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Community-associated methicillin-resistant Staphylococcus aureus prevalence: How common is it?
A methodological comparison of prevalence ascertainment

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Background: Community-associated methicillin-resistant Staphylococcus aureus (CA-MRSA) infections are becoming increasingly prevalent. There is geographic variation in their reported prevalence across the United States; however, studies reporting on CA-MRSA prevalence also demonstrate great variability in their case-finding methodology. We conducted a study to see how three different methods to ascertain CA-MRSA prevalence would lead to different estimates.

Methods: Different methods were used to identify cases of CA-MRSA colonization and/or infection in New York City. Method 1: retrospective review of clinical and surveillance cultures identified through a hospital computer database. Method 2: prospective collection of surveillance cultures in the same hospital’s emergency department. Method 3: prospective collection of surveillance cultures in a community setting.

Results: Differing values for CA-MRSA prevalence resulted depending on the method and denominator used. All nares cultures as the denominator led to prevalence estimates of 0.3%-0.6%; all S. aureus as the denominator led to rates of 1.2%-5%; all MRSA as the denominator led to estimates of 5.5%-50%.

Conclusions: A comparison of three methods revealed that variability in case-finding methodologies can lead to different prevalence estimates. Key factors to consider when comparing CA-MRSA rates include the definition of CA-MRSA, choice of denominator, and method and setting of sample collection. (Am J Infect Control 2007;35:359-66.)

Reported prevalence estimates of community-associated methicillin-resistant Staphylococcus aureus (CA-MRSA) vary widely, even within the United States.1-19 When comparing prevalence estimates from study to study, one very basic challenge has been the lack of a uniform case definition for CA-MRSA; existing studies have used a wide variety of CA-MRSA definitions. Moreover, while there appear to be true geographic differences in CA-MRSA prevalence, these may also be enhanced or distorted by methodological variability between studies. Key factors include both the choice of a denominator in reporting prevalence estimates and the methodologies used to identify cases (the numerator). Given the variability in published CA-MRSA rates and the multiplicity of factors that can affect a prevalence estimate, we conducted a methodological comparison of three different approaches to collecting data on CA-MRSA colonization and/or infection in the same geographic locale in northern Manhattan, New York City, in order to assess differences in prevalence estimates.

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METHODS

We estimated the prevalence of CA-MRSA infection and/or colonization in northern Manhattan, New York City, using three different methods.

Method 1 (hospital microbiology)

This was a nonoutbreak, retrospective review of clinical and surveillance cultures performed in a health care setting.

We performed a computer-assisted query of Columbia University Medical Center (CUMC)’s clinical data warehouse to identify all MRSA isolates. The clinical data warehouse includes all microbiological data obtained from CUMC, a large academic medical center with three hospitals and numerous associated outpatient clinics. The health care facilities encompass adult and pediatric patient populations and include community as well as tertiary referral centers. We requested an examination of the microbiological data over a 6-month period (April 1, 2004–September 30, 2004) for all cultures positive for S. aureus. These cultures represented all CUMC clinical cultures as well as nasal cultures sent for surveillance purposes. At CUMC, active surveillance for MRSA is performed in four out of eight intensive care units. These data were then divided into methicillin-susceptible S. aureus and MRSA by their susceptibility to oxacillin: MRSA was defined by the clinical microbiology laboratory as a S. aureus with an MIC >4 mcg methicillin/mL, as determined by MicroScan (Dade Behring, West Sacramento, CA) and oxacillin screen backup plating. Antibiotic susceptibility testing was performed by MicroScan against eight nonbeta-lactam antibiotics: trimethoprim-sulfamethoxazole, rifampin, vancomycin, erythromycin, clindamycin, gentamicin, ciprofloxacin, and levofloxacin.

An MRSA isolate was then provisionally categorized as possible CA-MRSA if it was susceptible to clindamycin, levofloxacin, and ciprofloxacin. This antibiotic susceptibility profile was selected based on observations of our institutional isolates, as well as those reported in the literature. The computer query also subdivided the isolates by specimen site. Based on our initial results from this “possible CA-MRSA” categorization, additional analysis was conducted to assess correlation of antimicrobial susceptibility profiles with staphylococcal chromosomal cassette (SCC) mec type. Hence, a convenience sample of available MRSA isolates identified by the computer-assisted query from February 2004–March 2005 were analyzed by SCCmec typing by multiplex polymerase chain reaction (PCR). A different time period was used for this analysis in order to maximize the number of samples still available for this additional testing. We also assessed the total number of antibiotics to which MRSA isolates with SCCmec type IV were susceptible.

For this assessment, samples from blood, wound, respiratory, and nares sites were included.

Method 2 (emergency department)

This was a nonoutbreak prospective survey of surveillance cultures in a health care setting.

A convenience sample of adult patients who came to the emergency department (ED) of CUMC was screened for MRSA nares colonization. From February to June 2004, 156 patients in the CUMC ED were prospectively enrolled. ED patients who were undergoing medical evaluation were approached and asked to participate in the study. Patients were eligible if they were over the age of 18. Patients were not eligible if they were too physically or mentally ill to provide full informed consent. A research assistant administered a 10- to 15-minute questionnaire in English or Spanish regarding overall health and risk factors for MRSA acquisition. Then a culture of the anterior nares was obtained.

Specimens were plated onto mannitol salt agar (Becton-Dickinson, Sparks, MD); if there was apparent S. aureus growth, the isolates were subcultured to blood agar plates, and colonies were tested using Staphaurex (Remel, Lenexa, KS) for confirmation. Kirby-Bauer disk diffusion (Becton-Dickinson BBL) was used to test antibiotic susceptibilities of all positive S. aureus isolates. Finally, multiplex PCR was used for SCCmec typing.

Method 3 (community)

This was a nonoutbreak prospective survey of surveillance cultures in a community setting.

As part of a Centers of Disease Control and Prevention–funded study, the cross-sectional prevalence of CA-MRSA in northern Manhattan was ascertained. Our target population was individuals living in northern Manhattan, defined as Manhattan addresses north of 145th Street. Random digit dialing was used to identify potential subjects. This entailed purchasing targeted lists of random digit dial telephone numbers from GENESYS Sampling Systems (Fort Washington, PA); computer programs were used to filter these numbers to eliminate nonworking and nonresidential numbers and to focus on the zip codes of interest.

Research assistants called numbers from this list and solicited participation in English or Spanish. If the subject agreed, the assistant visited the subject’s home and administered a 10- to 30-minute detailed questionnaire regarding health, activities, and potential risk factors for MRSA acquisition for the subject and for any other members in the household. Cultures of the anterior nares were obtained from the subject and from any other household members who consented. Additionally, swabs were taken from any open wounds.
All swabs were transported to the research laboratory where microbiological and molecular testing were performed as described in method 2.

For methods 2 and 3, SCCmec type IV was used as the biologic marker to identify CA-MRSA. Studies were approved by the CUMC Institutional Review Board.

Definitions and statistical analysis

CA-MRSA was defined as MRSA carrying SCCmec type IV for methods 2 and 3. In method 1, because it was not possible to perform mec typing for all (>1000) MRSA isolates received by the clinical microbiology laboratory, MRSA was instead categorized as possible CA-MRSA if susceptible to clindamycin, levofloxacin, and ciprofloxacin.

Different prevalence estimates were obtained using different denominators. Population prevalence was defined as CA-MRSA as a percent of all collected nares samples. CA-MRSA/S. aureus prevalence was defined as CA-MRSA as a percent of all S. aureus. Finally, CA-MRSA/MRSA prevalence was defined as CA-MRSA as a percent of all MRSA isolates. Prevalence estimates and antibiotic susceptibilities were compared by chi-square analysis.

RESULTS

Comparison of CA-MRSA prevalence by specimen site (method 1)

By method 1 (hospital microbiology), there were 3022 S. aureus isolates identified from the clinical microbiology laboratory during the 6-month period, of which 1087 (36%) were MRSA. Of these, 97 matched the defined antimicrobial susceptibility profile and thereby fell into the possible CA-MRSA category (Fig 1).

Fig 1. Method 1 (hospital microbiology)—determining CA-MRSA prevalence. S. aureus isolates from method 1 were categorized by antibiotic susceptibilities. MRSA susceptible to ciprofloxacin (C), levofloxacin (L), and clindamycin (C) were defined provisionally as “possible CA-MRSA.” 3022 S. aureus isolates were identified from the clinical microbiology laboratory during the 6-month period, of which 1087 were MRSA. Of these, 97 matched the defined antimicrobial susceptibility profile and thereby fell into the possible CA-MRSA category.
Table 1. Method 1 (hospital microbiology)—comparison of CA-MRSA prevalence by specimen site

<table>
<thead>
<tr>
<th>Specimen type</th>
<th>CA-MRSA/S. aureus Prevalence (CA-MRSA as % of all SA)</th>
<th>CA-MRSA/MRSA Prevalence (CA-MRSA as % of all MRSA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All specimens</td>
<td>3.2% (97/3022)</td>
<td>8.9% (97/1087)</td>
</tr>
<tr>
<td>Skin/soft tissue</td>
<td>7.8% (58/736)</td>
<td>22.8% (58/254)</td>
</tr>
<tr>
<td>Nares</td>
<td>2.1% (11/530)</td>
<td>5.5% (11/200)</td>
</tr>
<tr>
<td></td>
<td>(P^* \leq .001)</td>
<td>(P^1 \leq .001)</td>
</tr>
</tbody>
</table>

\(P^*\) denotes a \(P\)-value comparing CA-MRSA/S. aureus rates across different specimen sites. \(P^1\) denotes a \(P\)-value comparing CA-MRSA/MRSA prevalence rates across different specimen sites.

Thus, we performed SCCmec typing on all available MRSA isolates from February 2004–March 2005 (Fig 2). Out of this convenience sample of 106 MRSA isolates, 23 fell into the “possible CA-MRSA” category, of which all but 1 carried SCCmec type IV. However, 44 of the 83 MRSA in the other category also carried SCCmec type IV. Hence, if we were comparing it against the SCCmec type, our antibiotic susceptibility definition would have a sensitivity of 33% and a specificity of 97.5%, thus leading to an underestimation of CA-MRSA as we defined it.

In looking for another antibiotic susceptibility pattern to correlate with SCCmec type IV, we also assessed the total number of antibiotics to which MRSA isolates were susceptible. Out of 95 MRSA isolates, the median number of susceptible nonbeta-lactam antibiotics for these isolates was 5 (out of the 8 nonbeta-lactam antibiotics tested) for MRSA with SCCmec type IV and 4 for other SCCmec types. If SCCmec typing is considered the “gold standard” for defining CA-MRSA, then a definition of CA-MRSA as MRSA susceptible to 5 or more nonbeta-lactam antibiotics had a sensitivity of 79% and a specificity of 85%. An alternative definition of CA-MRSA as MRSA susceptible to 4 or more nonbeta-lactam antibiotics had a sensitivity of 95% and a specificity of 12%. Finally, percent susceptibilities to individual antibiotics were compared between SCCmec type IV and other SCCmec types (Table 2). Antibiotics to which percent susceptibilities were significantly higher in isolates with SCCmec type IV were erythromycin, clindamycin, ciprofloxacin, and levofloxacin (\(P < 0.05\)).

Comparison of CA-MRSA nares prevalence across three methods

When comparing CA-MRSA prevalence for staphylococcal colonization across methods (Table 3), population prevalence was 0.6% (1 out of 156 samples) for method 2 (ED) and 0.3% (2 out of 739 samples) for method 3 (community); this difference was not statistically significant (\(P = 0.47\)). There was also no significant discrepancy between CA-MRSA S. aureus prevalence when calculated by the three methods (\(P = 0.45\)). However, CA-MRSA/MRSA prevalence varied significantly, from 5.5% in method 1 to 50% in method 3 (\(P \leq .001\)), although it should be noted that total numbers of CA-MRSA were low in methods 2 and 3.

DISCUSSION

More so than with other infectious pathogens, there has been considerable diversity in reports regarding the prevalence of CA-MRSA.1-18 Our study is illustrative of the different ways in which CA-MRSA prevalence can be evaluated within the same geographic area. Three main issues lead to variability in CA-MRSA prevalence, both in our study and in general, and should be considered when comparing prevalence estimates in the literature: (1) the definition of CA-MRSA, (2) the choice of denominator for prevalence calculations, and (3) the method and setting of sample collection. The following discussion of these issues illuminates the epidemiologic issues that arise with CA-MRSA and many other infectious organisms.

Definition of CA-MRSA

The definition of CA-MRSA has been a moving target since it was first recognized and has become increasingly problematic. Presence or absence of risk factors,8 antibiotic susceptibility patterns,7,8,12,23 and molecular typing23-28 have all been thought to distinguish CA- from health care-associated (HA-) MRSA. At present, the optimum definition of CA-MRSA is unclear, particularly because the very distinction between CA- and HA-MRSA is becoming progressively ambiguous as community strains enter the hospital and vice versa.29-31

In our study, we used SCCmec type IV to identify CA-MRSA in methods 2 and 3, recognizing the limitations of this marker: SCCmec type IV has been described in some HA-MRSA strains as well.32-34 In method 1, we used a specific antibiotic susceptibility profile to define “possible CA-MRSA.” This possible CA-MRSA characterization in method 1 underestimated CA-MRSA (as defined by SCCmec type IV), supporting previous data demonstrating increasing nonbeta-lactam resistance in these strains, particularly to fluoroquinolones.7,8,12 While CA-MRSA isolates remain more susceptible overall to erythromycin, clindamycin, ciprofloxacin, and levofloxacin, the differences from HA-MRSA isolates are not distinct enough to be useful as a means of defining CA-MRSA.

Choice of denominator

Even if common ground regarding a CA-MRSA definition is reached, it is important to note that different
studies use different denominators to calculate CA-MRSA prevalence and that these denominators are not always clearly indicated. Possible denominators include all MRSA-positive patients (CA-MRSA/MRSA prevalence), all *S. aureus*-positive patients (CA-MRSA/*S. aureus* prevalence), and all patients from whom cultures were obtained (population prevalence). In our study, we used all three of these denominators, and this led to differing estimates. For instance, CA-MRSA prevalence from method 3 ranges from 0.27% to 50% depending on the denominator (Table 3).

Somewhat related to denominator issues is the choice of specimen site, which significantly affected prevalence estimates from method 1 \((P < .001)\). The highest CA-MRSA prevalence occurred in skin and soft tissue sites, with the lowest prevalence in nares. It should be noted, however, that the role of nasal colonization in CA-MRSA infections is not yet fully understood and that, unlike for HA-MRSA, nasal colonization may not be a significant antecedent of infection.\(^{35}\)

**Method and setting of sample collection**

In addition to the CA-MRSA definition and denominator choice, the method and setting of sample collection also strongly influence CA-MRSA prevalence estimates, specifically the following factors: (1) outbreak versus nonoutbreak setting, (2) clinical versus surveillance cultures, (3) retrospective versus prospective data collection, and (4) health care setting versus community setting. An examination of the current literature on CA-MRSA prevalence reveals the vast differences in their ascertainment methods.\(^{1,3-10,12,14-17,36}\)

Many studies report on CA-MRSA outbreaks. Any prevalence data collected in such a setting will necessarily be higher than what would be seen in nonoutbreak circumstances. For example, Zinderman et al.\(^{36}\) reported on a 2002 CA-MRSA outbreak in 235 military recruits at a training facility in Virginia. As part of the investigation, surveillance cultures were obtained from the nares of 874 workers at the training facility, and 2.7% were found to be colonized with MRSA. This is higher than what is generally seen in the community (0.8%).\(^{12}\)

Whether a prevalence study includes clinical isolates, surveillance cultures, or both, is also crucial to the interpretation of the results, along with whether the study is looking for prevalence of infection or colonization (or both). Fergie and Purcell\(^{15}\) reviewed data on all MRSA isolates in the computer system of a Texas children’s hospital from 1990–2000 and found 147 cases, of which 47% were determined to be CA-
MRSA. All of these cultures were clinical isolates, so it is plausible that this number is higher than what would have been found among surveillance cultures alone. Similarly, the collection of data retrospectively or prospectively affects the prevalence outcome as well, because in retrospective studies, it is difficult to control the mix of surveillance and clinical isolates in the pool. Finally, the setting where prevalence data are collected is a key determinant of the outcome. Even if data are collected in a nonoutbreak setting prospectively and include surveillance cultures alone, prevalence appears to be higher when the cultures are obtained in a health care setting such as a clinic or emergency room. In a recent meta-analysis of CA-MRSA prevalence, Salgado et al. reviewed seven studies in which cultures were obtained at the time of a hospital admission or outpatient visit and found that the pooled CA-MRSA prevalence was 1.8%; by contrast, when they looked at three studies in which cultures were obtained outside of a health care setting, prevalence was only 0.76%. This distinction may be due to the inherent differences in study populations between the “sick” who present in health care settings and those that are recruited from community settings, the former being at potentially higher risk for developing CA-MRSA infections due to a variety of underlying comorbidities and previous exposures to the health care setting. Hence, even when all other data collection methods are comparable, the setting in which the data are collected changes prevalence estimates.

In our study, method 1 was a retrospective study looking at clinical and surveillance cultures (collectively and separately), collected in a nonoutbreak, health care setting, whereas methods 2 (ED) and 3 (community) were both prospective studies using surveillance cultures only. In method 2, they were collected in a health care setting, while in method 3 they were collected in the community (by visiting people’s homes). These three different methodologies led to significant differences between CA-MRSA/MRSA prevalence estimates, with numbers ranging between 5.5% (for method 1) and 50% (for method 3). However, numbers of CA-MRSA isolates were extremely low in the prospective surveillance studies (one isolate in method 2, two isolates in method 3), making the interpretation of statistically significant differences between results problematic.

