle accidents, knife or gunshot wounds, etc) or from surgery (recovering in the SICU), were grouped into the semicritical category, with the remainder of patient care interactions considered noncritical.

Observation of an encounter began on a clinician's entry into the patient's room or after the most recent manual contact with a nonindex patient surface (eg, computer keyboard, another patient), whichever was earlier. Observation ended on the clinician's exit from the room or after manual contact with another nonindex patient surface, whichever was later. Study subjects were stratified by practitioner category, including physicians (stratified into attending physicians, fellows, and residents), nurses, physician assistants, medical students, physician assistant students, and other medical personnel. To minimize selection bias, reviewers performed observations on different dates, at different times, and in different units. Some providers were aware that their patient encounters were being observed; however, the reasons for observation were not revealed. Per protocol, observers did not communicate with the practitioners they watched. Although this limited the descriptive data that could be obtained regarding practitioners (and may have resulted in some practitioners being observed more than once), it served to minimize the potential for altered disinfection behavior owing to the Hawthorne effect.

Data recorded included practitioner category, date, location (ED, SICU, or L&D), trauma status, and the presence of any precaution status (droplet, aerosol, contact, or other). The practitioner's hand cleaning (defined as "disinfecting" with alcohol-based sanitizer or "washing" with soap and water) before or after encounter, use of gloves, performance of stethoscope disinfection before or after encounter, methods of stethoscope disinfection (use of alcohol pad or alcohol-and-ammonia germicidal wipe) before or after encounter, duration of the disinfection process in seconds ($<$15 seconds and $\geq$15 seconds), and parts of the stethoscope being disinfected (tubing, diaphragm, or both) were documented.

Subject identification protection

Waiver of consent for this study was granted by the institutional review board (Protocol Number: H-39736). Patient-provider identifying information was blinded to protect both parties' privacy and to shield providers from concern over possible repercussions for actions that might be considered noncompliant with accepted guidelines.

Statistical analysis

Data were analyzed using Stata 12.0 statistical software (StataCorp. EpiTools epidemiological calculators. College Station, TX) and are presented using descriptive statistics. Confidence intervals were calculated using the Wilson score interval.

RESULTS

Stethoscope disinfection frequency

Stethoscopes were disinfected in 72 of 400 (18%) encounters, with 8 (2%) occurring before and 65 (16%) occurring after the patient encounter. In only 1 encounter (with a noncritical patient) was the stethoscope disinfected both before and after, accounting for 73 total instances of disinfection (18.3%; 95% confidence interval [CI], 14.8%-22.3%) in the course of 72 encounters. During the 73 observed instances of disinfection, providers used germicidal wipes more than alcohol pads and disinfected diaphragms more than tubing, and most spent less than 15 seconds on the disinfection process (Table 1).

In noncritical interactions, stethoscopes were disinfected 15 of 288 times (5.2%; 95% CI, 3.2%-8.4%), 8 before and 8 after (2.8% and 2.8%, respectively). Although actual adherence to the CDC-recommended frequency of disinfecting between "each patient or once daily or once weekly" may have been higher than 5.2% owing to providers disinfecting their stethoscopes without observation at another time within the 1-week time frame, observers witnessed disinfection

Table 1
Stethoscope disinfection methods

	Total	Percentage	Before	After
Germicidal wipes	68/73	93.15	5	63
Alcohol pads	5/73	6.85	3	2
Diaphragms	39/73	53.42	4	35
Tubing	6/73	8.22	0	6
Both	28/73	38.36	4	24
Duration $<$15 s	66/73	90.41	5	61
Duration $\geq$15 s	7/73	9.59	3	4

NOTE. Methods observed among the 73 disinfections: disinfecting agent, parts disinfected, and duration of disinfection.

during 15 of 288 noncritical interactions. In semicritical interactions, no stethoscopes were disinfected before physical examinations, as recommended by the CDC, in any of 112 encounters (0%) but were disinfected afterward in 57 of 112 (51%) encounters. Ultimately, of the total 400 observed encounters, only 15 (3.8%; 95% CI, 2.3%-6.1%) could be confirmed to comply with CDC disinfection standards.

Stethoscope disinfection frequency stratified by provider

Provider-specific distribution frequencies are listed in Table 2, noting the total number of observations and disinfection instances, each divided into semicritical or noncritical interactions. Provider-specific stethoscope disinfection rates are shown as percentages of provider-specific observations in Figures 1, 2, and 3; groups with no observed instances of disinfection were omitted. In semicritical interactions, residents had the highest stethoscope disinfection rate, followed by physicians and then nurses. This is most likely related to residents having the greatest exposure to the obvious visible contaminants (eg, blood) that are more probable to occur with open wounds. When comparing provider-specific cohorts' respective percentages of CDC-compliant instances of disinfection (CDC-compliant instances of disinfection divided by observations), no cohort was found to be nearing compliance, although nurses had the highest rate (15.1%; 95% CI, 8.4%-25.7%) versus attending physicians (3.6%; 95% CI, 1.2%-10.0%) (Fig 3).

