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ORIGINAL ARTICLE

Contamination of Stethoscopes and Physicians' Hands After a Physical Examination

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Abstract

Objectives: To compare the contamination level of physicians' hands and stethoscopes and to explore the risk of cross-transmission of microorganisms through the use of stethoscopes.

Patients and Methods: We conducted a structured prospective study between January 1, 2009, and May 31, 2009, involving 83 inpatients at a Swiss university teaching hospital. After a standardized physical examination, 4 regions of the physician's gloved or ungloved dominant hand and 2 sections of the stethoscopes were pressed onto selective and nonselective media; 489 surfaces were sampled. Total aerobic colony counts (ACCs) and total methicillin-resistant *Staphylococcus aureus* (MRSA) colony-forming unit (CFU) counts were assessed.

Results: Median total ACCs (interquartile range) for fingertips, thenar eminence, hypothenar eminence, hand dorsum, stethoscope diaphragm, and tube were 467, 37, 34, 8, 89, and 18, respectively. The contamination level of the diaphragm was lower than the contamination level of the fingertips ($P<.001$) but higher than the contamination level of the thenar eminence ($P=.004$). The MRSA contamination level of the diaphragm was higher than the MRSA contamination level of the thenar eminence (7 CFUs/25 cm^2 vs 4 CFUs/25 cm^2; $P=.004$). The correlation analysis for both total ACCs and MRSA CFU counts revealed that the contamination level of the diaphragm was associated with the contamination level of the fingertips (Spearman's rank correlation coefficient, $\rho=0.80$; $P<.001$ and $\rho=0.76$; $P<.001$, respectively). Similarly, the contamination level of the stethoscope tube increased with the increase in the contamination level of the fingertips for both total ACCs and MRSA CFU counts ($\rho=0.56$; $P<.001$ and $\rho=.59$; $P<.001$, respectively).

Conclusion: These results suggest that the contamination level of the stethoscope is substantial after a single physical examination and comparable to the contamination of parts of the physician's dominant hand.

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The patient-to-patient transmission of microorganisms is a major threat to hospitalized patients and causes significant morbidity and mortality. The present evidence indicates that health care workers' hands are the main route of cross-transmission.[1,2] Small medical equipment, such as stethoscopes, may also contribute to the dissemination of microorganisms, but the evidence supporting this hypothesis is less robust and their role in microorganism propagation is poorly understood. Similar to any piece of medical equipment, stethoscopes have the theoretical capacity to be vectors of pathogens through a multistep process. First, stethoscopes must acquire microorganisms after contact with a source patient.[3] Second, these organisms must then survive on the object for at least several minutes and be transferred to the skin of a second patient during subsequent use. Numerous factors may affect the risk of transmission at each of these steps,[2,3] and assessing transmissibility is better achieved by studying 1 step at a time.

Many factors must be considered when conducting such studies. For example, as no piece of noncritical equipment used on patient wards is meant to be sterile, most objects in the health care environment will yield microorganisms when sampled. However, the clinical significance of detecting low levels of contamination is uncertain. One way to solve this difficulty and better understand the relative contribution of stethoscopes in the transmission of microorganisms is to place their levels of contamination into perspective with those of a universally recognized vector of dissemination, that is, the physician's own hands. If the number of bacteria recovered from stethoscopes is much lower

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than the number recovered from the examiner's hands, their role in the transmission of pathogens would be deemed more negligible. In contrast, if their contamination level is reported to be comparable with that of the examiner's hands, their capacity to transmit pathogens would be more significant and transmission mitigation measures would be more urgently needed.

We aimed to compare prospectively the contamination level of stethoscopes and physicians' hands after a single, standardized, physical examination by using quantitative cultures and 2 different markers of contamination.

PATIENTS AND METHODS

Setting

We conducted a structured prospective study between January 1, 2009, and May 31, 2009, at the University of Geneva Hospitals (HUG), Geneva, Switzerland. HUG is a 2200-bed primary and tertiary teaching hospital admitting 47,000 patients annually with a long-standing experience in hand hygiene promotion.[2,4] Patients were recruited from internal medicine and orthopedic operating wards by using a convenience-based recruitment strategy. Eligibility criteria included stable medical condition, absence of a life-threatening condition, absence of active skin infection, and age 18 years or more. Eligible patients colonized with methicillin-resistant *Staphylococcus aureus* (MRSA) were identified by reviewing infection control databases and ongoing surveillance activities. Screening for MRSA colonization after patient admission by sampling of the anterior nares and the perineal region with a sterile premoistened swab is a standard operating procedure at HUG in specified acute care wards.[5] The *mecA* gene is detected in samples by using gene multiplex, immunocapture-coupled, quantitative polymerase chain reaction.[5] The present study was approved by the institutional review board of HUG.