Limitations of this study include the general difficulty in defining CA-MRSA and the differing definitions used for the various methods in this study. We feel that, in the absence of a perfect or ideal CA-MRSA definition, SCCmec type IV is the best biologic marker to differentiate CA-MRSA isolates; unfortunately, it was not possible to use this in the CA-MRSA definition in method 1.

| Table 2. Method 1—comparison of percent antibiotic susceptibilities between MRSA isolates with SCCmec type IV and MRSA with other SCCmec types |
|-----------------|-----------------|-----------------|-----------------|
|                 | Susceptibilities to Antibiotics (%) |                 |
|                 | Trimethoprim-sulfamethoxazole | Rifampin | Vancomycin | Erythromycin | Clindamycin | Gentamicin | Ciprofloxacin | Levofloxacin |
| SCCmec type IV  | 93               | 95      | 100      | 20       | 74       | 95       | 39       | 48       |
| (n = 61)        |                 |         |          |          |          |          |          |          |
| SCCmec type II, III (n = 34) | 100 | 94  | 100 | 0  | 15  | 94  | 3  | 3  |
| *P* = ns | *P* = ns | *P* = ns | *P* = .014 | *P* < .0001 | *P* = ns | *P* = .0001 | *P* < .0001 |

*P*-values calculated using chi-square analysis.
ns = not significant.
*P*-value calculated using chi-square analysis with Yates’ correction for low frequencies.

| Table 3. All methods—comparison of CA-MRSA prevalence for nares specimens across all three methodologies |
|-----------------|-----------------|-----------------|
|                 | Population Prevalence (CA-MRSA as % of all obtained nares cultures) | CA-MRSA/S. aureus Prevalence (CA-MRSA as % of all SA) | CA-MRSA/MRSA Prevalence (CA-MRSA as % of all MRSA) |
| Method 1 (Hospital Microbiology) | not applicable | 2.1% (11/530)\* | 5.5% (11/200)\* |
| Method 2 (ED) | 0.6% (1/156)\* | 5% (1/20)\* | 33% (1/3)\* |
| Method 3 (community) | 0.3% (2/739)\* | 1.2% (2/173)\* | 50% (2/4)\* |
| \*P* = .47 | \*P* = .45 | \*P* = .0001 |

*P*-values were calculated using chi-square tests to compare prevalences across different case-finding methodologies.
\*P* denotes a *P*-value comparing CA-MRSA/S. aureus prevalence rates across different case-finding methodologies.
\#P* denotes a *P*-value comparing CA-MRSA/MRSA prevalence rates across different case-finding methodologies.
given the thousands of MRSA isolates at hand. We did attempt to correlate the phenotypic definition used in method 1 to our molecular definition and found that the former underestimated the latter. Future studies evaluating CA-MRSA prevalence may best be served by looking at a particular strain profile such as the USA300 pulsed-field type.57

Outbreak reports involving CA-MRSA create the impression that it is a very common problem. Indeed, in certain areas of the country, it is replacing and supplanting HA-MRSA strains.7,15,58 Before making changes in empiric therapy based on reported prevalence estimates, it is essential that one takes into account the methodological factors discussed above. Moreover, while MRSA may be causing more clinical infections in the community than previously, colonization of the general population still appears to be uncommon. Our community study (method 3) revealed that CA-MRSA is rarely found in a pure community setting, and this finding is supported by recent national data from the NHANES study, in which only 0.8% of 9622 noninstitutionalized subjects were colonized with MRSA.12,39 This suggests that, even when changing empiric therapy to cover CA-MRSA is appropriate, looking for asymptomatic colonization in community individuals may be low-yield.

Thus, we must remain aware of issues such as case definition, denominator, and the case ascertainment methods described above when looking at and comparing CA-MRSA reports and prevalence studies. These issues can be generalized to many infectious organisms, and CA-MRSA can thereby be viewed as a model for the evaluation of prevalence ascertainment for microbiologic pathogens.

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EFY was supported by grant T32 AI49821 from the National Institute of Allergy and Infectious Diseases, National Institutes of Health.

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Resistance of antimicrobial skin preparations to saline rinse using a seeded bacteria model

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Objective: We describe a randomized blinded study to evaluate the antimicrobial persistence following saline exposure of 2 commercially available skin antiseptic agents. One agent contained iodine povacrylex in alcohol and the second contained chlorhexidine gluconate in alcohol.

Method: Both agents were applied to the forearms of 36 healthy subjects according to manufacturers’ instructions and allowed to dry. The sites were then exposed to either a saline rinse or to a saline-saturated gauze, similar to the challenges that preps would face during most surgical procedures. Two analyses were performed: (1) An indicator organism was seeded onto the treated sites. After 30 minutes, samples were collected from the treated sites and surviving bacterial colonies were enumerated and log reductions calculated. (2) The saline-saturated gauze was analyzed chemically for presence of chlorhexidine or iodine.

Results: The baseline densities (stated as logarithms of colony forming units “log CFU”) of the sites to which the agents were applied had statistically equivalent microbial densities. Both agents reduced the density of organisms in a statistically significant manner. Chemical analysis of the gauze samples indicated that 35 of 36 samples had detectable chlorhexidine while no samples had detectable iodine (P < .0001).

Conclusion: The results indicate that chlorhexidine is removed by saline-soaked gauze while the iodine povacrylex water-insoluble film remains intact under the same conditions. The implication is that similar results may occur in surgery when saline is used. (Am J Infect Control 2007;35:367-73.)

Skin antisepsis prior to surgery has been a standard of practice for decades, although clear criteria for the choice of agents and their effects on surgical site infections and wound healing remain unclear.1,6 Iodophors and chlorhexidine gluconate are currently the most commonly used antimicrobial agents in preoperative skin preparation in the United States.7 Water soluble iodophors and chlorhexidine formulations are variably susceptible to inactivation by organic matter (blood and proteins)8,9 and can be removed by saline and/or irrigation fluids.10

The use of wound irrigation fluids, most commonly normal saline, has a long history of use to irrigate the wound, keep the exposed tissue moist, and maintain visibility of the operative site.11,12 A natural question arises as to whether there is an effect of wound irrigation fluids on the ability of a given antiseptic agent to remain on the skin and to remain active throughout the procedure. Because chlorhexidine has shown water solubility, the possibility exists that products based on chlorhexidine may be lost during surgical irrigation. The specific chlorhexidine product used in the present study was ChloraPrep With Tint skin preparation (MediFlex Inc., Leawood, KS), which contains 2% chlorhexidine gluconate in 70% isopropyl alcohol (IPA). The iodine used in the present study was 3M DuraPrep Surgical Solution (3M, St. Paul, MN). It is an iodine povacrylex/alcohol solution with 0.7% available iodine in 74% IPA, which forms a water-insoluble film upon drying. Previous work has indicated that the film retains active antimicrobial activity in a model using seeded bacteria.13

This study compares the persistence of antimicrobial activity of 2 commercially available antiseptic agents against transient organisms (modeled using a marker organism applied to the skin) following exposure to saline irrigation or a saline-soaked sponge, measured by a modification of the American Society for Testing and Materials Standard Test Method for Evaluation of Antibacterial Washes by Scrub Cup Technique.14,15
The primary objective of the study was to evaluate the resistance to wash off of chlorhexidine in a chlorhexidine/alcohol solution compared with iodine in an iodine povacrylex/alcohol solution as measured by antimicrobial activity following contact with saline using a seeded bacteria method. The secondary objective was to determine the removal of chlorhexidine and iodine by the saline-soaked gauze, which was collected after application to the skin at the site of the antiseptic agent. The presence of either antiseptic agent was assessed visually.

METHODS

This was a single-center, blinded, randomized study using a paired comparison design in which each subject received all study materials. Because the investigator could not be blinded to the study materials because of product characteristics, the personnel conducting microbiologic assessments of samples were blinded to the treatment assignments. A local institutional review board reviewed and approved the conduct of this study.

Subject criteria for inclusion/exclusion

The 36 subjects in the study were healthy volunteers of either gender and any race aged 18 to 65 years. Subjects followed study instructions, satisfied inclusion/exclusion criteria, and signed an informed consent statement prior to enrollment. Subjects’ volar forearm requirements were a minimum of 8 inches long; minimal hair; and no evidence of dermatitis, acne, open wounds, or other skin disorders.

Subjects were excluded from the study if they (1) had a history of skin allergies or known sensitivity to natural rubber latex (surgical gloves), medical tape, alcohol, chlorhexidine, propylene glycol (hand lotions and baby wipes), acrylics (adhesive tapes), paraben preservatives (cosmetics), or iodine-containing products; (2) had damaged or altered skin within the volar forearms (including previous skin cancer, sunburn, tattoos, scars, or other disfiguration); (3) had an existing thyroid condition, were diabetic or immunocompromised, had hepatitis or an organ transplant, or were on steroid therapy; (4) had sensitivities to any antibiotic; (5) were exposed to topical or systemic antimicrobial-containing products such as antibacterial soaps, lotions, dandruff shampoos, creams, ointments, perfumes, colognes or aftershave, hot waxes, depilatories, solvents, acids, bases, or other household chemicals; (6) bathed in chemically treated swimming pools and hot tubs or used tanning beds; or (7) were pregnant, thought they may be pregnant, were nursing, or attempting pregnancy.

Surgical simulation (saline treatments), application of marker organism, and bacterial sampling

The volar surfaces of the forearm were randomized to receive either the iodine povacrylex/alcohol solution or the chlorhexidine/alcohol solution, applied according to manufacturer’s directions. To prepare the site, 70% IPA was applied to the forearm and allowed to dry. This step removed normal skin flora that might mask the marker organism. The iodine povacrylex/alcohol solution was applied by painting a uniform coat, starting in the center and working outward, to cover a 2 × 6-inch area (leaving 2 inches unprepped at the wrist). The chlorhexidine/alcohol solution was applied using repeated back and forth strokes for 30 seconds over a contralateral 2 × 6-inch area (leaving 2 inches unprepped at the wrist). Timing of each prep application was recorded. The antiseptic agents were allowed to dry for 10 minutes ± 1 minute before any surgical simulation (ie, saline treatment) occurred.

Each arm had 5 treatment sites: the wrist served as a control for the saline rinse, 3 sites on the volar surface of the forearm were exposed to the antiseptic agent, and an area above the elbow was used as a control for the saline soaked gauze. The schema is summarized in Table 1.

Table 1. Example sampling schema for assessment of antimicrobial agent performance

<table>
<thead>
<tr>
<th>Sample</th>
<th>Site</th>
<th>Antiseptic agent applied?</th>
<th>Saline applied?</th>
<th>Bacteria applied?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wrist</td>
<td>No</td>
<td>Rinse</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>Forearm</td>
<td>Yes</td>
<td>None</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>Forearm</td>
<td>Yes</td>
<td>Rinse</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>Forearm</td>
<td>Yes</td>
<td>Gauze</td>
<td>Yes</td>
</tr>
<tr>
<td>5</td>
<td>Above elbow</td>
<td>No</td>
<td>Gauze</td>
<td>No</td>
</tr>
</tbody>
</table>

Stahl, Morse, and Parks
within the scrub cup. This inoculum was allowed to reside in situ for 30 minutes ± 1 minute. Surviving bacteria were recovered via the cup scrub technique using sampling solution containing sodium thiosulfate, lecithin, and Tween 80 as neutralizers. After all samples were collected, the forearms were decontaminated using 70% IPA and Hibiclens antiseptic skin cleanser (Regent Medical, Norcross, GA). Subjects returned within 4 to 8 days for skin condition observation to ensure no presence of infection.

Chemical testing of saline-saturated gauze

Bleach was added to the skin-contacting surface of the gauze removed from the site on which the chlorhexidine/alcohol solution had been applied. In the same manner, starch was added to the gauze removed from the site on which the iodine povacrylex/alcohol solution had been applied. Both samples were tested within 5 minutes of removal from the skin. A test was interpreted as positive for chlorhexidine when application of bleach resulted in a color change to brown. A test was interpreted as positive for iodine if application of starch resulted in a blue-black color change. Visual assessment was used to determine positivity, and digital images for each sample were created immediately after application of the chemical test substance.

Microbial evaluation methods

Quantitative cultures were obtained from sample sites using the cup scrub method of Williamson and Kligman. In addition to taping the scrub cups to the arm, pressure was exerted onto the wings to prevent leakage of the scrub solution. All samples were collected as follows: Scrub 1: 2.5 mL of Sampling Solution (0.04% KH2PO4, 1.01% Na2HPO4 buffer containing 0.1% Triton X-100, 0.3% lecithin, 3% Tween 80, and 0.1% sodium thiosulfate; pH 7.9 ± 0.1) was aseptically pipetted into the scrub cup. The skin was scrubbed in a circular motion with moderate pressure for 1 minute using a sterile rubber policeman. Using a sterile transfer pipette, the scrub solution was transferred to a sterile collection tube. Scrub 2: The 1-minute scrub solution from both scrubs was pooled into 1 sample tube for a total sample volume of approximately 5 mL per site. The sample tube was vortexed immediately.

A 1.0-mL aliquot of each sample was immediately diluted into sterile tubes containing 9.0 mL phosphate-buffered water (PBW). Serial 10-fold dilutions were performed in PBW; 0.1 mL aliquots of selected dilutions were spread plated in duplicate onto Trypticase Soy Agar containing 4 μg/mL tetracycline. For 100 samples, 1.0-mL aliquots (0.3, 0.3, and 0.4 mL across 5 plates) were plated in duplicate. Samples were plated within 20 minutes of collection. Spread plates were allowed to dry prior to inversion and incubation. After 48 (±4) hours of aerobic incubation at 35°C ± 2°C, surviving colonies were counted, and viable cells in the original sample were calculated using standard methods.

The adequacy and effectiveness of the neutralizer solution were validated prior to study initiation to demonstrate that the neutralizers effectively inactivated any active antimicrobials and exerted no effect on the growth of the marker microorganism (data not shown).

Evaluation criteria

The primary variable measured was the log reduction of the bacterial challenge applied to the prepped/treated surface of the skin. The log reductions were evaluated after both saline treatment and a bacterial residence time of 30 minutes. Log reduction was calculated as the log counts from the recovery control site minus the log counts from each of the prepped/treated sites. Safety was assessed by recording observed and reported adverse events.

Statistical methods

The test laboratory reported raw data from all treatments as average CFU/mL per test site. Log reductions for each condition studied were calculated by subtracting the recovery log count of the treated sample from that of the appropriate untreated recovery control.

A detailed algorithm was used to convert bacterial counts from CFU/mL to CFU/cm2 as follows:

- The CFU/mL data recorded on the case report form (CRF) (eg, 0 or 0.5 CFU/mL) were entered into the database.
- CFU/mL were converted to CFU/cm2 using the following formula: \( \text{CFU/cm}^2 = \frac{\text{CFU/mL} \times 5 \text{mL}}{5.07 \text{ cm}^2} \).
- CFU/cm2 values of <1.0 were programmatically set to 1.0 CFU/cm2 in SAS software (SAS Institute, Cary, NC).
- Log transformations were carried out by applying the \( \log_{10} \) of the values in CFU/cm2.

The paired difference in log reduction between the test products for control, saline rinse, and saline soak sites was calculated for each subject. Significance of the difference in log reduction between treatments was assessed using a paired t test. Significance was assessed at \( \alpha = 0.05 \) (2-sided). In addition, the 95% confidence limits on the paired difference between treatments were calculated. A nonparametric analysis (Wilcoxon signed-rank test) was conducted to verify the results.
The number of gauze samples that were positive for color change was analyzed using the Fisher exact test. Significance was assessed at $\alpha = 0.05$ (2-sided).

**RESULTS**

Thirty-six subjects were enrolled in the study. Among these subjects, 44.4% (16/36) were females, 55.6% (20/36) were male. The distribution of race was 94.4% (34/36) white, 2.8% (1/36) African American, and 2.8% (1/36) Asian. The mean (standard deviation) for the numerical demographic variables were: age, 36.6 (13.12) years; height, 5.72 (0.38) feet; and weight, 183.7 (55.23) lb. No adverse events occurred in this study.

Only randomized subjects who had at least 1 pair of efficacy measurements from the iodine povacrylex/alcohol solution and the chlorhexidine/alcohol solution were considered evaluable. Two subjects (No. 25 and No. 29) had missing efficacy data. Because the design of the study was paired, if the data from a treatment pair were not available, the data from a single treatment were not included in the analysis. For this reason, 34 subjects were evaluated for efficacy for log reduction for prepped control, and 35 subjects were evaluated for efficacy for log reduction of saline soak and saline rinse.

The log counts recovered from the control site were compared. The counts were statistically equivalent between treatment groups ($P = .222$). The posttreatment log counts recovered at each treatment site are summarized in Table 2.