Hand cleaning frequency

Hands were neither washed nor disinfected before or after 231 of 400 encounters (58%), although gloves were worn for 197 of those 231encounters (85.3%). Gloves were used a total of 329 of 400 (82%) times. In 34 encounters (8.5%; 95% CI, 6.1%-11.6%), providers neither wore gloves nor cleaned their hands at all. Providers who used gloves were generally noted to observe proper CDC-recommended glove removal methods,[17] although this practice was not specifically documented as part of this study.

Hands were washed or disinfected in 169 of 400 (42%) encounters. Hand cleaning occurred 37 (9.3%) times before examinations and 159 (39.8%) times after examinations. Hands were washed with soap and water 99 of 400 times (25%; 1 before, 98 after) and disinfected with alcohol-based sanitizer 116 of 400 times (29%; 36 before, 80 after), with some providers both disinfecting and washing after encounters. Because some form of cleaning is recommended by the CDC[18] to occur both before and after patient encounters, the total number of cleanings should have been double the number of patients (ie, 800 cleanings). However, the total number of cleanings was 215, and only 27 (6.8%) patients had providers who cleaned their hands both before and after examinations.

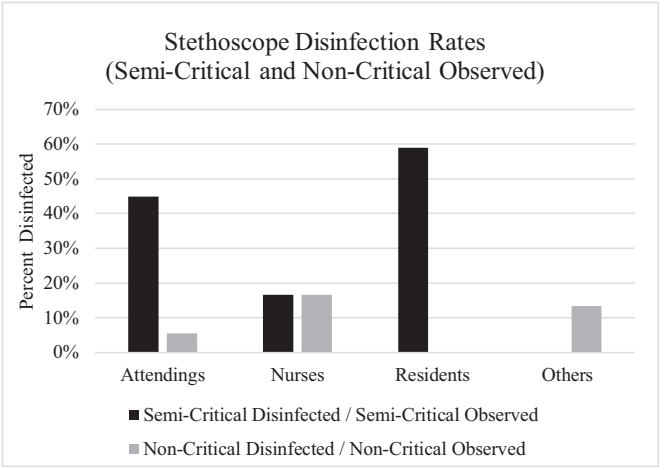

Fig 1. Provider-specific percentages of observed stethoscope disinfections performed during each respective group's semicritical and noncritical encounters, as defined in Table 2.

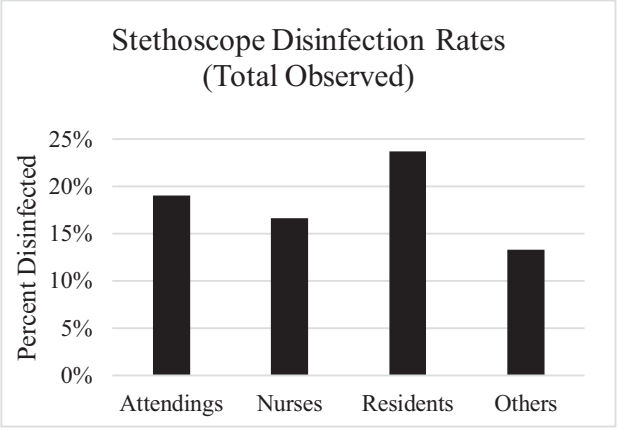

Fig 2. Provider-specific percentages of observed stethoscope cleanings performed during each respective group's total encounters, as defined in Table 2.

DISCUSSION

We found that stethoscopes underwent disinfection in less than 20% of patient encounters, almost never before an encounter, and that semicritical disinfection practices never met CDC-recommended standards. Our data are concerning. Although intact skin helps protect noncritical patients from pathogen-harboring stethoscopes, semicritical patients with nonintact skin must rely on their practitioners to minimize this infection transmission risk. Previous studies have been

Table 2
Provider-specific stethoscope disinfection rates

	Total observed	Semicritical observed	Noncritical observed	Total disinfected	Semicritical disinfected	Noncritical disinfected
Attendings	84	29	55	16	13	3
Nurses	66	6	60	11	1	10
Fellows	24	3	21	0	0	0
Residents	181	73	108	43	43	0
PAs	14	1	13	0	0	0
Medical students	11	0	11	0	0	0
PA students	5	0	5	0	0	0
Other	15	0	15	2	0	2

NOTE. Provider-specific categorization of total, semicritical, and noncritical observations, as well as number of disinfections performed among each group of providers in those encounters.
PA, physician assistant.