TABLE 1. Standardized Physical Examination[a]

1. Hand rubbing with alcohol-based formulation
2. Handshake
3. Palpation of radial artery for pulse measurement
4. Palpation of cervical and supraclavicular lymph nodes
5. Lung auscultation
• Posterior chest (6 locations)
6. Auscultation of heart (4 areas: pulmonic, aortic, tricuspid, and mitral)
7. Examination of abdomen
• Inspection and auscultation (4 quadrants)
• Percussion (evaluation of ascites and liver size)
• Superficial and deep palpation (including rebound tenderness)
• Palpation and auscultation of femoral pulses
8. Lower extremity examination
• Inspection of skin (color, temperature, and edema)
• Palpation of posterior tibial arteries
9. Final handshake

[a]The physical examination was conducted with and without sterile gloves by trained medical practitioners.

Standardized Physical Examination

After patient enrollment, 1 of 3 physicians (Y.L., C.T., or A.S.) was randomly selected to perform a physical examination at the patient bedside. The examination was standardized to ensure reproducibility (Table 1). Physicians were allowed to adapt to unforeseen events (such as unbuttoning the patient's gown or moving the bedside table) as long as the action was commonly encountered in routine clinical practice. An external observer ensured adherence to the standardized physical examination by using a checklist. A sterile stethoscope (Littmann Cardiology II, 3M) was used for each physical examination. Sterilization was conducted by using hydrogen peroxide gas plasma technology to preserve the integrity of the material (STERRAD 100NX Sterilizer, Advanced Sterilization Products).

The present study was divided into 2 phases. Phase 1 aimed to assess the total aerobic colony count (ACC). Sterile gloves (Protegrity Micro SMT PF, Cardinal Health) were worn by the examiner before the physical examination to ensure that the initial count would be zero. Phase 2 of the study focused solely on MRSA transmission, and the examiner conducted the physical examination with bare hands. The physician performed 2 consecutive hand hygiene procedures by using an alcohol-based hand rub formulation (Hopirub, B. Braun Medical AG) before the examination to ensure that hands were MRSA free. Each hand hygiene action strictly followed the World Health Organization–recommended technique and lasted at least 30 seconds.[1,3] To confirm the absence of MRSA, cultures of 4 regions of the examiners' hands were performed after hand hygiene and before the beginning of the physical

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examination by using agar impression on selective chromogenic plates (MRSA-ID, Count-tact, bioMérieux SA).[2]

Specimen Collection and Processing

After the completion of the physical examination, 4 regions of the physician's dominant gloved (phase 1, ACC study) or ungloved (phase 2, MRSA study) hand (ie, fingertips, thenar eminence, hypothenar eminence, and dorsum) were sampled in addition to 2 sections of the stethoscope (diaphragm and tube). Sampling of the hand and stethoscope diaphragm was conducted by gently pressing the region under study on contact plates for 5 seconds.[2] Sampling of the tube was conducted by rolling it across the plate by using a technique adapted from intravenous catheter culture.[6] The sampled section was located 10 cm from the head of the stethoscope.

Nonselective media were used to determine the total ACC (Count-Tact, bioMérieux SA), and selective chromogenic media were used to determine the MRSA colony-forming unit (CFU) count (MRSA-ID). After sampling, contact plates were incubated aerobically at 37°C for 18 to 24 hours. All colonies that grew on nonselective media were counted to assess the total ACC. Green colonies on MRSA-selective plates were considered presumptive MRSA isolates, and 1 colony per sample was subcultured onto Columbia blood agar for formal identification. The confirmation of MRSA isolates was achieved by a combination of tests, including a duplex quantitative polymerase chain reaction assay to evaluate the presence of the *mecA* gene and *femA* gene specific for *S. aureus*.[7]

The total ACC and the MRSA CFU count per 25 cm^2 were assessed using the following strategy developed in our laboratory: contact plates were digitally photographed, and the number of colonies was determined using a manual counting tool (Adobe Photoshop CS4 Extended). This strategy allows the precise measurement of CFU counts of up to 5000 CFUs/25 cm^2. Interrater reliability was evaluated in a pilot study during which 3 independent observers measured CFU counts on 34 digital photographs with a wide range of bacterial growth (range, 2-4805 CFUs/25 cm^2). The agreement between observers was high (intraclass correlation coefficient, 0.987; 95% CI, 0.977-0.993; $P<.001$; data not reported). The maximum colony count was fixed

TABLE 2. Characteristics of Patients Enrolled at the University of Geneva Hospitals, Geneva, Switzerland[a]