The log-count reduction data are summarized for each prep and treatment in Table 3. These data are also shown graphically in Fig 1. The log reductions were compared between the antiseptic agents for each of the 3 treatment types (control, saline soak, and saline rinse). The iodine povacrylex/alcohol solution had a log reduction that was statistically higher than the chlorhexidine/alcohol solution for the saline soak condition ($P = .006$ for the paired $t$ test and $P = .005$ for the Wilcoxon signed-rank test). The log reductions were not statistically different between the treatments for the other 2 conditions ($P$ value $= .756$ using a paired $t$ test for the prepped control condition, $P$ value $= .275$ using a paired $t$ test for the saline rinse condition). The paired differences in log reduction along with the 95% confidence limits are given in Table 4.
The chemical testing indicated that the iodine in the iodine povacrylex film was not removed by saline-soaked gauze (Fig 2). None of the gauze samples from 36 iodine povacrylex/alcohol solution-treated sites showed visible color, whereas 35 of 36 gauze samples from the chlorhexidine/alcohol solution-treated sites exhibited a visible brown color, indicating presence of chlorhexidine gluconate (Fig 3). One gauze sample from a chlorhexidine/alcohol solution-treated site was inadvertently discarded before chemical testing could

**Fig 2.** Iodine povacrylex/alcohol solution gauze after starch test for presence of iodine.

**Fig 3.** CHG/alcohol solution gauze after bleach test for presence of chlorhexidine.
be conducted. The $P$ value using the Fisher exact test is

< .0001.

**DISCUSSION**

The testing performed to address persistence of antiseptic agents is based on national guidelines, and these guidelines do not mandate the use of rinse fluids. The current study was designed to examine one aspect of persistence measured by susceptibility to saline rinse. We have demonstrated that saline removes chlorhexidine from the skin following its application, and this removal is reflected in a decreased effectiveness of the chlorhexidine to kill seeded bacteria. The reduction in effectiveness is greater with saline-soaked gauze than with a saline rinse. By comparison, the iodine in the iodine povacrylex film demonstrated a statistically significant difference in the ability to maintain bactericidal activity, and no removal of iodine could be demonstrated.

Chlorhexidine is known as a persistent antiseptic agent, and it has been widely accepted for surgical hand antisepsis and as a skin antiseptic agent for intravenous catheter insertion and care and blood culture collection. Chlorhexidine is recommended by the Centers for Disease Control and Prevention to prevent catheter-related bloodstream infections.16 By extension, the use of chlorhexidine as a preoperative antiseptic agent also has gained momentum. However, there are no scientific data that support the use of one antimicrobial over another1-17 in the preoperative setting.21 Likewise, it is often stated that iodophors have little or no persistent activity. These data are based on surgical hand scrub studies in which the iodophor is washed away.21 In patient antiseptic preparation studies in which the iodophor remains on the skin, iodophors have been shown to have comparable persistent activity to chlorhexidine.22,23 This may be why the CDC Guideline for the Prevention of Surgical Site Infection does not recommend one antimicrobial agent over another for preoperative patient prepping.

The literature on chlorhexidine inactivation by “organic matter” is mixed, and the variability in the literature reflects, in part, the inability to describe a fixed composition of “organic matter.” Although there is evidence in the literature10 that chlorhexidine is inactivated by saline, our study was not designed to investigate chlorhexidine inactivation. However, we were able to demonstrate visually that chlorhexidine is removed by saline-saturated gauze and by inference suggest that chlorhexidine could also be removed by a saline rinse, but we are unable to address whether this is accompanied by inactivation of the remaining antiseptic.

Because there is no standardized method for surgical rinse, nor any standard surgical rinse fluid, there are no objective guidelines against which to compare the present study. However, empirically, saline is commonly used as either a rinse or a major component of a rinse fluid, so the use of saline carries a sense of realism, albeit operationally. The practice of surgical rinsing is believed to reduce contamination by bacteria, by other microorganisms, and by malignant cells that might have been removed from a primary lesion during excision or biopsy. That the present study incorporated a saline challenge implies that it resembled more closely the surgical environment than in other studies in which no fluid challenge was provided. Patient exposure to fluids in the form of irrigation or saline-saturated sponges differs considerably from those situations encountered in intravenous line placement and in blood collection. The reality of removal of water-soluble skin preps by irrigation fluids, wet gauze, or dry gauze sponges during surgery has the potential to impact negatively the antimicrobial persistence of the skin prep as demonstrated by the data from this study. Although the differences were statistically significant, their absolute values were small. Therefore, differences at this level may only achieve clinical significance when a small inoculum is capable of causing significant morbidity, eg, in the case of implanted devices.18-20 Until definitive prospective studies clearly define a superior antiseptic agent and antiseptic process, the choice of agent will require consideration not only of the infection risk resulting from patient factors and virulence components but also whether removal of these agents as a result of standard therapy is an acceptable risk.

**CONCLUSION**

The study was conducted to determine the effects of saline as a rinse or soak on the persistent activity of skin antiseptic agents using a seeded bacteria method. The iodine povacrylex/alcohol solution had significantly higher log reductions of seeded bacteria compared with the chlorhexidine/alcohol solution for the saline-soak condition ($P = .006$). The chemical testing results indicated that the iodine in the iodine povacrylex water-insoluble film was more resistant to removal by saline-soaked gauze than the chlorhexidine/alcohol solution ($P < .0001$). Chlorhexidine from the chlorhexidine/alcohol solution was removed from the application site in 35 of 36 subjects, whereas the iodine in the iodine povacrylex film was removed in 0 of 36 subjects.

**References**

Disaster preparedness lessons learned and future directions for education: Results from focus groups conducted at the 2006 APIC Conference

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St. Louis, Missouri; Bethesda, Maryland; and Louisville, Kentucky

Background: Infection control professionals (ICP) who have experienced disaster response have not been assessed in terms of the lessons they have learned, gaps they perceive in disaster preparedness, and their perceived priorities for future emergency response training.

Methods: Focus groups were conducted at the APIC 2006 Conference to evaluate ICPs’ perceived needs related to disaster planning topics, products they feel are needed for education and reference materials, and lessons learned from past disasters.

Results: ICPs’ role in disaster preparedness and response is essential, even in noninfectious disease emergencies. Infection control issues in shelters, such as overcrowding, foodborne illness, lack of restroom facilities, inadequate environmental cleaning procedures and products, difficulty assessing disease outbreaks in shelters, inability to isolate potentially contagious patients, and too few hand hygiene supplies can contribute to secondary disease transmission. Other important topics on which ICPs need to be trained include surge capacity, employee health and safety, incident command system, educating responders and the public on disaster preparedness, addressing changing standards/recommendations, and partnering with public health. ICPs need quick reference materials, such as checklists, templates, tool kits, and algorithms to better equip them for disaster response.

Conclusion: Infection control must continue to partner with public health and other responding agencies to address gaps in disaster planning. (Am J Infect Control 2007;35:374-81.)

In 2005, the United States experienced 5 disasters that cost more than $1 billion each in damages and made it the second highest year in terms of the number of natural disasters occurring in a single year.1 Similar experiences have occurred around the world in the past few years. Natural environmental disasters, such as Hurricane Katrina in the United States and the tsunami in Asia; infectious disease disasters, such as the 2001 anthrax bioterrorism incident in the United States; plus the outbreak of severe acute respiratory syndrome (SARS) in Canada and other countries have illustrated the tremendous medical, social, and economic impact a disaster can have on any country.

Historically, infection control professionals (ICP) have responded to health care-associated infections and public health infectious disease outbreaks. Beginning in the late 1990s, many ICPs expanded their role to become involved in bioterrorism preparedness planning.2 Some recent disasters occurring in the early 21st Century, such as SARS and Hurricane Katrina, have illustrated the importance of ICPs becoming involved in planning and response for all types of disasters to decrease secondary morbidity and mortality. ICPs who have experienced disaster response have not been assessed in terms of the lessons they have learned, gaps they perceive in disaster preparedness, and their perceived priorities for future emergency response training. These ICPs’ experiences should be assessed, and their lessons learned should be incorporated into development of reference materials and future training for ICPs.

The purpose of this study was to evaluate ICPs’ perceived needs related to disaster planning topics and products required for education and reference materials. Specific aims of the needs assessment included
the following: (1) to determine disaster-related education products or reference materials, (2) to prioritize disaster preparedness topics for future ICP training and reference materials, and (3) to determine lessons learned from past disasters.

METHODS

The authors developed the questions for this study. All members of the Association for Professionals in Infection Control and Epidemiology, Inc. (APIC) who were registered for the 2006 National APIC conference were invited to participate in the focus groups, regardless of age, race, gender, or work location (within or outside the United States). The only inclusion criteria were attendance at the 2006 APIC conference and participation in a disaster response in the past.

The authors recruited potential participants via phone calls and e-mail. One focus group met each day in a meeting room located in a hotel near the conference site on June 11, 12, and 13, 2006. A meal was provided to the participants as an incentive for their participation. The Nominal Group Method was used to elicit information on the topics of interest. The focus group method of using opening-ended questions was used to elicit details from participants’ experience with disaster response as to why those categories were chosen and lessons learned from past disasters.

Participants were informed that information collected would remain anonymous and that all responses were voluntary. Focus group sessions were audiotaped, and the tapes were transcribed verbatim. Content analysis included identifying, coding, and categorizing participants’ response to the questions of interest. In addition, major themes that emerged were identified and categorized. Quotations that characterize the major themes are reported. The words enclosed in brackets of the quotations are used to explain the respondents’ quotes and are not the participants’ words. Subjects’ demographic data were obtained for descriptive statistics. The institutional review boards of St. Louis University, National Naval Medical Center, and University of Louisville approved this study. APIC Headquarters funded the costs of the focus groups and audiotape transcription.

RESULTS

All 2035 individuals registered for the APIC 2006 Annual Educational Conference were contacted. Thirty-two participants took part in the 3 focus groups: the first focus group had 15 participants, the second had 6, and the third had 11. A description of the participants’ demographic characteristics is reported in Table 1. Focus group participants reported that they resided in

<table>
<thead>
<tr>
<th>Type of disaster to which participant responded</th>
<th>N (n (%))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power outage</td>
<td>17 (53.1)</td>
</tr>
<tr>
<td>Hurricane</td>
<td>16 (50.0)</td>
</tr>
<tr>
<td>Anthrax 2001 bioterrorism incident</td>
<td>10 (31.3)</td>
</tr>
<tr>
<td>Flood</td>
<td>10 (31.3)</td>
</tr>
<tr>
<td>Emerging infectious disease outbreak</td>
<td>9 (28.1)</td>
</tr>
<tr>
<td>Fire</td>
<td>7 (21.9)</td>
</tr>
<tr>
<td>Airplane or multicar crash</td>
<td>4 (12.5)</td>
</tr>
<tr>
<td>September 11, 2001, terrorist events</td>
<td>3 (9.4)</td>
</tr>
<tr>
<td>Bombing</td>
<td>2 (6.3)</td>
</tr>
<tr>
<td>Building collapse</td>
<td>2 (6.3)</td>
</tr>
<tr>
<td>Earthquake</td>
<td>2 (6.3)</td>
</tr>
<tr>
<td>Tsunami</td>
<td>1 (3.1)</td>
</tr>
<tr>
<td>Other</td>
<td>3 (9.4)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Work setting</th>
<th>N (n (%))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital</td>
<td>22 (68.8)</td>
</tr>
<tr>
<td>Public health</td>
<td>4 (12.5)</td>
</tr>
<tr>
<td>Other</td>
<td>6 (18.8)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hospital bed size</th>
<th>N (n (%))</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤100 beds</td>
<td>1 (4.5)</td>
</tr>
<tr>
<td>101–250 beds</td>
<td>4 (18.2)</td>
</tr>
<tr>
<td>251–500 beds</td>
<td>12 (54.5)</td>
</tr>
<tr>
<td>501–1000 beds</td>
<td>2 (9.1)</td>
</tr>
<tr>
<td>≥1001 beds</td>
<td>3 (13.6)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sex</th>
<th>N (n (%))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>29 (90.6)</td>
</tr>
<tr>
<td>Male</td>
<td>3 (9.4)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Age, yr</th>
<th>N (n (%))</th>
</tr>
</thead>
<tbody>
<tr>
<td>30–39</td>
<td>2 (6.3)</td>
</tr>
<tr>
<td>40–49</td>
<td>6 (18.8)</td>
</tr>
<tr>
<td>50–59</td>
<td>14 (43.8)</td>
</tr>
<tr>
<td>60–69</td>
<td>10 (31.3)</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Highest education level</th>
<th>N (n (%))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Associate’s degree</td>
<td>1 (3.1)</td>
</tr>
<tr>
<td>Bachelor’s degree</td>
<td>14 (43.8)</td>
</tr>
<tr>
<td>Master’s degree</td>
<td>16 (50)</td>
</tr>
<tr>
<td>PhD</td>
<td>1 (3.1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Employer type*</th>
<th>N (n (%))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not-for-profit</td>
<td>15 (46.9)</td>
</tr>
<tr>
<td>Government</td>
<td>11 (34.4)</td>
</tr>
<tr>
<td>For profit (private)</td>
<td>8 (25)</td>
</tr>
<tr>
<td>Other</td>
<td>1 (3.1)</td>
</tr>
</tbody>
</table>

*Participants could choose more than one option for this question.

15 states from across the United States; 2 participants were from Canada, and 1 participant has worked in multiple countries. Twenty-five participants (78.1%) are certified in infection control. The participants reported that they had been involved in responding to a variety of types of disasters ranging from power outages and floods to terrorism and infectious disease emergencies; most (75%, n = 24) had been involved in the response to multiple events.

The participants identified many types of education products/reference materials needed for future disaster response and disaster preparedness education topics on which the participants believed that ICPs
need to be trained. The education products that received the most votes during the Nominal Group Method portion of the focus groups are outlined in Table 2. The education topics that received the most votes during the Nominal Group Method portion of the focus groups are outlined in Table 3. In addition, a number of themes emerged from the focus groups related to emergency preparedness issues encountered in previous disasters.

**Table 2. Education products/reference materials needed for future disaster response**

<table>
<thead>
<tr>
<th>Topics that require development into quick reference materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infection control preparedness needs by department</td>
</tr>
<tr>
<td>Personal protective equipment requirements for disasters</td>
</tr>
<tr>
<td>(signage, just-in-time training, fit testing, alternatives)</td>
</tr>
<tr>
<td>Supplies needed for disaster response</td>
</tr>
<tr>
<td>Immunizations specific to disasters</td>
</tr>
<tr>
<td>Infection control needs related to disasters</td>
</tr>
<tr>
<td>Infection control for shelters</td>
</tr>
<tr>
<td>First aid</td>
</tr>
<tr>
<td>Incident Command System (ICS) job action sheets</td>
</tr>
<tr>
<td>Infectious disease identification software and paper versions that include treatment and management information</td>
</tr>
<tr>
<td>Environmental decontamination</td>
</tr>
<tr>
<td>Management of patients and facilities in a bioevent</td>
</tr>
<tr>
<td>Types of quick reference tools/materials needed</td>
</tr>
<tr>
<td>Planning templates with supply lists</td>
</tr>
<tr>
<td>Templates for tiered contact information</td>
</tr>
<tr>
<td>Checklists, “cookbook”/tool kit tools</td>
</tr>
<tr>
<td>Scenarios with solutions/algorithms</td>
</tr>
<tr>
<td>Planning chart</td>
</tr>
<tr>
<td>Bullet-style flyers</td>
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<tr>
<td>Pocket-sized references</td>
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<td>Drug reference book</td>
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<tr>
<td>Handheld personal digital/data assistants (PDA) that do not require electricity</td>
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<tr>
<td>The Red Book (ie, pediatric infectious disease reference book)</td>
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<tr>
<td>Infectious/communicable disease reference book</td>
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Infection control issues in community-based shelters

One of the most frequently cited topics of importance to disaster planning was the need for better infection control in community-based shelters. Focus group participants from a variety of types of disasters indicated that infection control was lacking in crowded shelters and that this contributed to secondary disease transmission.

“Infected control in shelters is important. We had a child in a shelter in Alabama, not Hurricane Katrina, but prior to that, with meningitis, and they’d been there for several hours, and no one realized they had been there. We needed fast treatment [to prevent secondary spread]... and there were outbreaks of diarrhea [in the shelters].”

Focus group participants listed some specific infection control issues that must be addressed in shelters, such as overcrowding, foodborne illness, lack of restroom facilities, inadequate environmental cleaning procedures and products, difficulty assessing disease outbreaks in shelters, inability to isolate potentially contagious patients, and too few hand hygiene supplies. By far, lack of hand hygiene supplies or the inability to perform hand hygiene was the most frequently cited infection control issue in community-based shelters. ICPs recommended that disaster planners arrange to have a dedicated individual(s) for hand hygiene and infection control in alternate care sites:

“‘When they set up these shelters, they really don’t have any idea about what they’re going to do for hundreds and hundreds of people [to accommodate] handwashing and [provide] restroom facilities.’”

Focus group participants listed some specific infection control issues that must be addressed in shelters. Focus group participants listed some specific infection control issues that must be addressed in shelters. Focus group participants listed some specific infection control issues that must be addressed in shelters. Focus group participants listed some specific infection control issues that must be addressed in shelters.

“‘[In disasters] there ought to be people that are just responsible for hand hygiene. I know we talk about it in the hospitals, and we push it, push it, push it, but really in a disaster... hand hygiene is probably the most important thing.’”
Real-time assessments and surveillance

ICPs stressed the need to perform real-time assessments during disaster response, including general disaster response needs as well as disease surveillance.

“In shelters and out in the community, [you need to] go and see: do they need food, do they need child care, do they need deceased care? You know, what do they need? Do they need an ambulance to get someone to a higher level of care?”

“You have to come up with a list of what everyone needs to run a clinic. How many bottles of disinfectant do we need, how are you going to mix it, where are you going to store it?”

ICPs also discussed the difficulty in assessing disease outbreaks during disaster response, even in non-infectious disease emergencies.

“You know the thing about disasters is that you see a lot of diseases that you don’t get normally.”

“One of the major problems I had immediately post Hurricane-Katrina, was trying to assess exactly what were my problems, because I was trying to [assess] all these ER [emergency room] patients, through the influx.”