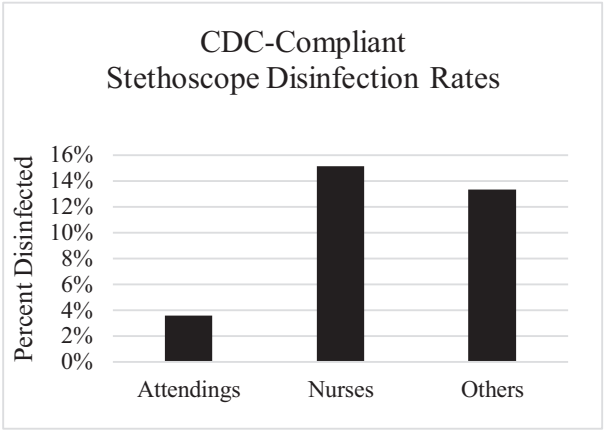

Fig 3. Total observed, provider-specific, Centers for Disease Control and Prevention–compliant stethoscope disinfection percentages, all performed during noncritical encounters. No Centers for Disease Control and Prevention–compliant disinfections were observed during semicritical encounters. Actual noncritical compliance may have been greater owing to unobserved disinfection within 1 week of the encounter.

largely survey based and have assumed stethoscope usage on intact skin. Noting that self-reported surveys may reflect overestimations of actual disinfection rates as the result of social desirability bias, these studies report compliance ranges from 80%[7] of health care workers disinfecting their stethoscopes daily to only 10%[12] of health care workers ever cleaning their stethoscopes at all.[6,7,9,12,16,19] In 2 other observational studies, stethoscope disinfection rates were reported to be 16% (58/352)[20] and 0% (0/128).[21]

We also found that hand cleaning did not meet guideline-recommended standards. Although hands were cleaned in less than half of encounters, gloves were commonly (82%) worn, although in 8.5% of encounters hands were neither cleaned nor gloved, and only 6.8% of providers were fully CDC compliant. In comparison, according to a review of 33 different observational studies, hand cleaning varied between 5% and 81%, with an average of 40% compliance.[18]

There are several reasons stethoscope disinfection may be uncommon. First, for patients in semicritical condition presenting to fast-paced acute care environments, rapid assessment of pulmonary and/or cardiovascular function may require prioritization over stethoscope cleanliness. Second, health care workers may find stethoscope disinfection to be inconvenient. In one survey, providers cited a lack of convenient means of disinfecting their stethoscopes as the most prevalent reason for disinfection infrequency.[19] Even though disposable gloves and hand disinfection "stations" are readily available in most hospitals, there is often no glove or disinfection equivalent for stethoscopes. Although a disposable hand glove may be spread over a stethoscope diaphragm, most providers do so primarily for patients requiring "contact precautions," and the efficacy of this practice has not been widely studied. To properly disinfect a stethoscope, one must take the extra time to obtain a disinfecting agent, such as a germicidal wipe, which additionally requires the use of gloves. Ironically, the highly acute, semicritical scenarios in which stethoscopes most need to be disinfected are, by nature, the same scenarios in which there is the least time to disinfect them. Third, stethoscope disinfection may be related to health care providers' overall perception and understanding of disinfection practices. Additional research may discover a correlation between hand cleaning and stethoscope disinfection practices, and it may be possible that health care facilities that heavily emphasize CDC-compliant hand hygiene may also emphasize CDC-compliant stethoscope disinfection. Finally, resistance to stethoscope disinfection may result from providers underestimating the role that stethoscopes may play in HAI transmission. It is equally difficult to definitively identify or rule out stethoscopes as a major cause of HAIs owing to the number of possible contaminants in any given scenario. However, one study linked neonatal bloodstream infection directly to stethoscope contamination,[22] and another study found that 30% of providers caring for patients infected by multidrug-resistant organisms exited their patients' rooms with their hands or gloves still contaminated by the same strain of multidrug-resistant organism.[23] The medical community of 1861 flagrantly resisted Semmelweis' evidence that hand washing decreased puerperal fever mortality. Now, 150 years later, with the knowledge not only that stethoscope and hand contamination levels are correlated[3,16] but also that stethoscopes have been shown to harbor dangerous pathogens[4,6–9,12] and have been linked to HAI transmission,[22] are we not in the same position if we dismiss the importance of stethoscope disinfection?