Characteristic	Type of contamination study[b]		Total (N=71)
	Total ACC (n=33)	MRSA (n=38)	
Sex: male	21 (63.6%)	22 (57.9%)	43 (60.6%)
Age (y)	62±15	72±15	68±16
Hospital ward			
Internal medicine	33 (100%)	27 (71.1%)	60 (84.5%)
Orthopedics	0	11 (28.9%)	11 (15.5%)
Antibiotic use[c]	10 (30.3%)	13 (34.2%)	23 (32.4%)
Central venous line	3 (9.1%)	3 (7.9%)	6 (8.5%)
Indwelling urinary catheter	2 (6.1%)	13 (34.2%)	15 (21.1%)
Presence of skin wound	4 (12.1%)	17 (44.7%)	21 (29.6%)
Mean time since last bath/shower (h)	10±7	9±5	10±6
Type of bathing			
Shower	17 (51.5%)	8 (21.1%)	25 (35.2%)
Sponge bath by self at the sink	16 (48.5%)	19 (50.0%)	35 (49.3%)
Sponge bath by health care workers in bed	0	10 (26.3%)	10 (14.1%)
Unknown	0	1 (2.6%)	1 (1.4%)
MRSA decontamination[d]	NA	1 (2.6%)	1 (1.4%)

[a]ACC = aerobic colony count; MRSA = methicillin-resistant *Staphylococcus aureus*; NA = not applicable.
[b]Data are presented as mean ± SD or as No. (percentage).
[c]Includes amoxicillin-clavulanate (3), cefazolin (1), ceftriaxone (3), trimethoprim/sulfamethoxazole (2), ciprofloxacin (2), levofloxacin (2), clindamycin (1), imipenem (2), clarithromycin (1), metronidazole (3), and vancomycin (3).
[d]Only patients colonized with MRSA.

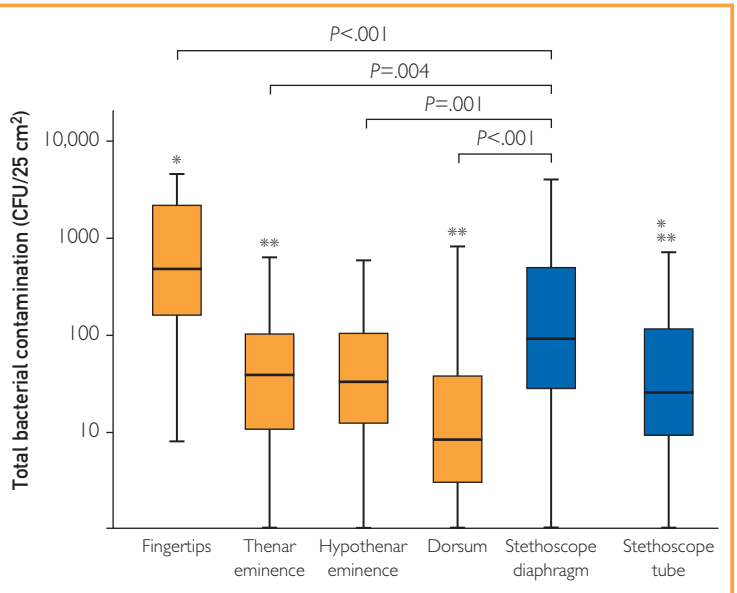

FIGURE 1. Total aerobic colony count recovered from physicians' gloved hands (orange boxes) and stethoscopes (blue boxes) after a single physical examination. Results are presented on a logarithmic scale. The top and bottom of the box plots represent the interquartile ranges, and the horizontal lines represent the median values. The error bars extend to the maximum and minimum values. Differences between levels of contamination were tested using Wilcoxon paired rank-sum tests. CFU = colony-forming unit. *P<.001 compared with stethoscope tube. **P=.04 compared with stethoscope tube.

at 5000 CFUs; beyond this, colonies formed a confluent surface.

Statistical Analyses

Descriptive analysis results are expressed as percentages for categorical variables and as median values and interquartile ranges (IQRs) or as mean ± SD for continuous variables, as appropriate. Because of skewed distributions, the levels of contamination of different parts of the hands and stethoscopes were described as medians with 25th and 75th percentiles (ie, IQR) and depicted in the form of box plots. The contamination of different regions of hands and stethoscopes was compared using Wilcoxon signed-rank tests for paired continuous variables. We generated scatter plots and used the Spearman's rank correlation coefficient (ρ) to measure correlations between the contamination of different parts of hands and the contamination of stethoscopes. All tests were 2-sided, and a P value of less than .05 was considered to indicate statistical significance. Statistical analyses were performed using PASW statistics, version 18 (SPSS Inc).

RESULTS

Baseline Characteristics

A total of 489 quantitative cultures were taken to evaluate bacterial contamination of 83 study participants (ACC study: 33; MRSA study: 50). Because MRSA was not recovered from the physicians' dominant hand or the stethoscope after the examination of 12 of 50 patients colonized with MRSA (24%), these patients were excluded from the final analysis. The clinical characteristics of participants are listed in Table 2. Most participants were men (43 of 71 [60.6%]), with a mean age of 68±16 years. A total of 23 participants (32%) were undergoing antibiotic therapy, 8% had a central venous line, and one-fifth had an indwelling urinary catheter. Twenty-one of 71 patients (30%) had 1 or more skin wounds. The mean time since their last bath/shower was 10±6 hours. Half of the patients had last bathed themselves by using a sponge by the sink, one-third had taken a shower, and 14% had received a sponge bath in their bed. One patient colonized with MRSA was undergoing decolonization at the time of the study.