“Surveillance... has to be on-going. For us, we had 4200 evacuees from New Orleans that came [to our area], and, very shortly after they came, we started experiencing gastroenteritis among them. It spread into the health care workers,... the people who were managing the clinic, the evacuation center. [We needed] to dig out from what the surveillance told us [about what was going on] and try to get everybody back on track.”

Surge capacity

Many focus group participants stated that they and their hospital/facility are “extremely concerned about surge capacity.”

“Well, for [our area], hospitals are already at capacity. There’s not a hospital in my city that has the room to take people into if there’s a disaster.”

“We were a small hospital, and we literally had to go into lockdown [after the disaster struck]. We had to be conservative in who we took; otherwise, we would not have been available at all.”

Staff surge capacity

One component of surge capacity that was stressed was staff surge capacity or the ability of a facility to have sufficient numbers of staff to handle an influx of patients. Comments such as “staffing is going to be a major issue” illustrated the importance of this issue to participants. The number of available staff was mentioned as contributing to a facility’s ability to stay open and provide patient care or halt routine procedures to accommodate disaster victims.

“The biggest [problem] I’ve seen [after a disaster hits]—and I’ve responded to many different kinds [of disasters]—is the staff wanting to leave. So your facility staff has just gone home to do something for their home, or to be with their family, and your nurses are trying to get out the doors, and only a basic crew is remaining... so how do you continue with your current, everyday operations when your staff just left?”

“[Surge capacity is] a big issue because we’ve got to switch over to responding to the disaster and then which of our routine services can we stop, and when do we need to restart those services?”

The issue of staff surge capacity was most evident in infectious disease disasters, such as the 2003 SARS outbreak.

“Lack of staff [during the SARS outbreak] was a [major issue], because staff didn’t want to come in... because nobody knew what [was going on], except we had this unknown bug that was killing people and quite a few actually: 44% of the positive Corona virus [infections] were in health care workers. So we were really having to deal quite a bit one-on-one with the staff [to convince them to stay], and we were there pretty long—24 hours of the day.”

However, staffing became an issue anytime a communicable disease outbreak occurred during disaster response. One participant described the difficulty in getting staff to go work at a community-based shelter after an outbreak of gastrointestinal disease had been detected there:

“[We had to make] sure that people were willing to go back to the center after they heard about the problems we were having [with the outbreaks]. [The staff] were thinking, ‘You go in there, you’re going to get sick.’”

Employee health and safety issues

Focus group participants discussed the importance of monitoring and managing employee health and safety issues during disaster response. Doing so will have the advantage of maximizing staff surge capacity by keeping staff able to continue working without contributing to secondary disease spread. ICPs mentioned a number of employee health issues, such as monitoring staff’s mental health, holding daily staff meetings to communicate how they were doing, providing adequate time for rest and sleep, having appropriate...
personal protective equipment, and ensuring food safety. One important component of employee health and safety is to teach staff to protect themselves before attempting to rescue disaster victims. As one participant explained, “You have to take care of your staff. [Sometimes] you have to stop what you’re doing, which [in our case] was evacuating patients [from flooded areas], because... the staff was getting injured.” If health care staff does not protect themselves before entering a potentially dangerous situation, “you’ve got more casualties than when you started.” Another participant described a situation in which a physician could have potentially harmed himself by not following the appropriate procedures during a response to a possible anthrax incident:

“The doctor had some white powder on himself because he wasn’t following the right protocol, and he didn’t know what he was supposed to ask or do... so he said [to the patient] ‘Let me see,’ and then he got [the powder] on himself.”

Employee health and safety includes the need to monitor staff for development of infection during an infectious disease emergency. Infected staff can contribute to secondary spread of disease and should be furloughed if they develop signs of infection. One participant described the challenge of monitoring and managing staff for infection, especially during disaster response when staff shortages are common.

“[For] pandemic flu [planning]... they’re talking about how do you evaluate the nurse who arrives for his or her shift febrile...[and even more challenging] is what I’m hearing about influenza... 30% to 50% of people who are contagious are asymptomatic. You’re going to be short staffed to start with, and now you’ve got a febrile nurse. So you call the employee health nurse, and what happens next?”

One ICP described her hospital’s procedure for monitoring and managing staff during the 2003 SARS outbreak:

“We actually had somebody at the door [of the hospital], every single door, or port of entry into our facility... and we have a 1500-bed facility... so at every entrance it was either locked, or there was somebody there monitoring [people]. They took everybody’s temperature coming into the facility. If you were febrile, you went home. No ifs, ands, or buts about it. You went home.”

Chain of authority/command

Focus group participants discussed many problems and challenges related to the chain of authority in disaster response and use of the incident command system (ICS). Problems included a general lack of knowledge or experience with ICS, inability of responding agency leaders to function within ICS in non-commander positions, and reluctance on the part of individuals in command positions to make decisions. Comments such as, “I think that incident command is not very well-known or understood in general outside of [first responder groups]” indicated that participants feel that hospital and public health staff needs additional training on ICS. A frequently heard complaint was the difficulty of trying to function within the ICS when responding agency leaders were assigned to non-commander positions. This led to mixed messages being communicated to staff and general confusion because no one knew who was in charge. This problem was mentioned in relation to a variety of disasters.

“We had the major blackout in New York City, and... nobody knew who to answer to, nobody knew who was responsible, who was in charge.”

“I think it all goes back to... the chain of command, and who really is in charge. If you don’t know who’s in charge of your facility and 3 people are trying to make a decision and they each have their own little miniagenda [it’s confusing].”

“[After Hurricane] Katrina... everybody wanted to be in charge, but then when they were in charge, nobody knew what they wanted to do.”

Although the ICS is intended to streamline disaster response communication and reporting, focus group participants pointed out that it only works when staff know the system and everyone follows the system appropriately.

Participants also discussed the advantages to the ICS and the importance of being in compliance. They stressed that responding agencies should be educated regarding why they need to follow the ICS. One participant suggested explaining the financial appeal of following ICS to a facility to get everyone on board:

“If you don’t ask for [supplies from] logistics [within the ICS], if you don’t go through your local emergency management agency to ask for any resources [you need], then you lose any hope of even applying for federal disaster reimbursement.”

Education

Focus group participants discussed many education topics on which ICPs should be trained; these topics are outlined in Table 3. Comments such as “[The training]
is going to depend on the type of disaster it is ... one size doesn’t fit all,” and “biological casualties ... [are] very different [from other disasters]. ... You have very different issues altogether” indicated that participants believe that there are some topics that are specific to infectious disease emergencies and that ICPs should be trained on these.

Focus group participants frequently mentioned “just-in-time” training as vital to an effective disaster response. Participants indicated that all responding staff will require some level of training during the disaster response, but they also stressed that disaster planners need to “think outside the box” in terms of the groups for which they plan just-in-time training. One participant described it in this way:

“It’s not going to be health care workers that we’re going to be ‘just-in-time’ training with, it’s probably going to be college students ... so they can train the other volunteers. Or it ... may be families teaching families how to care for each other.”

Participants indicated that just-in-time training can improve disaster response by decreasing dependency on the health care system, allowing health care to focus on the truly ill victims. They also stressed that it must involve public service announcements and should be coordinated through the ICS’ public information officer. These announcements should include information on “what is recommended, [whether people should] shelter in place ... whether [people should] go to the ER or not.” Participants felt that communicating this information and training to the public will prevent “10,000 people [from] ... show[ing] up at your hospital.”

Focus group participants stressed that it is important to have education or reference materials that do not rely on electricity because power outages may occur after disasters. They emphasized that disaster responders need education or reference tools that are “rechargeable in some way other than electricity,” such as a personal digital assistant (PDA) that uses batteries. Another option suggested by focus group participants was to have paper versions of reference materials and notebooks for recording information. One participant described it this way:

“When we thought [Hurricane Katrina] was coming, we started bringing a bunch of notebooks, and we walked out the door with those, and then we were out of power for weeks. Those notebooks were the only things we had...”

Partnering with public health

Focus group participants discussed the importance of ICPs partnering with public health in disaster preparedness because ICPs are often the liaison between public health and hospitals in a community. Participants indicated that establishing a partnership between hospitals and public health enhances the entire community’s ability to respond more effectively during a disaster. ICPs who had responded to various types of disasters mentioned this lesson learned.

“I think we learned from the last hurricane that [infection control] interface with the county health department is so important. They become your best friend. I think that’s a huge lesson, and I think that if we learned nothing else from that hurricane, we learned that.”

“I think it’s critical that both [infection control and public health] get together and start way up front, knowing who the people are that are working at the Health Department in the kind of areas that are going to affect you, and we in health departments have to find our partners in the private side, so we get [disaster planning] done up front, and we know each other and we plan together.”

ICPs also stated that partnering with public health would bridge gaps in public health’s knowledge of infectious disease emergency planning and foster the reciprocal sharing of information. ICPs felt that some public health professionals “are not very well trained” on communicable disease issues “because they’re so stretched in everything they have to cover, they don’t necessarily have the expertise in infection control and infectious diseases in all of the public health departments across the country.” One participant stated that public health frequently calls their hospital during a disaster and asks, “Can you help us out with what we should tell the public about this and this and this?”

ICPs felt that they should share their expertise of infection prevention and control knowledge with public health, which would result in a better prepared community. Shared training and participating together in disaster exercises were mentioned as 2 ways that ICPs could share information and education with public health. Participants indicated that working together through disaster exercises and training programs would strengthen the relationship between public health and ICPs. One participant described it in this way: “[Training and exercising together] made everybody on the same level, and everybody gets along better now after that.”

Changing and/or different standards

One challenge participants identified that was unique to infectious disease emergencies was the difficulty in maintaining staff compliance and trust in the
face of changing practice recommendations/standards. This was most evident in infectious disease emergencies involving a new agent (such as SARS) or in a new situation (such as anthrax used in a bioterrorism attack as opposed to naturally occurring disease). ICPs indicated that disasters involving an element of the unknown and frequent changes to practice as likely to create an evolution of fear and mistrust in health care workers and first responders.

"[My facility] is still trying to get rid of [chemical decontamination] suits. That’s what we used [to respond to] SARS, because on Easter Sunday that was the only piece of equipment that we could get a lot of in a very short period of time. So of course [now] we have these [chemical decontamination] suits—which aren’t used for infectious diseases—and we’re trying to educate [our responders why they aren’t necessary] and of course our unions, and everybody [is] saying ‘Well, we’re not going to be protected because now you’re taking this piece of equipment away from us.’ Three years later, this is what we’re dealing with:”

“It’s difficult to change health care workers’ way of thinking. [They think], ‘Well, we [wore N95 respirators for patients] with SARS’... and now it’s very difficult to try and say, ‘well, [you don’t need to do that anymore]; you are protected with this [surgical] mask.’”

Focus group participants indicated that the fear of a potential avian influenza pandemic is causing many education and planning challenges in their facility and community. One of the biggest challenges is related to the unknown mechanism of transmission for avian influenza, resulting in conflicting guidance that has been released and the recommendation to change isolation precautions midway during the response to an outbreak.

“The California plan [for responding to avian influenza] actually says, ‘While we are not sure we’re going to use N95s [early in the outbreak] ... once we’re sure [how it is transmitted], then we’re going to use surgical masks.’ I just can’t wait to see how our health care workers are going to take [the changing standard]:”

“The first responders are also a concern [in planning for avian influenza] because they want to [wear] the full Hazmat [gear]. They look at [avian influenza] as an unknown. I’ve been saying to them, ‘What do you do during seasonal flu?’ And [they respond], ‘Nothing!’”

Focus group participants stressed that changing recommendations and standards also have legal and ethical considerations. The general public does not always understand why medication recommendations (such as postexposure prophylaxis for anthrax) change, and this can be interpreted as discrimination in that it appears that health care and public health are providing a lower standard of care for different victims. One participant described the challenges and potential legal consequences of changing recommendations/standards midway through disaster response this way:

“It became a real issue after [the 2001 anthrax bioterrorism attack] with the lawsuits that we had. Lawyers said, ‘Why did you do this, why did you do that?’ It was all very confusing.”

Another participant described the difficulty in providing adequate follow-up care for victims when the recommendations change midway through the response:

“Our physicians got really aggravated with [changing standards] because we had 3000 people [affected], and 100 of them would come to the hospital at a time [for treatment] and then they go back to their facility ... and you have a health department come in and they would change the regimen and it was impossible to follow-up on [earlier cases].”

**DISCUSSION**

The focus group discussions provided several important findings. Information provided by the focus group participants highlights a number of educational/reference materials that are needed for future disasters. Most of these consist of quick reference materials, such as checklists, templates, charts, tool kits, and algorithms. Participants recommend that these materials be available in paper versions or electronically using products such as PDAs that do not require electricity so that they may be accessed during times when electricity is not available. Participants also provided a list of educational topics for ICPs. Mass casualty incidents, infection control during disasters, communication, incident command, physical plant needs, improving health care worker basic knowledge of how infectious organisms are transmitted, and business continuity issues were all identified as being essential training topics.

ICPs’ role in disaster preparedness and response is considered to be essential, regardless of whether it is an infectious disease emergency, such as outbreak of an emerging infection or bioterrorism, or a natural disaster such as a hurricane or earthquake. Although ICPs are essential to disaster preparedness and response,
ICPs indicate that participation is not always easy. ICPs’ role in disaster response can be complicated by a lack of supplies, inability to conduct real-time surveillance, difficulty in communicating information between facilities, too few staff, need to provide training to non-health care individuals, and challenges in functioning within the ICS. Disasters involving an element of the unknown, such as an outbreak of a new or reemerging pathogen, increase the difficulty in response. Changing standards and recommendations must be communicated carefully to prevent mistrust among the staff and/or the general public. Failure to do so can impinge on a facility or community’s ability to mount an effective disaster response.

Another notable finding from this study is that even natural disasters can result in significant public health crises if infection prevention and control strategies are not implemented rapidly and appropriately. Infectious disease outbreaks following disasters can devastate a community, and ICPs’ expertise is needed to help prevent secondary spread within alternate care sites as well as their facility. To be most effective, ICPs need to partner with public health professionals in their region before a disaster and establish strong linkages between hospitals and community agencies. These partnerships can strengthen facility preparedness and maximize a community’s ability to respond to a disaster. They should also result in stronger health care and public health systems by strengthening surveillance, communication, and basic infection prevention and control needed for day-to-day duties as well as disaster situations.

Overall, the focus group method of inquiry served as a valuable tool in eliciting rich, detailed information about ICPs’ opinions of lessons learned from past disasters. Structured surveys with closed-ended responses opposed to the open-ended questions used in this study may have revealed different opinions about references materials needed for future disasters and educational priorities for ICPs. It is not known whether the ICPs who chose to participate differed from those who were eligible but chose not to participate. It is also not known whether ICPs who have no experience with disaster response may have provided different answers compared with experienced ICPs in terms of preferred training topics and reference materials. However, this study was designed to elicit information from those who have responded to an actual disaster to identify gaps in preparedness in real situations rather than simulated events in disaster drills.

CONCLUSION

ICP preparedness for all types of disasters, especially infectious disease emergencies, has become essential. This study identifies lessons learned from past disasters and highlights gaps in disaster preparedness most in need of being addressed: infection control in mass casualty incidents, behavioral health issues, communication, incident command, and maintaining quality of care in suboptimal situations. Disaster planners must continue to address gaps in disaster preparedness. One way to accomplish this is through the creation and distribution of ICP-specific educational tools and reference materials for disaster preparedness and response. The topics identified by experienced ICPs should be used as the basis for these new educational initiatives.

The authors are the 2006-2007 Chair and members of the APIC Emergency Preparedness Committee and this research was conducted in their role as members of this Committee. A primary goal of this project was to provide information to be used in APIC strategic planning and meeting membership and organizational needs. The authors thank the other members of the APIC Emergency Preparedness Committee who assisted in project development and design. The authors would also like to thank the focus group participants for their dedication to past and future disaster preparedness, as well as the time taken to participate in these focus groups. Without your knowledge and experience, none of this would be possible.

References

"Public Health Investigation": A pilot, multi-county, electronic infectious disease exercise

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Introduction: Funding increases after September 11, 2001 have provided impetus to improve public health emergency preparedness plans. Training of local health department staff and coordination between counties are important components of these plans. Electronic media have been used to facilitate dissemination of training, and a need for evaluation has been identified.

Methods: Public Health Investigation (PHI) was conducted in 6 Kansas counties during February 2005 in an electronic, in-office format. The quantitative evaluation consisted of pre- and postsurveys. Questions measured self-reported improvements in 4 areas: surge capacity, coordination between counties, risk communication, and protocols and procedures.

Results: Although all 4 areas showed improvement, 2 showed statistically significant improvement. At the postsurvey, participants reported significantly improved abilities to (1) participate in a coordinated, multidisciplinary response to an infectious disease outbreak (P = .003) and (2) identify the need for and implement surge capacity (P = .017).

Conclusions: Increased collaboration between counties and partner agencies may be the greatest strength of PHI, a multi-county, real-time exercise. This format strengthens regional bonds and is cost-effective. The PHI may be a useful model for other states wishing to use a regional approach for training, thereby strengthening regional bonds. (Am J Infect Control 2007;35:382-6.)

After the terrorist attacks in 2001, the U.S. Congress provided approximately $1 billion to states to improve the public health infrastructure for response to terrorism, infectious disease outbreaks, and other public health threats and emergencies.1 Since that time, one area of emphasis for preparedness has been on local health departments, because of their role in front-line defense efforts.2,3 During public health emergencies, local health departments may be responsible for event detection, coordination with emergency response and health care partners, recommendation of treatments, contacting potential victims of exposure, and informing the public.3

In addition to improving response capacity of individual local health departments, strengthening collaboration with regional partners and state resource agencies has been identified as an important component of preparedness.3 Public health emergencies often cross county borders, and counties may request assistance from each other with regard to surge capacity and other elements of response. Knowing appropriate contact people, building strong networks, and maintaining regular contact increase the likelihood of effective collaboration in a real public health emergency.