Studies have shown that the relative risk of infection from stethoscope contamination is multifactorial, increasing with the number of patients examined,[5] the level of patient skin contamination, the degree of humidity of the patient's skin, body mass index,[24] and male sex.[25] Further, overall numbers of colony-forming units cultured from stethoscopes decrease with increased frequency of disinfection,[10,16] thus suggesting an intervention effect. Although semicritical interactions require disinfection beforehand, simply maintaining vigilance by disinfecting between noncritical interactions may reduce the risk of infection when that stethoscope is unexpectedly urgently used during a semicritical interaction. Because the personal stethoscopes of providers in acute care settings are commonly used in both semicritical and noncritical interactions without designation for or limit to either type of encounter, stethoscope disinfection must address both scenarios. One solution would be to use dedicated stethoscopes for each semicritical patient. However, the loss of sound quality during auscultation, or even providers' preference for their own stethoscopes, may present an obstacle to implementing the use of dedicated stethoscopes. Another solution would be to consider all stethoscopes used in acute care settings as semicritical equipment, requiring providers to disinfect their personal stethoscopes before each patient interaction. However, even though this would be the most risk-reducing practice, the medical community may be more amenable to reinforcement of understanding of and adherence to current CDC guidelines so that providers consistently disinfect their stethoscopes prior to each use over nonintact skin and at least once weekly when auscultating over intact skin. Even if no other action is taken to enhance stethoscope disinfection practices, health care facilities may decrease risk of HAI transmission by merely implementing stethoscope-disinfection training with each episode of hand-cleaning training, especially in acute care settings.

Unfortunately, stethoscope disinfection with existing technology is limited. In the hospital, the most readily available options are alcohol swabs, but their effectiveness is questionable, and alcohol-and-ammonia germicidal wipes often require use of gloves. Barrier systems exist but are either difficult to apply or require digital application, resulting in cross-contamination. Ultimately, use of wipes containing a stringent germicide that can be safely touched, such as chlorhexidine gluconate, or a "no-touch" dispenser system for an audiologically transparent single-use barrier could address the challenge of current stethoscope disinfection practices.

Our study has several strengths. Primarily, by its observational nature and blinded methodology, our study likely reflects more accurate rates of stethoscope disinfection in acute clinical care than survey-based studies might have reported. One review of 326 studies comparing self-reported compliance to actual observation found that rates of self-reported adherence to clinical guidelines exceeded observed rates by 27%.[26] Self-reported surveys are subject to recall bias owing to discrepancies in subject recollection,[27] as well as social desirability bias owing to participants' desire to report more socially acceptable responses.[26] Although observational studies may be confounded by

the Hawthorne effect if subjects are aware that their actions are being recorded, we mitigated this effect by blinding the subjects to the purposes of the study. Even though observational research is preferred for measuring surface contact hygiene,[28] as far as we know this study is the first to focus on stethoscope disinfection in emergency/acute care environments, taking into consideration the difference in disinfection protocol between CDC-specified noncritical and semicritical interactions. Additionally, the inclusion of multiple practitioners from multiple cohorts in multiple units (ED, SICU, and L&D) served to diversify the subject population, rendering a broad representation of disinfection practices across acute care environments.

Limitations

Our study had several limitations. First, because hand and stethoscope contamination levels are strongly correlated, and because stethoscope diaphragms came in contact with nonindex patient surfaces (eg, the practitioner's hand, clothing) multiple times in virtually every encounter, observers recorded practitioners' manual contact directly before and after patient examinations, as well as practitioners' stethoscope contact with patients, but they did not record instances of stethoscope contact with the practitioner either during the encounter or during the interim between patient encounters. Therefore, some stethoscopes may have become contaminated soon after having been disinfected. Second, guideline compliance may have been underestimated because, unlike semicritical guidelines that specify disinfection before each physical examination, adherence to noncritical guidelines, relaxed to include as few as 1 disinfection per week, cannot be comprehensively observed in a single patient encounter. Therefore, the percentage of providers who were compliant with CDC noncritical guidelines but were not observed while performing their weekly disinfection may have been greater than 5.2%. Finally, the blinded nature of our protocol may have resulted in the categorization of patient encounters as noncritical when, in actuality, a greater severity of illness was present. Conversely, in the semicritical interactions, we were not able to consistently observe whether stethoscopes had contact directly over broken skin. Practitioners who disinfected their stethoscopes after a semicritical encounter most often did so in response to contact with patients' blood, but although some stethoscopes were observed to become soiled by direct contact with the patient (on or near the wound), some may have been contaminated via contact with soiled gloves. In this fashion, a higher compliance than we were able to document may have occurred in both the semicritical and noncritical patient cohorts, respectively. Ultimately, the performance of stethoscope disinfection was such a rare event that even a 300% increase in disinfection rates would seem insufficient to protect patients from the risk of a disease transmission adverse event.

CONCLUSIONS

CDC-compliant stethoscope disinfection rates were observed to be rare, occurring in only 4% (15/400) of encounters, and were nonexistent in semicritical interactions. CDC-compliant hand cleaning occurred in only 6.8% (27/400) of encounters, but gloves were worn 82% (329/400) of the time. Although gloves help protect both providers and patients from manual contact exposures, no such equivalent exists for stethoscopes. In acute care interactions in which open wounds near auscultation sites increase patients' risk of infection, stethoscope disinfection must not continue to be overlooked.

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