Bacterial Contamination Levels

Figure 1 depicts the levels of bacterial contamination of stethoscopes and physicians' hands. After a single examination, the most heavily contaminated region in terms of the total ACC was the fingertips (median contamination [IQR], 467 [141-2239] CFUs/25 cm^2), followed by the stethoscope diaphragm (median [IQR], 89 [27-691] CFUs/25 cm^2). The contamination levels of the thenar and hypothenar eminences were comparable (median [IQR], 37 [11-117] and 34 [11-117] CFUs/25 cm^2, respectively). The median level of stethoscope tube contamination was 18 [IQR 4-120] CFUs/25 cm^2. The least heavily contaminated region was the dorsum of the hand (median [IQR], 8 [2-41] CFUs/25 cm^2). When comparing these various regions, we found that the contamination level of the diaphragm was significantly lower (P<.001) than the contamination level of the fingertips but significantly higher than the contamination level of the thenar eminence, hypothenar eminence, and dorsum of the

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hand ($P \leq .004$ for each comparison). The contamination level of the stethoscope tube was lower than that of the fingertip and thenar eminence ($P \leq .04$), similar to that of the hypothenar eminence ($P = .10$), and higher than that of the dorsum of the hand ($P = .04$).

After the examination of patients colonized with MRSA (Figure 2), the most heavily contaminated region was again the fingertips (median [IQR], 12 [3-113] CFUs/25 cm^2), followed by the stethoscope diaphragm (median [IQR], 7 [0-71] CFUs/25 cm^2), thenar eminence (median [IQR], 4 [0-13] CFUs/25 cm^2), and hypothenar eminence (median [IQR], 2 [1-23] CFUs/25 cm^2). The median levels of the contamination of the stethoscope tube and hand dorsum were 0. When comparing these various regions in terms of MRSA contamination, we found that diaphragm contamination was not significantly different from fingertip contamination ($P = .54$) and was higher than thenar eminence ($P = .004$), hypothenar eminence ($P = .02$), and hand dorsum ($P < .001$) contamination. Tube contamination was lower than the fingertip ($P < .001$), thenar eminence ($P = .02$), and hypothenar eminence ($P = .008$) contamination, but similar to hand dorsum contamination ($P = .42$).

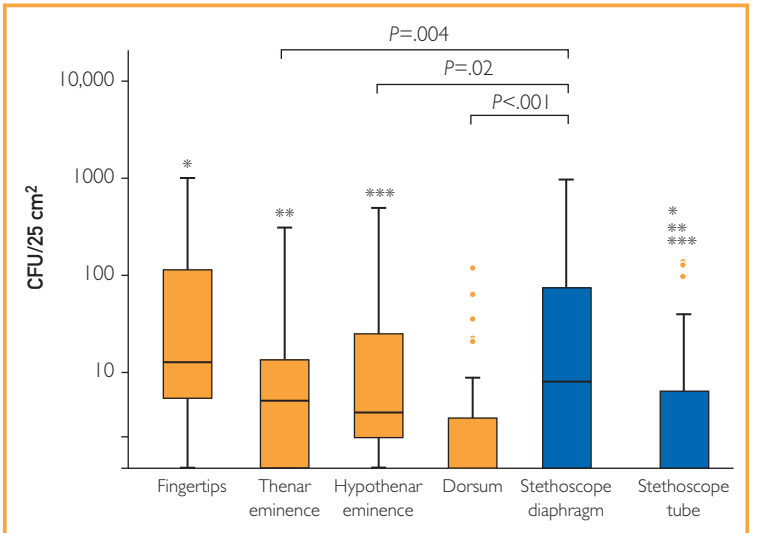

FIGURE 2. Methicillin-resistant *Staphylococcus aureus* CFU counts recovered from physicians' hands (orange boxes) and stethoscopes (blue boxes) after a single physical examination. Results are presented on a logarithmic scale. The top and bottom of the box plots represent the interquartile ranges, and the horizontal lines represent the median values. The error bars extend to the maximum and minimum values. Differences between contamination levels were tested using Wilcoxon paired rank-sum tests. CFU = colony-forming unit. *$P < .001$ compared with stethoscope tube. **$P = .02$ compared with stethoscope tube. ***$P = .008$ compared with stethoscope tube.