There is some indication that, although preparedness levels of local health departments have increased overall, rural counties are less prepared than are urban counties.3-5 The pressure to strengthen the public health infrastructure has created challenges with disseminating training to a widely dispersed public health workforce. The need to reach many areas with training has resulted in innovative solutions, such as the use of electronic media to provide training to public health employees in their local offices.6-8

As training efforts increase, it also has become increasingly necessary to evaluate these trainings to determine which are effective. Disaster exercises can be effective in improving response to subsequent exercises and real incidents.9,10 However, there is a paucity of articles discussing the evaluation components of disaster training and exercises. As a result, there has been a call for more evaluation in public health training efforts.10-12

PURPOSE

The current study describes the quantitative evaluation of a month-long, multi-county, real-time infectious
disease pilot exercise that was conducted using electronic media, which allowed participants to work from their health department offices as they would in a real incident. The purpose of the exercise was to determine whether this format would be useful in increasing self-reported abilities with regard to surge capacity, coordination between counties, risk communication, and disease investigation protocols and procedures. The exercise also was designed to encourage participants to coordinate with their state and regional partners, which prompted local health departments within the region to coordinate efforts in order to respond effectively.

**EXERCISE DESIGN**

The project originated with the need to develop disease investigation protocols that could be used by all local health departments across the state. Common work practices and protocols within local health departments in Kansas is a major component of the state’s regionalization and surge capacity strategies. Because many rural communities cannot hire or have on staff experienced or trained epidemiologists, the Kansas Association of Local Health Departments (KALHD) contracted with an epidemiologist to write disease investigation protocols with significant input from practicing disease investigators. Subsequently, the Public Health Investigation (PHI) exercise was developed for local health departments to become familiar with the new protocols.

The exercise was designed as a simulated outbreak of an undisclosed, unintentional infectious disease. Participants received scenarios and injects, and submitted scene answers via the Kansas Health Alert Network, referred to as Public Health Information Exchange. Although the infectious disease initially was reported in one county, other counties and state agencies became involved as the disease spread and assistance was requested. The PHI exercise was conducted in the Central Kansas Region for Public Health Preparedness, one of 15 regional partnerships formed by Kansas local health departments as a result of federal bioterrorism grant funds in 2003 and 2004. During the exercise, the Kansas Department of Health and Environment (KDHE) served as PHI exercise planners and implementers, and as the state resource for infectious diseases. Local health departments within the preparedness region were encouraged to contact KDHE employees with questions, concerns, and resources to build ongoing communication patterns.

**METHODS**

**Participants**

The PHI was conducted during February 2005 at the local public health departments in the Central Kansas Region for Public Health Preparedness. The region is made up of Barton, McPherson, Pawnee, Rice, Saline, and Stafford counties, all 6 of which volunteered to pilot the exercise. All health department employees were invited to participate, except full-time and contract employees of the Special Supplemental Nutrition Program for Women, Infants, and Children, because it was determined that these employees would have minimal involvement in an infectious disease outbreak. The participant population was not defined further, in order to allow participants to choose the appropriate people to respond, as would occur in a real event. The coordinator for the Central Kansas Public Health Preparedness Region provided e-mail addresses for all health department employees as described above. All were invited to take the pre- and post-surveys.

**Evaluation tools and instruments**

The quantitative evaluation, which used Zoomerang, an Internet survey tool, was administered by the Workforce and Leadership Development Center of the Department of Preventive Medicine and Public Health in the University of Kansas School of Medicine-Wichita. Pre- and post-surveys included demographic items and encouraged respondents to rate their own abilities and their agencies’ abilities with regard to various aspects of responding to an incident. The surveys included questions regarding the four PHI objectives: surge capacity, coordination between counties, risk communication, and protocols and procedures. Respondents rated abilities based on a 5-point Likert scale from “very poor” to “excellent.” The instrument and methods described were approved by the Institutional Review Board of the University of Kansas School of Medicine-Wichita.

**RESULTS**

**Demographics**

Of the 65 surveys sent, 56 participants responded to the pretest, for an 86% response rate. Forty-eight of the 56 pretest respondents took the posttest survey, also an 86% response rate. Data were collected on position in agency, years with the agency, and level of education. At pretest, most respondents were nurses (n = 25), had worked at their agencies for 1 to 4 years (n = 19), and had an Associate Degree (n = 19). Posttest demographics were not significantly different from pretest demographics, which allowed comparison of surveys. Table 1 reports pre- and postexercise questionnaire demographics.

**Comparison between pre- and post PHI results**

The pre and post PHI surveys included questions regarding the 4 PHI objectives. Most self-ratings on
the presurvey were average or less, whereas most post-survey ratings were above average. All areas showed improvement. Missing values were nominal and without pattern; therefore, they were not included in the results.

To assess improvements in surge capacity, respondents were asked to rate their “health departments’ abilities to identify the need for and implement surge capacity.” Respondents at postexercise (n = 58) reported significantly improved ability in this area compared with pre-exercise (n = 45; z = 2.297; P = .003) (Fig. 1).

With regard to coordination between counties, respondents rated their own abilities “to participate in a coordinated, multidisciplinary response to infectious disease cases.” This area also showed statistically significant improvement from presurvey (n = 45) to post-survey (n = 60; z = −2.389; P = .017) (Fig. 2).

To address risk communication abilities, respondents rated their own abilities “to implement [their] risk communication skill set.” At the presurvey, 46% of respondents reported their abilities in this area as average, and 12% reported their abilities were good. At the postsurvey, 44% reported average, 22% reported good, and 5% reported excellent (Fig. 3). Although this showed improvement, it was not statistically significant.

During the exercise, participants were asked to use the protocols and procedures that they normally would use for investigation of an infectious disease case. The survey question for this competency was specific to the exercise: “Rate your ability to identify and locate your agency infectious disease resources (including the Kansas Association of Local Health Department’s Disease Investigation Guidelines, and Kansas Foodborne Illness and Outbreak Investigation Manual).” Forty-nine percent rated their abilities as better than average pre-exercise. Postexercise, 60% reported their abilities as better than average (Fig. 4). Again, this showed improvement, although it was not statistically significant.

**Table 1. Participant demographics on pre- and postsurveys**

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<th>Pretest</th>
<th>Posttest</th>
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<td>Saline</td>
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<td>Rice</td>
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<td>6 13%</td>
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<td>McPherson</td>
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<td>10 21%</td>
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<td>Pawnee</td>
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<td>6 13%</td>
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<td>4 9%</td>
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<td>3 6%</td>
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</tr>
<tr>
<td>Nurse</td>
<td>25 42%</td>
<td>18 38%</td>
<td></td>
</tr>
<tr>
<td>Program coordinator</td>
<td>3 5%</td>
<td>2 4%</td>
<td></td>
</tr>
<tr>
<td>Social worker</td>
<td>3 5%</td>
<td>2 4%</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>60 100%</td>
<td>47 99%*</td>
<td>NS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Years with agency</th>
<th>Pretest</th>
<th>Posttest</th>
<th>Differences/change</th>
</tr>
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<tr>
<td>1-4</td>
<td>19 32%</td>
<td>12 26%</td>
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<tr>
<td>5-10</td>
<td>13 22%</td>
<td>11 23%</td>
<td></td>
</tr>
<tr>
<td>11-15</td>
<td>16 27%</td>
<td>12 26%</td>
<td></td>
</tr>
<tr>
<td>16-20</td>
<td>6 10%</td>
<td>6 13%</td>
<td></td>
</tr>
<tr>
<td>21+</td>
<td>6 10%</td>
<td>6 13%</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>60 101%*</td>
<td>47 101%*</td>
<td>NS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
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<th>Posttest</th>
<th>Differences/change</th>
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</thead>
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<td>High school or less</td>
<td>8 13%</td>
<td>5 11%</td>
<td></td>
</tr>
<tr>
<td>Technology school</td>
<td>2 3%</td>
<td>0 0%</td>
<td></td>
</tr>
<tr>
<td>Associate degree</td>
<td>19 32%</td>
<td>15 32%</td>
<td></td>
</tr>
<tr>
<td>Some college</td>
<td>8 13%</td>
<td>7 15%</td>
<td></td>
</tr>
<tr>
<td>BS/BA degree</td>
<td>14 23%</td>
<td>10 21%</td>
<td></td>
</tr>
<tr>
<td>Masters degree</td>
<td>5 8%</td>
<td>4 9%</td>
<td></td>
</tr>
<tr>
<td>Diploma nurse</td>
<td>4 7%</td>
<td>6 13%</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>60 99%*</td>
<td>47 101%*</td>
<td>NS</td>
</tr>
</tbody>
</table>

NS, Not significant.

*Due to rounding of percentages, totals do not equal 100%.
DISCUSSION

The results of this survey show that the PHI pilot exercise was effective in improving self-reported abilities with regard to the 4 exercise objectives (surge capacity, coordination between counties, risk communication, protocols and procedures). Statistically significant improvement was demonstrated in 2 areas: (1) participants’ self-reported abilities to participate in a coordinated, multidisciplinary response to an infectious disease outbreak, and (2) participants’ self-reports of their health departments’ abilities to identify the need for and implement surge capacity. Both of these abilities emphasize relationships between counties and resource agencies.

Because collaboration of local health departments with each other and with state partners is an important component of public health preparedness, exercises that provide opportunities to increase collaboration are extremely valuable. Although shorter simulations and tabletop exercises can increase collaboration, the
longer duration of PHI encouraged participants to communicate over a period of time, which reinforced functional partnerships. Improved collaboration is likely to foster common work practices and protocols among local health departments within regions.

The PHI format, in many ways, reinforced the process of making contact with other health departments. In a real event, counties may be more likely to assist each other with regard to surge capacity, because they will have gone through the actual steps from their own offices. During the exercise, participants were required to locate contact information within their office settings, use existing communications technology and equipment (eg, for conference calling), and make contacts during the course of a normal workday. A qualitative evaluation after the exercise (unpublished data) included reports of established conference calling accounts and procedural changes based on increased awareness of other counties’ practices.

This study used self-reported measures as a proxy for response capacity. Although self-reported measures are useful, they measure respondents’ perceptions, rather than direct abilities. The fact that respondents across counties perceived that their coordination with each other had improved is important, however. Perceptions of gains in this area are likely to facilitate earlier requests for assistance and sharing of information in a real incident.

CONCLUSIONS

Since the fall of 2001, bioterrorism preparedness efforts have prompted an increase in regionalization efforts in many states. It may be expected that these efforts will carry over to other types of public health functions, such as preparedness for unintentional infectious disease outbreaks. The PHI exercise may be a useful model for other states wishing to use a regional approach for training, thereby strengthening regional bonds.

Additionally, the PHI format can be a cost-effective use of federal training funds, saving travel, facility, and speaker expenses. As public health departments begin to train for National Incident Management System (NIMS) compliance to remain eligible for federal funding, an exercise in the format of PHI may be a useful way to disseminate this training quickly, as well as to practice the use of the NIMS structure in a multi-county public health setting. Electronic, in-office simulations may provide an effective, efficient method for training public health employees to remain current with changing training needs.

The training program offered to Kansas local health departments discussed in this paper was funded by a Centers for Disease Control and Prevention grant. Special thanks to the 6 participating counties and their regional bioterrorism coordinator, because this pilot study could not have been conducted without them.

References

Factors associated with health care-acquired urinary tract infection

Nicholas Graves, PhD,a,b Edward Tong, BS (Hons),a Anthony P. Morton, MScAppl,a Kate Halton, MSc,a,b Merrilyn Curtis, MPH,a David Lairson, PhD,c and Michael Whitby, MPHa
Brisbane, Australia, and Houston, Texas

Background: Health care-acquired urinary tract infection is common, and the risk factors should be understood by those who manage hospitalized patients and researchers interested in interventions and programs designed to reduce rates.

Methods: We used multivariable logistic regression to identify factors that demonstrated a statistical association with infection.

Results: The incidence rate for infection was 1.66%, and risks increased for patients with prolonged length of stay (odds ratio [OR], 5.28; 95% confidence interval [CI]: 2.46-11.34), urinary catheter (OR, 5.16; 95% CI: 2.84-9.36), unresolved spinal injury (OR, 4.07; 95% CI: 1.04-15.92), transfer to/from another hospital (OR, 2.9; 95% CI: 1.39-6.04), some assistance for daily living prior to admission (OR, 2.58; 95% CI: 1.51-4.41), underlying neurologic disease (OR, 2.59; 95% CI: 1.49-4.49), previous stroke (OR, 1.94; 95% CI: 1.05-3.67), and fracture or dislocation on admission (OR, 5.34; 95% CI: 1.75-6.38). Male sex was protective (OR, 0.44; 95% CI: 0.26-0.77).

Conclusion: Our data describe a general hospital population and therefore have relevance to many hospital-based health care professionals. The statistical model is a good fit to the data and has good predictive power. We identify high-risk groups and confirm the need for good decision making for managing the risks of health care-acquired urinary tract infection. This requires information on the effectiveness of risk-reducing strategies and the changes to economic costs and health benefits that result and the synthesis of these data in appropriately designed economic models. (Am J Infect Control 2007;35:387-92.)

Health care-acquired urinary tract infections (HA-UTI) are the most frequently occurring1,2 of all health care-acquired infections among a general hospitalized population, and factors that increase risk should be understood by those who manage hospitalized patients and researchers interested in interventions and programs designed to reduce the incidence. HA-UTIs increase patient morbidity and cause minor costs.3-6 Because some of these infections can be prevented,7 a careful assessment of the change to costs and health benefits from prevention programs will inform the decision about increases to infection control.8-11 The risk of acquiring a UTI during the hospital admission has been studied for intensive care patients (ICU) patients,12,13 all admissions,14-20 general surgical patients,21 patients requiring orthopedic surgery,22,23 patients with an indwelling catheter in situ,24,25 patients with spinal cord injury,26 and stroke patients admitted to a comprehensive rehabilitation center.21 The following were found to be associated with risk of UTI among these patient groups: presence of indwelling urinary catheter,14-17,19-22,24,26 length of hospital stay,13-16,18,22 female sex,15-16,19-21,23-25 age,16-18,20,21 invasive procedure,24,26 diabetes,14,15,24,25 other urinary tract disorders,17,20,27 prior surgery,16,19 azotemia (creatinine > 2.0 mg/dL),24 previous use of quinolones,18 reoperation,12 duration of surgery,18 malnutrition,24 other sites of infection,24 use of β-blockers,27 unit of admission,16 ethnicity,16 patient unconscious,19 poor preoperative American Association of Anaesthetists (ASA) score,23 mechanical ventilation,12 hospital size,19 and serum creatinine > 2 mg/dL at time of catheterization.25 The objective of this article is to test the current understanding of risk factors for HA-UTI with new data that describe a consecutive cohort of hospitalized patients and includes values for a comprehensive set of potential risk factors.

METHODS

Data

We use data collected between October 2002 and January 2003. The primary purpose was to test associations between HAI and length of hospital stay/costs, and an article has been published4 that describes these analyses alongside the data collection and definitions. We review key aspects of the data collection here. We recruited participants from a 712-bed tertiary referral hospital and a 312-bed district hospital in Southeast Queensland, Australia. Inclusion criteria were ≥18 years of age and a minimum inpatient stay of 1 night.
to the clinical specialities described in Appendix 1. Consecutive patients were identified from a register of new admissions. Data were collected by 5 research nurses who were seconded from the infectious diseases wards of the tertiary referral hospital. The data collection tools were developed and tested during a 10-week pilot study, and criteria for selecting values for all variables were established. This process involved the research nurses, a senior infectious diseases physician, the project coordinator, and an epidemiologist with a background in acute hospital services and infection control. The result was an extensive data dictionary that summarized definitions agreed on by the research team. This document was the reference for any decision to assign a value to a variable and is available from the authors on request. We used the Centers for Disease Control and Prevention (CDC) definitions to diagnose a HA-UTI, and ambiguity was resolved by a diagnosis from the senior infectious diseases physician on the research team. Patients were recruited from bedside by the research nurses, and demographic data were collected using personal digital assistants that linked to a custom designed access database. After recruitment, data collection was completed from a review of the patients’ medical record, Hospital Based Corporate Information Systems (HBCIS), and the hospital pathology system, Auslab (Queensland Health, Queensland, Australia). Values were collected for variables that describe the occurrence of any health care-acquired infection (including HA-UTI) and demographic and clinical characteristics as well as all observable risk factors for length of stay and health-care acquired infection. The complete list of variables available for analysis and descriptive statistics are available from the previous publication.

**Model specification**

The list of variables available for analysis was screened by an infectious diseases physician, and those that were uncommon as risk factors for UTI or were not supported by existing literature were excluded. Length of stay in hospital was dichotomized into those patients who stayed longer than the mean for the relevant patient ICD-10 code and those who did not. The mean value was based on all admissions (ie, census data) to Australian public hospitals in 2002-2003 that had a single ICD-10 code assigned (ie, an uncomplicated admission). Age was dichotomized at 60 years based on clinical judgement.

**Statistical analyses**

The data were explored with univariate analyses (ie, Fisher exact tests with significance assumed at P < .05) and backward and forward stepwise selection procedures in multivariable models. The final and parsimonious model was driven by theory and clinical opinion. The risk of UTI was modelled using 3 different approaches: ordinary logistic regression, generalized estimating equations (GEE), and random intercept logistic regression. GEE analysis with exchangeable correlation structure was performed to accommodate the dependence among patients with multiple admissions; this assumes that patients who are admitted more than once during the data collection period have correlated outcomes on each admission. Random intercept logistic regression was performed to account for variation between the 2 hospitals. The statistical significance of individual predictors was assessed with the Wald test with significance set at P < .05. Interaction terms were assessed with the likelihood ratio test, and significance of interactions was assumed at P < .05. Interactions were sought only for main effect risk factors of length of stay, urinary catheter, and gender. The goodness-of-fit of the logistic regression model was assessed by the Hosmer-Lemeshow test. Model calibration was determined by the area under the receiver operator characteristic (ROC) curve. Standardized Pearson residuals-fitted plots of the logistic regression and GEE models were compared. Statistical analyses were performed with Stata version 9.2 and R version 2.2.1 (Stata Corporation, College Station, TX).

**RESULTS**

The full data set consisted of 4488 observations of which 123 (2.74%) were censored because of death and therefore were removed. After 208 case-wise deletions of variables because of missing values (4.77%), the working data set consisted of 4157 observations with 24 predictors. There were 849 multiple admissions (20.42%), and a total of 69 UTIs were diagnosed, which implies an incidence rate of 1.66% for the 4 months during which patients were recruited. The results of the analyses are presented in Tables 1 and 2. Multiple admissions were not a risk factor for UTI with similar estimates and inference from the ordinary logistic regression and GEE models. Hospital type was not a risk factor with the random intercept model suggesting no effect from the hospital-level variance component, $\rho = 0$ ($\chi^2 \text{bar}(1) = 0.00, P = 1.00$). There was no reason to use either of the 2 more complex models. The ordinary logistic regression model showed a nonsignificant difference between the observed and predicted number of urinary tract infections across 10 groups of predicted risk ($P = .51$), and, therefore, this model is appropriate. The McFadden Pseudo R2 is 27.2% for the parsimonious version. The results in Fig 1 suggest a nonlinear relationship between the log odds of UTI and covariates of length of stay and age, and this supports the decision to dichotomize length of stay and age. The standardized
### Table 1. Descriptive summaries and univariate analyses of candidate predictors

<table>
<thead>
<tr>
<th>Predictor description</th>
<th>Response</th>
<th>No UTI</th>
<th>UTI</th>
<th>Fisher exact test (2-sided) P value</th>
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<tr>
<td>Length of stay &gt; national average for ICD-10 code</td>
<td>No</td>
<td>2415</td>
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</tr>
<tr>
<td></td>
<td>Yes</td>
<td>1879</td>
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</tr>
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<td>Male</td>
<td>No</td>
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<td>49</td>
<td>.001</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>2219</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Age &gt; 60 yr</td>
<td>No</td>
<td>2228</td>
<td>16</td>
<td>&lt;.001</td>
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<tr>
<td></td>
<td>Yes</td>
<td>2066</td>
<td>55</td>
<td></td>
</tr>
<tr>
<td>Transferred from/to another hospital</td>
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<td></td>
<td>Yes</td>
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<td></td>
<td>Yes</td>
<td>130</td>
<td>6</td>
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<tr>
<td></td>
<td>Yes</td>
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<td>Urology unit</td>
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<td>318</td>
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<td>Diseases of genitourinary system (ICD-10)</td>
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<td></td>
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<td>298</td>
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<tr>
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<td></td>
<td>Yes</td>
<td>279</td>
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<td>Adverse event this admission†</td>
<td>No</td>
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<td></td>
<td>Yes</td>
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<td>Impaired conscious state</td>
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<td>1538</td>
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<td>Neurogenic bladder</td>
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<td>69</td>
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<td></td>
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<td>15</td>
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<tr>
<td>Underlying gastrointestinal disease</td>
<td>No</td>
<td>2982</td>
<td>42</td>
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<td></td>
<td>Yes</td>
<td>1312</td>
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<tr>
<td>Underlying neurologic disease</td>
<td>No</td>
<td>3836</td>
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<td>Yes</td>
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<td>Diabetes</td>
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<td>687</td>
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<td>Ever had a stroke</td>
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<td>Urinary catheter in situ during admission</td>
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<td></td>
<td>Yes</td>
<td>1105</td>
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<td>Instrumentation of bladder during admission</td>
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<td>Unresolved spinal injury</td>
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<tr>
<td>Admitted with fracture or dislocation</td>
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<td>55</td>
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<td>Other ethnic group</td>
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<td>Yes</td>
<td>139</td>
<td>0</td>
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<td>Admitted to teaching hospital</td>
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<td>Yes</td>
<td>2830</td>
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<td>Multiple admissions</td>
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<td></td>
<td>Yes</td>
<td>876</td>
<td>11</td>
<td></td>
</tr>
</tbody>
</table>

*These variables describe whether the patient required some assistance with daily tasks such as cooking, cleaning, and shopping prior to their hospital admission.

†An adverse event was assigned if the patient suffered any of the following during their admission: fall, cardiac arrest, deep vein thrombosis, pulmonary embolism, pneumothorax, nausea or vomiting in 12 hours postgeneral anaesthetic, pressure ulcer, shock, anaphylactic reaction, gastrointestinal bleed, or any other site of health care-acquired infection.
deviance residual-fitted plot of Fig 2 suggested that only 4 of the observations had standardized deviance residuals greater than 2.5 in absolute value suggesting the model is a good fit to the data. The area under the ROC curve of Fig 3 was 0.893, which indicates high predictive power. Risks increase dramatically for patients with a length of stay that exceeded the average for the ICD-10 code and those with a urinary catheter during their hospital admission or an unresolved spinal injury. Risks also increased for females; those who transferred to/from another hospital; those who required some assistance required for daily living prior to admission; and those with underlying neurologic disease, a previous stroke, and fracture or dislocation on admission. The only protective factor was male sex.

DISCUSSION

The incidence rate of 1.66% is typical of the epidemiology of HA-UTIs. The existing evidence is strong for the risk factors of prolonged length of stay,13-16,18,22 urinary catheter,14,17,18,20-22,24-26 and sex.13,16,19,20,23-25 There are no published studies that suggest unresolved spinal injury or fracture/dislocation increases risk of HA-UTI, but these patients are likely to be immobile for long periods, and this might be the mechanism for increased risk. The remaining predictors included in the parsimonious model were transfer to another hospital, underlying neurologic disease, some assistance required for daily living prior to admission; and those with underlying neurologic disease, a previous stroke, and fracture or dislocation on admission. The only protective factor was male sex.

Table 2. Summary ORs of marginal and conditional effects logistic regression models

<table>
<thead>
<tr>
<th>Fixed part</th>
<th>Marginal effects</th>
<th>Conditional effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of stay &gt; national average for ICD-10 code</td>
<td>5.28 (2.46-11.34),&lt;.001</td>
<td>5.34 (2.37-12.01),&lt;.001</td>
</tr>
<tr>
<td>Male</td>
<td>0.44 (0.26-0.77),.004</td>
<td>0.44 (0.26-0.76),.003</td>
</tr>
<tr>
<td>Transferred from/to another hospital</td>
<td>2.90 (1.39-6.04),.004</td>
<td>2.88 (1.35-6.13),.006</td>
</tr>
<tr>
<td>Some assistance§</td>
<td>2.58 (1.51-4.41),.001</td>
<td>2.60 (1.48-4.57),.001</td>
</tr>
<tr>
<td>Underlying neurologic disease</td>
<td>2.59 (1.49-4.49),.001</td>
<td>2.57 (1.49-4.44),.001</td>
</tr>
<tr>
<td>Ever had a stroke</td>
<td>1.94 (1.03-3.67),.041</td>
<td>1.95 (1.04-3.62),.036</td>
</tr>
<tr>
<td>Urinary catheter in situ during admission</td>
<td>5.16 (2.84-9.36),&lt;.001</td>
<td>5.21 (2.85-9.53),&lt;.001</td>
</tr>
<tr>
<td>Unresolved spinal injury</td>
<td>4.07 (1.04-15.92),.044</td>
<td>4.04 (1.15-14.24),.030</td>
</tr>
<tr>
<td>Admitted with fracture or dislocation</td>
<td>3.34 (1.75-6.38),&lt;.001</td>
<td>3.43 (1.84-6.41),&lt;.001</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Random part</th>
<th>Marginal effects</th>
<th>Conditional effects</th>
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</thead>
<tbody>
<tr>
<td>$\sigma_u$</td>
<td>0.033</td>
<td>0.033</td>
</tr>
<tr>
<td>$\rho$</td>
<td>0.001</td>
<td></td>
</tr>
<tr>
<td>Log likelihood</td>
<td>$-255.77$</td>
<td>$-255.77$</td>
</tr>
</tbody>
</table>

*Exchangeable correlation was equal to -0.033.

†Hospital type as random effect.

§These variables describe whether the patient required some assistance with daily tasks such as cooking, cleaning, and shopping prior to their hospital admission.

Fig 1. Log odds of UTI by (A) length of stay and (B) age.
other sites of infection,^{24} unit of admission,^{16} ethnicity,^{16} hospital size,^{19} and diabetes^{14,15,24,25} all increase risk, but the model we present here did not indicate a statistically significant association. The literature also suggests that invasive procedure,^{20,24-26} prior surgery,^{16,19} reoperation,^{12} poor preoperative ASA score,^{23} and duration of surgery^{18} increase risks, but we did not have sufficient surgical patients in the data set with which to develop statistical models.

The strength of this study is that many risk factors for HA-UTI were tested concurrently using a prospective data set of 4157 consecutive admissions. The data collection process was undertaken carefully, with quality control and data cleaning performed alongside data collection. Bias from omitted variables is unlikely, and selection bias (that plagues case-control studies) is completely avoided. Also, we describe a ‘‘typical’’ hospital population because we recruited from the high-volume general medical and general surgical specialties and excluded admission to tertiary specialties such as burns, transplant, and nephrology. The results might therefore be generalizable to many other settings. Our data describe a general hospital population and therefore have relevance to many hospital-based health care professionals.

In summary, we were able to test most of the recognized risk factors for HA-UTI using a method that avoids some major sources of bias. We find good evidence for the recognized risk factors and no evidence for risk factors others have proposed. We summarize factors that predispose to HA-UTI and suggest that this information is used to make good decisions about managing the risks of HA-UTI. Further research should focus on the effectiveness of risk-reducing strategies and the changes to economic costs and health benefits that result and the synthesis of these data in appropriately designed economic models.^{8,9}

References


APPENDIX 1
Clinical specialties from which patients were recruited
Breast endocrine and thoracic; cardiac surgical unit; cardiology; colorectal; diabetes/endocrine; ear, nose, and throat; gastroenterology; general medicine; gynecology; hepatopancreato-biliary; infectious diseases; intensive care unit; medical stroke unit; neurology; orthopedic; respiratory; rheumatology; general surgical unit; upper GI and soft tissue; urology; vascular; and women and child health.
Long-term outcomes from nosocomial infections in persons with spinal cord injuries and disorders

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Background: Nosocomial infection may contribute to poor long-term consequences in persons who have spinal cord injuries and disorders (SCI&D).

Methods: This is a cohort study of individuals who had SCI&D and were hospitalized at least once during 2002. They were followed for 3 years to assess inpatient (IP) admissions, total IP length of stay (LOS), outpatient (OP) visits, and mortality. Count data models and a Cox proportional hazards model were used to assess the relationship between previous infection and subsequent IP and OP use and long-term mortality, respectively.

Results: Of persons who had SCI&D, 59% had at least one nosocomial infection. Multivariable regression indicated that veterans who had SCI&D had more IP admissions ($b = 0.405; P < .0001$) and longer IP LOS ($b = 0.843; P < .0001$) if they had a previous infection; however, infection status was not a predictor of future OP visits. Survival time was lower (915.93 versus 1034.75 days, $P = .004$) in the infection group. Death rate was higher in the nosocomial infection group (30.11% versus 10.77%; $P = .004$), but the association did not achieve significance in the Cox proportional hazards model ($P = .12$).

Conclusions: Nosocomial infections have serious subsequent consequences that result in future hospitalization and shorter survival. Efforts to prevent nosocomial infections are needed to reduce long-term adverse effects in persons who have SCI&D.

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Individuals who have SCI&D are predisposed to infection during the acute and chronic stages after injury.8 The incidence of infections, usually related to the urinary tract, respiratory tract, and infected pressure ulcers, continues to be high for patients who have SCI&D across their lifespan.2 The impairments that are associated with SCI&D may disrupt many of the body’s defenses to invasion by microorganisms. For example, impaired emptying of the bladder gives rise to localized infection and serves as a potential source of sepsisemia; altered tissue and body composition (ie, namely increased extracellular fluid) may lead to the presence of edema that may serve as a medium for local spread of infection; and ineffective cough may lead to infectious respiratory complications (eg, increased risk for pneumonia).5 In addition, many medications commonly used by individuals who have SCI&D (eg, opiates, diazepam, nonsteroidal anti-inflammatory drugs) are known to influence immune response.9

Individuals who have traumatic and nontraumatic spinal cord impairments have high risk for hospital admission and prolonged hospitalization,4 and increased hospital exposure increases their risk for nosocomial infections.2 Controlling for functional status and acute severity of illness at the time of admission to an acute rehabilitation unit, Mylotte and colleagues10 found that the proportion of admissions in which nosocomial infections occurred was significantly higher in persons who had SCI (26% compared with

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A portion of the findings presented in this paper was presented at the Association for Professionals in Infection Control Annual Conference on June 14, 2006.

This paper reflects only the authors’ opinions and does not necessarily reflect the official position of the Department of Veterans Affairs.

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17% in a non-SCI group (e.g., traumatic brain injury, acute stroke, cancer)). Another study also reported a significantly higher prevalence of nosocomial infections in persons who had SCI&D compared with a non-SCI&D group (22% versus 4%, respectively).11

Often, studies that have evaluated the health care outcomes that are attributable to infections have observed patients for only short follow-up periods following infection.12,13 Outcomes that are directly attributable to infections are examined most often during a hospital admission or shortly after discharge. The adverse long-term effects that are associated with previous infections have seldom been evaluated. This led Fätkenheuer et al14 to suggest that in addition to focusing on common short-term outcomes, such as 30-day mortality, there is an “urgent need for prospective studies that assess long-term outcome[s].”

It is plausible that nosocomial infection occurrence might be an independent marker of increased health care utilization and a higher risk for death, months or even years later. Hence, the purpose of this study was to examine the long-term outcomes that are associated with the occurrence of nosocomial infections in persons who have SCI&D.

METHODS

Design

This was a cohort study of veterans who had SCI&D who were admitted at least one time to a Midwest Veterans Affairs (VA) facility during fiscal year (FY) 2002 (10/01/01-9/30/02). Administrative data were used to assess long-term outcomes for 3 years (36 months; through 9/30/05) for this cohort.

Participants

The study cohort included individuals who were diagnosed with traumatic and nontraumatic injuries to the spinal cord. Diagnoses included traumatic lesions of the spinal cord; intraspinal, nonmalignant neoplasms resulting in neurologic deficit; vascular insults of a thromboembolic, hemorrhagic, or ischemic nature; cauda equina syndrome producing a neurologic deficit; inflammatory disease of the spine, spinal cord, or cauda equina resulting in nonprogressive neurologic deficit; demyelinating disease of the spinal cord; unstable traumatic lesions of the spinal column; and multiple sclerosis. Individuals who had multiple sclerosis were excluded from this study.

Using VA administrative data, 176 veterans with SCI&D who had at least one hospital admission during FY 2002 were identified; analyses were limited to individuals with complete data (n = 158). The cohort included two groups: those who had at least one nosocomial infection during FY 2002 (n = 93) and those who did not have any nosocomial infections during an inpatient stay in FY 2002 (n = 65). The occurrence and site of infection were identified previously by primary data collection through comprehensive medical record review (e.g., microbiology data) that was performed for an earlier study (Evans et al, unpublished data).

Using the date of the first admission during FY 2002 for each individual, 3 years of outcome data (administrative data: number of hospital admissions, total length of stay [LOS] for hospitalizations and nursing home care per patient, number of outpatient visits, mortality) was examined. Data were obtained from several VA databases. The VA National Patient Care Database (NPCD) medical inpatient SAS dataset was used to identify the initial sample of those who were admitted at least once during the timeframe. The VA NPCD medical inpatient and outpatient SAS datasets were used to collect additional data elements, including subject demographics (age, gender, marital status, race); diagnosis, and comorbidity information (using ICD-9 code data) during the hospitalization and 1 year prior; discharge destination; and health care utilization information per patient during the 36-month follow-up, including number of admissions, clinic visits, and total LOS per patient. The VA Spinal Cord Dysfunction Registry was used to obtain level of injury, age at onset, and duration of injury data.

Mortality was determined from the “discharge destination” and “date of death” variables available in the inpatient data set and the “date of death” field in the VA Beneficiary Identification Record Locator System (BIRLS) death file. The inpatient data set only identified veterans who died in the hospital or if a survivor reported the death to the hospital. The BIRLS database contained records of all beneficiaries, including veterans whose survivors applied for death benefits. Deceased veterans who received compensation and pension are usually more likely to appear in this dataset than are veterans with a nonservice-connected disability without cash benefits.15 Fisher et al16 found that this dataset had a 94.5% accuracy rate in ascertaining death, however. As a result of the limitations of both of these datasets, they were used in combination to identify deaths. Because cause of death could not be determined accurately from these data sources, all-cause mortality was reported.