Correlation Between Hand and Stethoscope Contamination

For both total ACCs and MRSA CFU counts, the contamination level of stethoscopes was strongly associated with the contamination level of physicians' hands. As illustrated in Figure 3, A-D, the total ACC contamination level of the diaphragm increased with the contamination level of the fingertips ($\rho = .80$; $P < .001$), thenar eminence ($\rho = .47$; $P = .006$), hypothenar eminence ($\rho = .47$; $P = .006$), and hand dorsum ($\rho = .71$; $P = .001$). Similar findings were found for tube contamination (Figure 3, E-H). The contamination level of the tube increased with the contamination levels of the fingertips ($\rho = .56$; $P = .001$), thenar eminence ($\rho = .48$; $P = .005$), hypothenar eminence ($\rho = .56$; $P = .001$), and hand dorsum ($\rho = .61$; $P = .001$).

Figure 4, A-D, illustrates the association between the MRSA contamination level of the stethoscope diaphragm and the MRSA contamination of examiners' hands. The increased MRSA contamination level of the diaphragm was associated with the increased contamination level of the fingertips ($\rho = .76$; $P < .001$), thenar eminence ($\rho = .76$; $P = .006$), hypothenar eminence ($\rho = .68$; $P < .001$), and hand dorsum ($\rho = .44$; $P = .005$). Similarly, the MRSA contamination level of the stethoscope tube was associated with the contamination of each of the 4 regions of the hand ($\rho > .59$; $P < .001$ for all comparisons; Figure 4, E-H).

DISCUSSION

The risk of cross-transmission of bacteria through health care workers' hands has been studied extensively.[1,2] Despite a strong theoretical basis, cross-transmission through small medical equipment, such as stethoscopes, sphygmomanometers, and thermometers, is much less understood. The present study found that the contamination of stethoscopes is not negligible after a physical examination. In general, stethoscope diaphragms are contaminated as much as (or even more than) the physician's own thenar eminence. Furthermore, we observed a direct relation between hand and stethoscope contamination, with higher levels of hand contamination associated with the increased levels of stethoscope contamination. This observation