Variable definitions

Nosocomial infection. A nosocomial infection was defined as any infection (not present or incubating at the time of admission) that was identified 48 hours or more after admission to the hospital (community-acquired
infections were excluded). If the patient was readmitted within 48 hours after initial discharge with a primary admission for infection, this was considered a nosocomial infection, because the infection was likely to have been incubating during the previous admission, but had not become evident until after discharge.

**Infection site.** Definitions based on the Centers for Disease Control and Prevention criteria and modified slightly for SCI&D were used to identify specific sites of infection. Site infection classifications were based on algorithms that combined specific clinical findings with laboratory results and other diagnostic tests that were derived from chart reviews. The following infection sites, taken collectively, were included in this study: bloodstream, lower respiratory, pneumonia, urinary tract, surgical, bone and joint, skin and soft tissue, gastrointestinal system, central nervous system, reproductive, cardiovascular system, and eye/ear/nose/throat/mouth. Individuals were included in the infection group if they experienced at least one infection (from any site) during FY 2002; it is possible that they had multiple infections.

**Comorbidities.** The ICD-9 codes were used to identify comorbidities. Comorbidities assessed included: myocardial infarction, congestive heart failure, cerebrovascular disease, peptic ulcer, chronic pulmonary disease, peripheral vascular disease, dementia, connective tissue disease (eg, arthritis), liver disease, diabetes (includes with end organ damage), hemiplegia, renal disease, cancer, and AIDS.

### Analyses

The \( \chi^2 \) tests and \( t \)-tests were used to assess differences between individuals who had at least one nosocomial infection during FY 2002 and those with none, in terms of demographic, injury, and health characteristics, and outcomes at the bivariate level. Count data models were used to control for identified confounders in assessing the relationship between having had a past infection and subsequent inpatient admissions and total LOS and outpatient visits health care utilization. Because outpatient (OP) visits and inpatient (IP) discharges are count variables, Poisson and negative binomial regression methods were used to address skewness of patient utilization data. Because the variance and mean of IP admissions were statistically equivalent, a Poisson regression model was used to explore the impact of infection on inpatient health care use. A goodness-of-fit test verified that the Poisson model was appropriate for the IP data analysis. For OP utilization and IP LOS, the data showed signs of overdispersion, and a \( \chi^2 \) goodness-of-fit test indicated that negative binomial models were more appropriate. A Cox proportional hazard regression model was used to assess the relationship of prior infection with long-term mortality, controlling for confounders.

In addition to past infection status, the models included the following independent variables that may impact infection: age, race, marital status, level of injury, duration of injury, and number of comorbidities. Completeness of injury was not included in the models because of concerns about data quality, in addition to large numbers of missing values; gender was not included in the models because 98% of the sample was male. Because age at onset and duration of injury were collinear, only duration of injury was included in the multivariable models for any of the outcomes assessed. All analyses were conducted using SAS software version 8.1 (SAS Institute, Inc., Cary, NC) and STATA version 8.1 (Stata Corporation, College Station, TX).

### RESULTS

Of the 176 veterans who had SCI&D who had any hospital admissions at the VA hospital during FY 2002, 18 were excluded because of missing injury data (all were missing duration of injury and 5 were missing level of injury). Those excluded were not significantly different, by gender, race, age, marital status, number of comorbidities, or level of injury, from those who had complete data. The final sample included 93 individuals (58.86%) with at least one infection and 65 (41.14%) with no infections during an IP stay in FY 2002 (n = 158). Among those who had at least one nosocomial infection, frequency of infection site was as follows: urinary tract (26%), bloodstream (17%), bone and joint (16%), central nervous system (10%), gastrointestinal (9%), respiratory (7%), cardiovascular (7%), skin (5%), eye/ear/nose/throat (2%), surgical site (1%), and reproductive (1%). The two groups did not differ by gender, ethnicity, marital status, duration of injury, level of injury, or age at injury onset. Individuals who had SCI&D who had at least one past occurrence of a nosocomial infection were older (60.44 years versus 54.41 years; \( P = .007 \)) and had more comorbidities (\( P < .0001 \)). Table 1 presents subject characteristics by infection status.

### Health care utilization

During the 3-year follow-up, persons who experienced a past infection had more mean IP admissions (4.94 versus 3.20, \( P < .0001 \)) and a longer total LOS for IP admissions (21.72 versus 90.15; \( P < .0001 \)) than did those with no infections. There were no significant differences in the mean number of nursing home admissions, nursing home LOS, or number of OP visits (Table 1).

Table 2 shows the results of the Poisson model with number of IP admissions as the dependent variable.
Individuals had more subsequent IP admissions if they had experienced a prior infection \((b = 0.405; \ P < .0001)\). As age increased each year, the number of IP admissions decreased by 1.1% \((b = 0.011, \ P = .001)\). Veterans who had paraplegia were less likely than were those who had tetraplegia to utilize IP care \((b = -0.272; \ P = .002)\). As the number of comorbidities increased, IP utilization increased by 13.1% \((b = 0.131; \ P < .0001)\). The number of predicted IP admissions was not related to race, marital status, or duration of injury.

Table 2 depicts the results of the negative binomial regression model applied to total IP LOS over 36 months. Veterans who had SCI&D who had a nosocomial infection during FY 2002 were more likely to have higher total IP LOS \((b = 0.843; \ P < .0001)\). None of the other variables was a significant predictor of IP LOS.

Table 2 also shows the negative binomial regression findings with OP visits (days) as the dependent variable. Infection status was not a predictor of future OP VA

---

**Table 1. Subject characteristics and outcomes by infection versus no infection** \((n = 158)\)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>No infection, (n = 65) (frequency, %)</th>
<th>Infection, (n = 93) (frequency, %)</th>
<th>(P)-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>65 (100)</td>
<td>91 (97.8)</td>
<td>.23</td>
</tr>
<tr>
<td>Female</td>
<td>0 (0)</td>
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<tr>
<td>Ethnicity</td>
<td></td>
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<td></td>
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<tr>
<td>White</td>
<td>40 (61.5)</td>
<td>54 (58.1)</td>
<td>.66</td>
</tr>
<tr>
<td>Non-white</td>
<td>25 (38.5)</td>
<td>39 (41.9)</td>
<td></td>
</tr>
<tr>
<td>Age groups (years)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-49</td>
<td>27 (41.5)</td>
<td>20 (21.5)</td>
<td>Reference</td>
</tr>
<tr>
<td>50-64</td>
<td>23 (35.4)</td>
<td>38 (40.9)</td>
<td>.04</td>
</tr>
<tr>
<td>65+</td>
<td>15 (23.1)</td>
<td>35 (37.6)</td>
<td>.006</td>
</tr>
<tr>
<td>Mean age (years)</td>
<td>54.41</td>
<td>60.44</td>
<td>.007</td>
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<tr>
<td>Marital status</td>
<td></td>
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<td></td>
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<tr>
<td>Married</td>
<td>17 (26.2)</td>
<td>32 (34.4)</td>
<td>.27</td>
</tr>
<tr>
<td>Not married</td>
<td>48 (73.8)</td>
<td>61 (65.6)</td>
<td></td>
</tr>
<tr>
<td>Duration of neurological condition (years)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0-19</td>
<td>33 (50.8)</td>
<td>45 (48.4)</td>
<td>Reference</td>
</tr>
<tr>
<td>20-29</td>
<td>21 (32.3)</td>
<td>20 (21.5)</td>
<td>.35</td>
</tr>
<tr>
<td>30+</td>
<td>11 (16.9)</td>
<td>28 (30.1)</td>
<td>.14</td>
</tr>
<tr>
<td>Mean duration of neurological condition (years)</td>
<td>19.56</td>
<td>22.58</td>
<td>.14</td>
</tr>
<tr>
<td>Level of injury</td>
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<tr>
<td>Paraplegia</td>
<td>30 (46.2)</td>
<td>48 (51.6)</td>
<td>Reference</td>
</tr>
<tr>
<td>Tetraplegia</td>
<td>35 (53.9)</td>
<td>45 (48.4)</td>
<td>.50</td>
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<tr>
<td>Age at injury (years)</td>
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<td>18-49</td>
<td>57 (87.7)</td>
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<td>50-64</td>
<td>5 (7.7)</td>
<td>13 (14.0)</td>
<td>.18</td>
</tr>
<tr>
<td>65+</td>
<td>3 (4.6)</td>
<td>9 (9.7)</td>
<td>.19</td>
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<tr>
<td>Mean age at injury/illness (years)</td>
<td>34.86</td>
<td>37.86</td>
<td>.22</td>
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<tr>
<td>Comorbidities</td>
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<tr>
<td>No comorbidities</td>
<td>38 (58.5)</td>
<td>29 (31.2)</td>
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<td>1 comorbidity</td>
<td>22 (33.8)</td>
<td>25 (26.9)</td>
<td>.30</td>
</tr>
<tr>
<td>&gt;1 comorbidity</td>
<td>5 (7.7)</td>
<td>39 (41.9)</td>
<td>.0001</td>
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<td>Charlson Comorbidity Index</td>
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<td></td>
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<tr>
<td>Mean number of comorbidities</td>
<td>1.54</td>
<td>2.55</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Outcomes 36 months following first FY 2002 admission</td>
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<td></td>
<td></td>
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<tr>
<td>Mean number of IP admissions</td>
<td>3.20</td>
<td>4.94</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Mean number of nursing home admissions</td>
<td>0.23</td>
<td>0.38</td>
<td>.3145</td>
</tr>
<tr>
<td>Mean number of OP visits</td>
<td>61.05</td>
<td>66.99</td>
<td>.5497</td>
</tr>
<tr>
<td>Total IP LOS per patient (days)</td>
<td>90.15</td>
<td>217.72</td>
<td>&lt;.0001</td>
</tr>
<tr>
<td>Total nursing home LOS per patient</td>
<td>17.37</td>
<td>36.58</td>
<td>.2697</td>
</tr>
<tr>
<td>Mean survival time (using lifetest)</td>
<td>1034.75</td>
<td>913.92</td>
<td>.004</td>
</tr>
</tbody>
</table>

The statistically significant \(P\)-values are in bold type.

\(x^2\) tests were used for categorical variables and t-tests were used for continuous variables.

The index was developed including hemiplegia in the definition.

All-cause mortality.
health care utilization, nor was race or number of co-
morbidities. Veterans who had SCI&D who were older
(b = −0.016; P < .035), had paraplegia (b = −0.494; P = .029), or had a longer duration of injury (b = −0.027; P = .003) had fewer OP visits. Individuals who were married had more OP visits (b = 0.593; P = .006).

Mortality

During follow-up, 10.77% (n = 7) of veterans without infections died compared with 30.11% (n=28) of veterans who had SCI&D who had experienced at least one infection (P = .004). Individuals without infections lived longer than those who experienced nosocomial infection(s) (mean survival time, 1054.75 days versus 913.92 days; P = .004; Table 2). Figure 1 shows a significant difference in survival curves between those who had an infection and those who did not.

After controlling for other factors, the Cox proportional hazards model did not show a significant trend in the association between having had a past infection and long-term mortality (hazard ratio [HR], 2.01; 95% confidence interval [CI], 0.83-4.85; P = .12; Table 3). Mortality was associated significantly with increased age (HR, 1.05; 95% CI, 1.02-1.09; P = .001) and having a longer duration of injury (HR, 1.03, 95% CI, 1.0-1.1; P = .02). Mortality was less likely in individuals who had paraplegia rather than tetraplegia (HR, 0.35; 95% CI, 0.16-0.78; P = .16). Race, marital status, and number of comorbidities were not significant predictors of long-term mortality in the cohort.

DISCUSSION

Estimates hold that 5% to 10% of patients who are admitted to acute care hospitals acquire one or more nosocomial infections; the risks have increased progressively during recent decades.21,22 The findings of the current study of a cohort of individuals who had SCI&D and who were admitted to a hospital during FY 2002 indicate, however, that nearly 60% acquired a nosocomial infection. The high risk for nosocomial infections in persons who have SCI&D is consistent with research that found that SCI&D was an independent predictor of nosocomial infection.10 This increased risk in SCI&D emphasizes the importance of understanding the long-term consequences that are associated with nosocomial infections in this population.

Nosocomial infection occurrence was associated significantly with increased numbers of, and longer, subsequent IP admissions. This relationship was significant after controlling for other factors. In addition, an increased number of comorbid conditions was independently related to IP admissions during the 36-month follow-up. Previous studies showed that a patient’s risk for infection increases with an increased number of comorbidities.23,24 In fact, patients who have SCI&D tend to have more comorbidities and secondary conditions than do individuals in the general population.25,26 The current study indicated that nosocomial infections were associated with greater numbers of subsequent IP hospitalizations, even after the number of comorbidities was controlled for in the analyses. To assess whether comorbidity was an effect modifier of the relationship between infection and number of subsequent hospital admissions, a subset analysis (data not shown), controlling for the same confounders, was conducted only on individuals with zero comorbidities. This analysis revealed that nosocomial infection was an independent predictor of increased IP admissions (P = .003) and total IP LOS (P = .005). Regardless, many individuals who have SCI&D do have multiple comorbid medical conditions and long-term mortality (hazard ratio [HR], 2.01; 95% confidence interval [CI], 0.83-4.85; and long-term mortality (hazard ratio [HR], 2.01; 95% confidence interval [CI], 0.83-4.85; and long-term mortality (hazard ratio [HR], 2.01; 95% confidence interval [CI], 0.83-4.85;
conditions that may influence the course and recovery of infection; this makes it even more important to understand how this affects long-term outcomes of nosocomial infection.

Nosocomial infection occurrence was not associated with increased future OP visits. This is not necessarily surprising given the usually less serious nature of OP care compared with IP care. Although marital status did not affect IP outcomes, individuals who were married had more future OP visits. This suggests that issues of social support, which might impact access or decisions to seek care, are more likely with OP visits than with IP visits in the SCI&D population.

Bivariate findings showed that nosocomial infection was associated with shorter survival times and higher all-cause mortality rates in persons who had SCI&D who were followed for 3 years. In fact, the 36-month all-cause long-term mortality in those who had infections (30.11%) was almost three times higher than in those who did not have a nosocomial infection (10.77%). After controlling for confounding variables (eg, number of comorbidities), however, nosocomial infection did not show a significant trend in the association of having had a past infection and a higher risk for death at the 0.05 level. Still, the high hazard ratio may be suggestive of a true association, but statistical significance may not have been achieved because of the small sample size of this study. Few studies have examined the relationship between nosocomial infection and long-term mortality. Among those that have, Poulsen and colleagues followed surgical patients (and matched controls) for 4 to 8 years after hospital discharge; those who had a deep surgical wound infection had a significantly increased mortality. Fätkenheuer et al assessed the long-term outcomes in patients who had bacteremia and found increased long-term mortality (>50 days to 1 year following diagnosis).

Efforts to reduce long-term adverse effects should focus on prevention of nosocomial infections. Literature holds that at least one third of nosocomial infections are preventable. Within hospital settings, health care workers should be encouraged to take direct and indirect precautions to alleviate the spread of infection. For example, one study found that asepsis is often overlooked in intensive care units; another found that only half of health care workers who had direct contact with individuals who had SCI&D had received an annual influenza vaccination. Infection control efforts by hospital staff are effective in the reduction/prevention of nosocomial infections in the SCI&D population. Prevention is of utmost importance in this population that may spend more time in a hospital setting, be more likely to rely upon medical equipment and devices, and have more skin infections while hospitalized because of multiple changes in skin morphology and susceptibility to pressure ulcers. As the results of this study suggest, persons with previous nosocomial infections are more likely to spend increased time in a hospital setting, which puts them at even more risk for subsequent infections.

In considering our findings, there are several limitations that should be noted. First, as a single-facility study, the ability to generalize to other populations who have SCI&D is limited. Because of the small
sample size, adequate power was not achieved to assess the association between mortality and infection status while controlling for confounders. Mortality data were limited to individuals who died within the hospital, those whose survivors applied for benefits, or those whose survivors reported the death to the hospital; it is possible that mortality was underreported. Fisher et al found that the BIRLS dataset had a 94.5% accuracy rate in ascertaining death, however. Utilization data were limited to VA use; therefore, it is possible that some of the individuals utilized non-VA care. Data from the national VA SCI population, however, indicated that among survey respondents, 24% utilized some non-VA care during a 12-month period (2003/2004); among the non-VA care users, only 20% used non-VA care exclusively (Weaver 2006, unpublished data). Thus, it is likely that we have captured the majority of care utilized by veterans who have SCI&D. In addition, this study focused broadly on all nosocomial infections, and not on specific infections. Therefore, there could be some effect modification across infections (eg, bloodstream infections may shower higher mortality than do skin and soft tissue infections). Stratifying by individual infections was not possible because of the limited sample size. Finally, data about nosocomial infection history were not available and this may have confounded findings; however, data on other host factors, such as age, comorbidities, and SCI characteristics, were used.

CONCLUSIONS

Nosocomial infections are associated with greater numbers of, and longer, IP hospital stays. Although bivariate analyses indicated higher subsequent all-cause mortality and shorter survival time in persons who had SCI&D who had a nosocomial infection, the Cox proportional hazards model did not find a significant association between nosocomial infection and risk for long-term death after 3 years of follow-up. The OP utilization did not differ, which suggested that nosocomial infections have more serious consequences that result in long-term hospitalization. Efforts to reduce long-term adverse effects should focus on the prevention of nosocomial infections in persons who have SCI&D.

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References


Infection control consultation in a 150-bed acute care hospital: Making this unobserved and unmeasured critical job function visible

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Background: One qualified infection control director, reporting directly to administration, was responsible for the Infection Prevention and Control Program of a 150-bed acute care, non-teaching, for-profit hospital. To observe for potential trending, questions (consultations) and determinations related to infectious processes were documented.