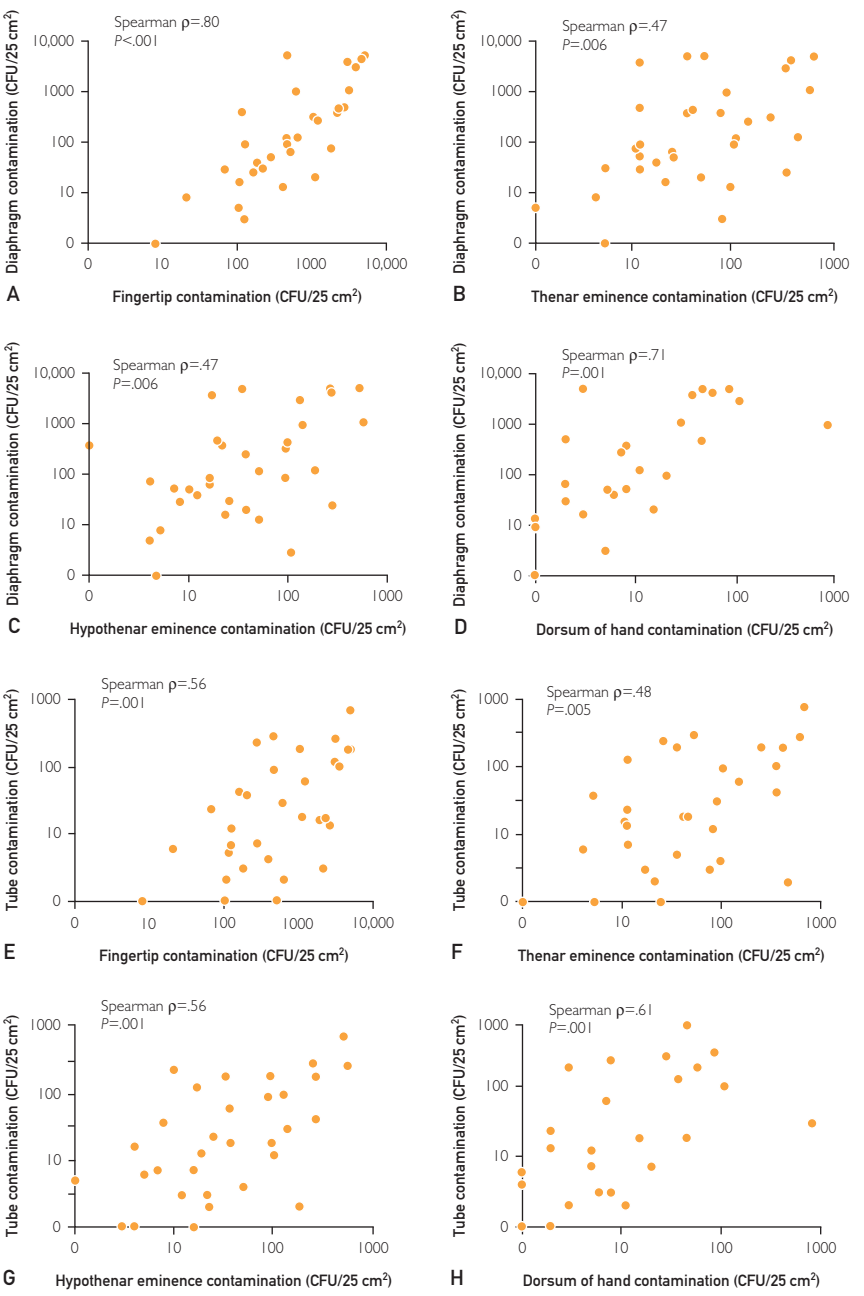

FIGURE 3. A-D, Relation between total ACC contamination of *stethoscope diaphragm* and physicians' fingertips (panel A), thenar eminence (panel B), hypothenar eminence (panel C), and hand dorsum (panel D). E-H, Relation between total ACC contamination of *stethoscope tube* and physicians' fingertips (panel E), thenar eminence (panel F), hypothenar eminence (panel G), and hand dorsum (panel H). Data are presented on a logarithmic scale. ACC = aerobic colony count; CFU = colony-forming unit.

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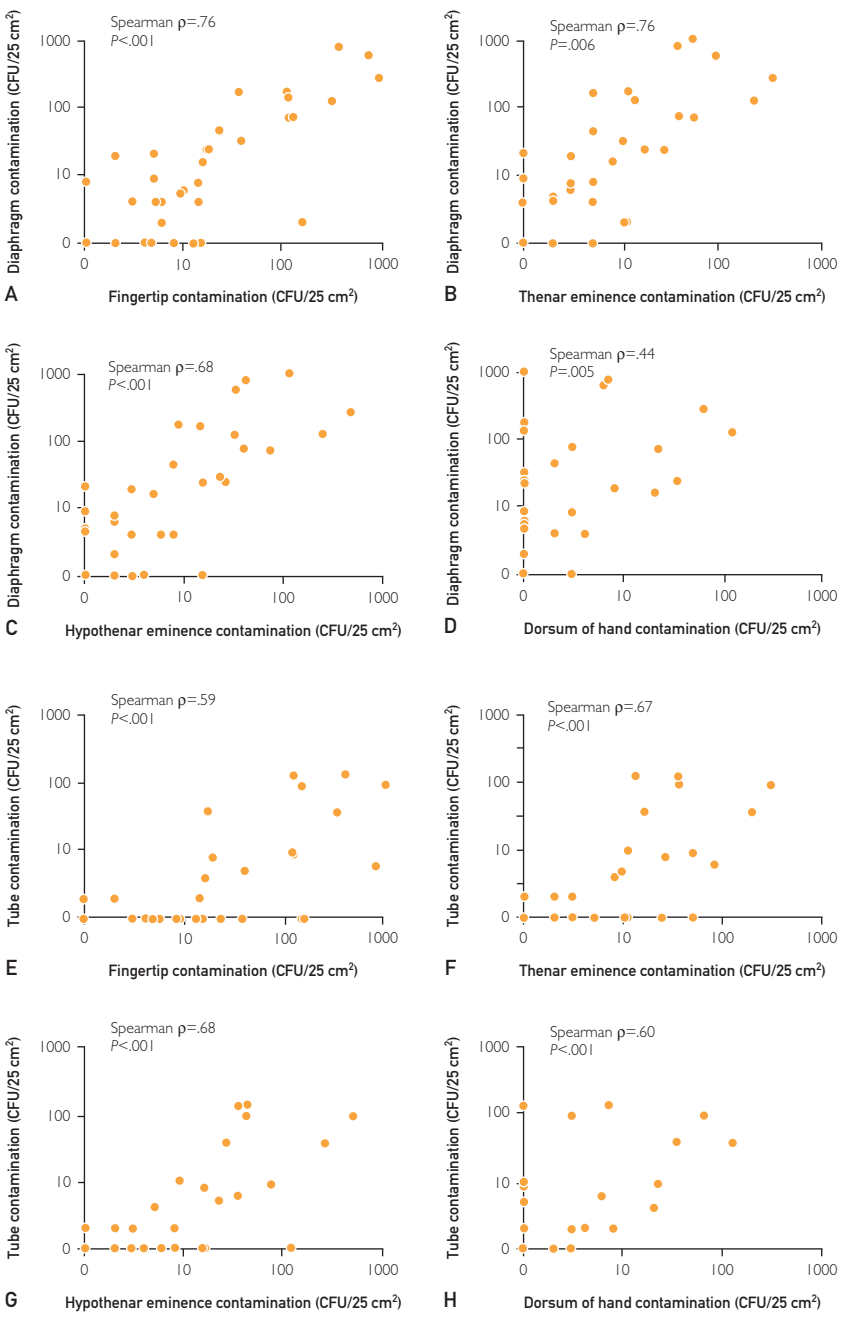

FIGURE 4. A-D, Relation between methicillin-resistant *Staphylococcus aureus* contamination of *stethoscope diaphragm* and physicians' fingertips (panel A), thenar eminence (panel B), hypothenar eminence (panel C), and hand dorsum (panel D). E-H, Relation between methicillin-resistant *Staphylococcus aureus* contamination of *stethoscope tube* and physicians' fingertips (panel E), thenar eminence (panel F), hypothenar eminence (panel G), and hand dorsum (panel H). Data are presented on a logarithmic scale. CFU = colony-forming unit.

suggests that the patient's skin and immediate surroundings are the common denominators and determinants of both physicians' hands and stethoscope contamination. Why some patients apparently shed bacteria more readily than others remains to be elucidated and deserves further study.

Most studies have investigated the levels of stethoscope contamination by using a point prevalence methodology.[8-14] These studies have found considerable variation in stethoscope contamination, ranging from a few CFUs to several hundreds. This variation could be due to factors that are difficult to control in cross-sectional studies, such as the frequency of stethoscope use, the exact use of the instrument (eg, taking blood pressure, auscultation of the lungs, heart, abdomen, or great vessels), or the frequency of disinfection. In addition, the "opportunity for contamination" is often not considered in these studies.[8-14] This observation probably partly explains the wide discrepancy in the frequency of MRSA contamination of stethoscopes between cross-sectional studies, which ranges from 0% to 27%.[15-20] We controlled for potential confounders by standardizing the physical examination, using sterile stethoscopes, assessing MRSA colonization in patients, and comparing stethoscope contamination with the contamination level of the examiner's own dominant hand. Furthermore, although quantification of bacterial contamination has so far been hampered by the difficulty to count high numbers of CFU on relatively small culture plates, we developed a new strategy to precisely quantify high bacterial counts on these media.

To our knowledge, stethoscope tube contamination has not been studied so far, probably because it does not come into contact with the patient's skin and is not perceived as a significant vector of transmission. The present study finds that the contamination level of the stethoscope tube is not only comparable to that of the examiner's hand dorsum but also greater. Contamination probably occurs indirectly through its manipulation with contaminated hands, and these findings highlight the need to disinfect the stethoscope tube as well as the diaphragm.

It is generally recognized that most physicians and nurses do not disinfect their stethoscopes frequently (ie, less than once a month, if at all). Most surveys support this perception and reveal that 70% to 90% of the physicians do not disinfect systematically their stethoscope after every patient contact.[10,17,21-24] By considering that stethoscopes are used repeatedly over the course of a day, come directly into contact with patients' skin, and may harbor several thousands of bacteria (including MRSA) collected during a previous physical examination, we consider them as potentially significant vectors of transmission. Thus, failing to disinfect stethoscopes could constitute a serious patient safety issue akin to omitting hand hygiene. Hence, from infection control and patient safety perspectives, the stethoscope should be regarded as an extension of the physician's hands and be disinfected after every patient contact. However, the optimal method of disinfection remains to be determined. Alternatively, cross-transmission could be interrupted by assigning stethoscopes to individual patients. Clearly, there is an urgent need to identify effective transmission mitigation strategies.

This study has some limitations. It was conducted in a single hospital with the participation of a limited number of physicians and patients, thus limiting its generalizability to other settings. We used a convenience-based strategy to recruit patients. We assessed contamination of 4 regions of physicians' dominant hands and 2 sections of stethoscopes, and our findings may not be generalizable to the nondominant hand. The contamination level of the entire surfaces of hands and stethoscopes was not assessed, because these are technically difficult to evaluate. It is possible that the overall contamination of both hands is quantitatively much higher than the overall contamination of stethoscopes, thereby reducing the relative transmission potential of stethoscopes. Subsequent studies are required to investigate the transmission potential of each part of hands and stethoscopes and better understand which ones are more likely to transmit pathogens. With the exception of MRSA, we did not distinguish pathogenic and nonpathogenic bacteria. The identification of all microorganisms recovered from hands and stethoscopes would require considerable resources. Whether a similar relation exists between hand and stethoscope contamination for other health care–associated pathogens such as *Clostridium difficile* remains to be determined. In addition, the exact source of contamination of stethoscopes and hands could not be identified. We hypothesize that

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most contamination originates from patients, but contamination with the physicians' own hands also probably occurred. As mentioned initially, this study focused solely on the first step of the cross-transmission process. Transmission is affected by a multitude of other variables, such as a pathogen's capacity to survive on the surface, the frequency of the use of the object, and the quality of disinfection.

CONCLUSION

Our findings provide strong evidence of the potential for stethoscope-mediated transmission of microorganisms and the need to systematically disinfect stethoscopes after each use. Consequently, our results may help convince physicians of the importance of proper and timely disinfection. Further studies will be required to better understand microorganism survival on stethoscopes as well as their transmissibility onto a recipient's skin. Furthermore, additional studies are needed to better understand how stethoscopes can be efficiently and safely disinfected.

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Abbreviations and Acronyms: **ACC** = aerobic colony count; **CFU** = colony-forming unit; **HUG** = University of Geneva Hospitals; **IQR** = interquartile range; **MRSA** = methicillin-resistant *Staphylococcus aureus*

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REFERENCES

1. WHO Guidelines on Hand Hygiene in Health Care. Geneva: World Health Organisation; 2009.
2. Pittet D, Dharan S, Touveneau S, Sauvan V, Perneger TV. Bacterial contamination of the hands of hospital staff during routine patient care. *Arch Intern Med*. 1999;159(8):821-826.
3. Pittet D, Allegranzi B, Sax H, et al. Evidence-based model for hand transmission during patient care and the role of improved practices. *Lancet Infect Dis*. 2006;6(10):641-652.
4. Pittet D, Hugonnet S, Harbarth S, et al. Effectiveness of a hospital-wide programme to improve compliance with hand hygiene. Infection Control Programme. *Lancet*. 2000;356(9238):1307-1312.
5. Harbarth S, Fankhauser C, Schrenzel J, et al. Universal screening for methicillin-resistant Staphylococcus aureus at hospital admission and nosocomial infection in surgical patients. *JAMA*. 2008;299(10):1149-1157.
6. Raad I, Hanna H, Maki D. Intravascular catheter-related infections: advances in diagnosis, prevention, and management. *Lancet Infect Dis*. 2007;7(10):645-657.
7. Cherkaoui A, Renzi G, Francois P, Schrenzel J. Comparison of four chromogenic media for culture-based screening of methicillin-resistant Staphylococcus aureus. *J Med Microbiol*. 2007;56(Pt 4):500-503.
8. Marinella MA, Pierson C, Chenoweth C. The stethoscope. A potential source of nosocomial infection? *Arch Intern Med*. 1997;157(7):786-790.
9. Smith MA, Mathewson JJ, Ulert IA, Scerpella EG, Ericsson CD. Contaminated stethoscopes revisited. *Arch Intern Med*. 1996;156(1):82-84.
10. Breathnach AS, Jenkins DR, Pedler SJ. Stethoscopes as possible vectors of infection by staphylococci. *BMJ*. 1992;305(6868):1573-1574.
11. Garner TK, Rimland D. Stethoscopes and infections. *JAMA*. 1982;248(3):310.
12. Gerken A, Cavanagh S, Winner HI. Infection hazard from stethoscopes in hospital. *Lancet*. 1972;1(7762):1214-1215.
13. Lecat P, Cropp E, McCord G, Haller NA. Ethanol-based cleanser versus isopropyl alcohol to decontaminate stethoscopes. *Am J Infect Control*. 2009;37(3):241-243.
14. Tang PH, Worster A, Srigley JA, Main CL. Examination of staphylococcal stethoscope contamination in the emergency department (pilot) study (EXSSCITED pilot study). *CJEM*. 2011;13(4):239-244.
15. Kerr JR, Martin H, Chadwick MV, Edwards A, Hodson ME, Geddes DM. Evidence against transmission of Pseudomonas aeruginosa by hands and stethoscopes in a cystic fibrosis unit. *J Hosp Infect*. 2002;50(4):324-326.
16. Youngster I, Berkovitch M, Heyman E, Lazarovitch Z, Goldman M. The stethoscope as a vector of infectious diseases in the paediatric division. *Acta Paediatr*. 2008;97(9):1253-1255.
17. Cohen SR, McCormack DJ, Youkhana A, Wall R. Bacterial colonization of stethoscopes and the effect of cleaning. *J Hosp Infect*. 2003;55(3):236-237.
18. Guinto CH, Bottone EJ, Raffalli JT, Montecalvo MA, Wormser GP. Evaluation of dedicated stethoscopes as a potential source of nosocomial pathogens. *Am J Infect Control*. 2002;30(8):499-502.
19. Cohen HA, Amir J, Matalon A, Mayan R, Beni S, Barzilai A. Stethoscopes and otoscopes—a potential vector of infection? *Fam Pract*. 1997;14(6):446-449.
20. Sengupta S, Sirkar A, Shivananda PG. Stethoscopes and nosocomial infection. *Indian J Pediatr*. 2000;67(3):197-199.
21. Wood MW, Lund RC, Stevenson KB. Bacterial contamination of stethoscopes with antimicrobial diaphragm covers. *Am J Infect Control*. 2007;35(4):263-266.
22. Bernard L, Kereveur A, Durand D, et al. Bacterial contamination of hospital physicians' stethoscopes. *Infect Control Hosp Epidemiol*. 1999;20(9):626-628.
23. Fenelon L, Holcroft L, Waters N. Contamination of stethoscopes with MRSA and current disinfection practices. *J Hosp Infect*. 2009;71(4):376-378.
24. Muniz J, Sethi RK, Zaghi J, Ziniel SI, Sandora TJ. Predictors of stethoscope disinfection among pediatric health care providers. *Am J Infect Control*. 2012;40(10):922-925.