Objective: To explore the possibility of measuring the essential although “hidden” function of the infection control consultation (process), which is a role not formerly linked to infection rates (outcomes).

Methods: A 7-year retrospective study was conducted of all infection control consultations requiring more than a 5-minute intervention, as part of routine job responsibilities. The XmR Statistical Process Control charts (XmR Charts) and Pearson’s Correlation Coefficient were used to analyze the activity of infection control consultations.

Results: From January 1, 1998 to December 31, 2004, there were 770 infection control consultations logged for 375.1 hours. Beginning with 2003, the variation in both the number and duration of infection control consultations in the XmR Charts become more standardized and has a smaller moving range between data points. The Pearson’s Correlation Coefficient shows statistical significance ($P < .05$) between the number and duration of consultations.

Conclusions: Assessment of infection control consultations at this 150-bed hospital illustrates that this essential component can be measured, and should be formerly tracked to document overall assessment of infection prevention and control interdisciplinary interaction. The consultation process became more efficient over the 7-year study period because, as the number of questions increased, the duration required to achieve closure decreased. (Am J Infect Control 2007;35:401-6.)

Health care administration has a fiduciary responsibility to balance resources and the quality of services provided within their institution, and the decisions to invest funds are, in part, balanced against the ability of a service or department to produce revenue to augment their health care responsibilities. The discipline of infection prevention and control frequently does not fit well into the traditional model(s) of business, despite its strong patient safety mission. This quandary remains a challenge in our escalating health care milieu that now includes the reality of hospital comparisons through mandatory reporting of infectious events and the demand that health care improve their outcomes while lowering all forms of untoward events.1-4

The discipline of infection control has moved from its infancy of exploration in the 1960s to its present form of interventional epidemiology in the 21st century.5,6 This specialty is grounded in science and has developed gold standards of process and outcome performance, including the designated “Certified in Infection Control” as the marker of competency, which is updated every 5 years based on the evolution of the profession.7-11

Aside from involvement with the decrease in risk-stratified infection rates (outcome measures), the infection control and prevention professional (ICP) provides the additional, albeit often undocumented service, of consultation on all aspects of microbial life transmission risk. The ability to provide accurate and customized responses through the consultative function involves literature search and review, application of research, and the ability to customize those findings to the unique characteristics of the individual health care facility, and all those who interact within.

While documenting these infection control questions, it seemed that as the number of consultations increased, the time it took to resolve issues decreased. Was there a correlation between the stability and efficacy of an in-house infection prevention and control program, over time, not related to outcomes? The
The purpose of this study is to explore the possibility of using a nontraditional business approach to measure the fundamental although "hidden" function of the infection control consultation (process), which is a function that is not always linked to infection rates.

**METHODS**

**Setting**

A 150-bed non-teaching, for-profit, suburban, community acute-care hospital. Services include a broad range of medical and surgical specialties with the exception of level I trauma services, pediatric, neurological surgery, burn, organ/bone marrow transplant, or care level three neonatal intensive care. The director of the infection prevention and control program reported directly to the chief nursing officer and did not have any other direct clerical or practitioner support personnel. A board-certified infectious disease physician was available for consultation on issues requiring medical expertise.

**Data collection**

A retrospective observational study was conducted from January 1, 1998 through December 31, 2004. Infection control consultations were responded to and documented by an ICP with 14 years of experience, who is certified in infection control. As part of normal operations, the consultation was documented each time the ICP was consulted on a question related to the prevention or control of infection, and the issue involved at least 5 minutes duration including any written communication or references. Quarterly, a formal nonconfidential report of the infection control consultations was shared at the director level and within the infection prevention and control committee.
Consultation documentation included: a) date of query; b) person(s) initiating the consultation and/or patient identification information; c) location by unit or service; d) description of the question; and, e) duration to resolution of the consultation. Consultations less than five minutes were excluded. If a consultation uncovered the need for an internal process change or investigation, the entire process was not tallied, but only the initial investment of time required to discern the issues involved. Although the consultations were prospective (ie, done as the question arose), the actual cumulative data analysis was done retrospectively.

Data analysis

Infection control consultations were grouped by quarterly intervals per year. Each quarter block of infection control consultations were added together to determine the number of consultations and the duration required to finalize the question or issue under consideration. Each infection control consultation block was entered into Microsoft Excel 2000. Using the XmR Statistical Process Control Chart (XmR Chart), the number of and the duration of consultations were analyzed separately to identify any patterns. To determine if there was a correlation between the number of consultations increasing and duration of infection control consultations decreasing, a Pearson’s Correlation Coefficient was performed using the Statistical Package for the Social Sciences (v.11.0).

RESULTS

With the exception of 1999, the number of consultations increased to remain above baseline, while the collective time (duration) it took to process the consultations, with rare exception, continued to require less time for each successive year during the study period (Fig 1). From 1998 through 2004 there were 770 infection control consultations that required greater than or equal to 5 minutes to resolve the question at hand (Fig 2). The area requesting the most guidance is related to the specifics surrounding disease transmission scattered throughout the hospital, with the least requested from the housekeeping service.

The XmR Chart for the number of consultations (Fig 3) and the duration of those consultations (Fig 4) shows the infection control consultation process to be in control throughout the data collection period. However, beginning with 2003 the variation in both the number and duration of infection control consultations becomes more standardized and has a smaller moving range between data points.

The Pearson’s Correlation Coefficient revealed a positive correlation ($r = 0.50; P = .006$) between the number of infection control consultations and the duration of those same consultations. Beginning in 2003, because the XmR Chart showed a more standardized process emerge, a separate Pearson’s Correlation Coefficient was performed on 2003 and 2004 data only, showing a stronger correlation ($r = 0.82; P = .015$) for this 2-year period versus the 7 years in totality.
Infection prevention and control has been attempting to quantify their impact in health care since the 1980s in a system that is driven by reimbursement for medical services and diagnostics rendered. Despite the preventive nature of this discipline, human and financial resources have been sparse even with the

**Fig 3.** Number of infection control (IC) consultations per quarter* in 150-bed nonteaching community hospitals, January 1, 1998–December 31, 2004.

**Fig 4.** Duration of infection control (IC) consultations in hours* in 150-bed nonteaching community hospitals, January 1, 1998–December 31, 2004.

**DISCUSSION**

Infection prevention and control has been attempting to quantify their impact in health care since...
recent push brought about by consumer attention and demand for consumer access to outcomes related to health care-associated infections. Aside from traditional outcome measurement, infection prevention and control provides the service of “having the answers” to microbial transmission crisis issues and everyday clarifications related to breaking the chain of infection.

The infection control consultation process, as illustrated by both XmR Charts, shows a process that was in control from the beginning with a narrowing of variation after 2003, indicating a standardization of the process to be more in control (efficient). This might be interpreted that an adequately resourced infection prevention and control program becomes ingrained within the health care facility, when given the proper authority, support, and autonomy essential to affect change.

It is a theoretical assumption that this efficiency might be due, in part, to several factors specific to the organizational structure where this study occurred: 1) the certified ICP was hired in and maintained at the director level as a separate department; 2) reported directly to the Chief Nursing Officer, who is a member of the administrative team; 3) adequate resources were consistently available for attendance at annual international infection control educational conferences; 4) sufficient hardware and software programs were maintained; and 5) the same ICP was in this role for the entire 7 years, enhancing familiarity and ability to network among director level peers, to implement infection prevention at the bedside through each department’s personnel.

Despite study limitations, tracking of infection control consultations is one way of documenting that the role and scope of the program is interdisciplinary for compliance with the Centers for Medicare and Medicaid Services and the Joint Commission on Accreditation of Healthcare Organizations. The logging of consultations serves as a formal report for historical reference to discussions and decisions rendered, while serving as a fluid risk assessment tool to identify any trends in issues or concerns identified by the noninfection prevention personnel within the health care facility.

Study limitations

This investigation is an initial attempt to quantify the fluid and basic, yet advanced, function of consultation that is often not formally accounted for, and illustrate its value over time as a critical and stable function that can and should be measured. There are not any comparison groups for this type of observational study because one has not been published before; therefore, findings must be considered within the narrow milieu as described in the Methods section of this study. Also, confounding variables cannot be accounted for because the issues which prompt initiation of an infection control consultation are distinctive to each health care institution’s unique qualities and services, as well as global issues that must be customized into any program, and, therefore, cannot be generalized retrospectively.

CONCLUSION

This preliminary endeavor to measure the potential impact and value of the infection control consultation is not complete; however, it has shown this responsibility can be measured using statistical process control methods as a vital part of any infection prevention and control program. Even though the consultation function cannot always be linked directly to outcome measures, this analysis used the Pearson’s Correlation Coefficient to reveal a positive correlation ($r = 0.50; P = .006$) between an increase in the number of infection control consultations and a decrease in the duration of those same consultations, indicating that dedicated resources over time should strengthen the ability of a program to decrease the chance of infection transmission.

This research can be used to place a “value” on an infection prevention and control program that is not linked to any specific infectious outcome measurement in the traditional sense. This study has placed the previously unmeasured function of the infection control consultation into a format that shows significance of this professional asset, beyond the attempts to place contributions into a traditional business model.

References


A long-term study of sharps injuries among health care workers in Japan

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Kyoto and Nagoya, Japan

Background: The risk of transmission of occupational blood-borne infection is a serious problem for health care workers (HCWs) in Japan. Although the Japanese version of Exposure Prevention Information Network (EPINet) was introduced in 1997, no published data in the clinical setting have been available yet.

Objective: To examine the epidemiology of occupational sharps injuries of HCWs in a university hospital using EPINet and to analyze the trends and changes in epidemiologic characteristics of needlestick injuries in a detailed situation.

Methods: The HCWs were requested to report sharps injury incidents to the Infection Control Nurse when the incidents occurred. Those who were involved in the incidents were required to personally complete an EPINET form.

Results: A total of 259 cases of sharps injuries occurred during the 7-year period. Registered nurses accounted for 72.2% of the cases, constituting the largest group of the HCWs. The incidents occurred most frequently in the hospital wards. Thirty-three cases (55.9%) of the injuries with syringe-needle units occurred "after use before disposal," whereas 34 cases (73.9%) of the injuries with suture needles occurred "during use of device." More than half of the injuries with a winged steel needle occurred despite the protective mechanism.

Discussion: There was no apparent difference in the characteristics of the subjects compared with other reports. The circumstances of the injuries varied with the kinds of instruments. This fact may provide useful information for planning measures to prevent sharps injuries.

Conclusions: With the problem of underreporting aside, a detailed study, such as ours, comprising by job category and by kind of instrument or the like would provide more useful and effective information in terms of sharps injury prevention. (Am J Infect Control 2007;35:407-11.)
trends in the epidemiological characteristics of sharps injury were analyzed in detail.

METHODS

Subjects

The study was conducted in Nagoya University Hospital in Japan, which had 1346 employees and 1015 beds, with separate facilities for adults, children, and dental patients. During the 7-year study period from 1997 to 2004, the hospital had an average staff of 558 physicians and 621 nurses, with a mean bed occupancy rate of 82.2%.

Serological testing of health care workers and patients

We carried out testing of all staff members who had reported sharps injuries as well as the patients who were the source of contamination and agreed to the testing for anti-hepatitis B antibody, anti-hepatitis B antigen, anti-hepatitis C antibody, and anti-HIV antibody. Blood samples of the HCWs who might have been exposed to blood infection were tested for the presence of seroconversion at 1, 3, 6, and 12 months subsequent to the initial injury.

Data collection and analysis

The surveillance of sharps injuries of HCWs was conducted over the period of 7 years from April 1, 1997 to March 31, 2004. The HCWs were requested to report sharps injuries to the infection control nurse when the incidents occurred. Those who were involved in the incidents were required to personally complete an EPINet form. If their reports were found to be vague, a person in charge of analysis reexamined the cases and completed the reports.

RESULTS

Characteristics of the subjects

The number of sharps injury incidents in our hospital was 259 in the 7-year study period. The incident rate per 100 beds was 3.6, which was consistent with the previous report. The annual rates of the incident were not significantly changed during the 7-year period. The injured workers are shown by occupation in Table 1. Of the 259 HCWs, 187 (72.2%) were nurses and 51 (19.7%) were doctors. By location, 141 cases (54.4%) occurred in the hospital wards, 64 cases (24.7%) occurred

Table 1. Characteristics of subjects

<table>
<thead>
<tr>
<th>Profession</th>
<th>N = 259 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nurses</td>
<td>187 (72.2)</td>
</tr>
<tr>
<td>Doctors</td>
<td>51 (19.7)</td>
</tr>
<tr>
<td>Clinical laboratory workers</td>
<td>9 (3.5)</td>
</tr>
<tr>
<td>Students</td>
<td>5 (1.9)</td>
</tr>
<tr>
<td>Sanitation staff</td>
<td>5 (1.9)</td>
</tr>
<tr>
<td>Others</td>
<td>2 (0.8)</td>
</tr>
</tbody>
</table>

Table 2. Department where injury occurred

<table>
<thead>
<tr>
<th>Departments</th>
<th>N = 259 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital ward</td>
<td>141 (54.4)</td>
</tr>
<tr>
<td>Operating room</td>
<td>64 (24.7)</td>
</tr>
<tr>
<td>Outpatient clinic</td>
<td>30 (11.6)</td>
</tr>
<tr>
<td>Clinical laboratories</td>
<td>12 (4.6)</td>
</tr>
<tr>
<td>Others</td>
<td>12 (4.6)</td>
</tr>
</tbody>
</table>

Table 3. When the injury occurred

<table>
<thead>
<tr>
<th>N = 259 (%)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>During use of the device</th>
<th>86 (33.2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between steps of a multi step procedure</td>
<td>48 (18.5)</td>
</tr>
<tr>
<td>During use of item</td>
<td>35 (13.5)</td>
</tr>
<tr>
<td>Assistance of patient</td>
<td>3 (1.2)</td>
</tr>
<tr>
<td>After use/before disposal</td>
<td>119 (45.9)</td>
</tr>
<tr>
<td>While recappping a used needle</td>
<td>38 (14.7)</td>
</tr>
<tr>
<td>In preparations for reuse of reusable instrument</td>
<td>13 (5.0)</td>
</tr>
<tr>
<td>Withdrawing a needle from rubber or other resistant material</td>
<td>11 (4.2)</td>
</tr>
<tr>
<td>Disassembling device or equipment</td>
<td>3 (1.2)</td>
</tr>
<tr>
<td>Other after use, before disposal</td>
<td>54 (20.8)</td>
</tr>
<tr>
<td>During or after disposal of the device</td>
<td>41 (15.8)</td>
</tr>
<tr>
<td>While putting the item into the disposal container</td>
<td>21 (8.1)</td>
</tr>
<tr>
<td>After disposal, item protruded from trash bag</td>
<td>11 (4.2)</td>
</tr>
<tr>
<td>or inappropriate waste container</td>
<td></td>
</tr>
<tr>
<td>After disposal, stuck by item protruding from opening of disposal container</td>
<td>6 (2.3)</td>
</tr>
<tr>
<td>Item pierced side of disposal container</td>
<td>3 (1.2)</td>
</tr>
<tr>
<td>Before use of the device</td>
<td>5 (1.9)</td>
</tr>
<tr>
<td>Other</td>
<td>8 (3.1)</td>
</tr>
</tbody>
</table>

Table 4. Device that caused sharps injuries

<table>
<thead>
<tr>
<th>N = 259 (%)</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>1. Hollow bore devices</th>
<th>172 (66.4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Syringe-needle unit</td>
<td>59 (22.8)</td>
</tr>
<tr>
<td>Winged steel needle</td>
<td>23 (8.9)</td>
</tr>
<tr>
<td>(includes winged-set type devices)</td>
<td>41 (15.8)</td>
</tr>
<tr>
<td>Unattached hypodermic needle</td>
<td>15 (5.8)</td>
</tr>
<tr>
<td>Pre-filled cartridge syringe</td>
<td>13 (5.0)</td>
</tr>
<tr>
<td>Needle on IV line</td>
<td>11 (4.2)</td>
</tr>
<tr>
<td>Vacuum tube blood collection holder/needle</td>
<td>10 (3.9)</td>
</tr>
<tr>
<td>IV catheter stylet</td>
<td>55 (21.2)</td>
</tr>
<tr>
<td>2. Solid devices</td>
<td>45 (17.4)</td>
</tr>
<tr>
<td>Suture needle</td>
<td>6 (2.3)</td>
</tr>
<tr>
<td>Scalpel</td>
<td>4 (1.5)</td>
</tr>
<tr>
<td>Scissors</td>
<td>32 (12.4)</td>
</tr>
<tr>
<td>3. Others</td>
<td>40 (15.8)</td>
</tr>
</tbody>
</table>
in the operating rooms, and 30 cases (11.6%) occurred in the outpatient clinic (Table 2).

Serologic characteristics of the sharps injuries

Among blood contamination incidents, hepatitis C virus (HCV)-positives accounted for the largest number with 52 cases, 20.1% of the total sharps injuries. In 130 cases (50.2%), it was determined that there were no infections. In 20 cases, 19 (7.3%) showed hepatitis B virus (HBV)-positive and one case (0.4%) HIV-positive. One hundred and twenty-six (48.7%) had negative test results and the remaining 57 (22%) were not tested. The data on hepatitis B antibody-positive conversion rates of the staff showed 131 cases (50.6%) of "positive conversion by vaccination," 7 cases (2.7%) of "natural positive conversion," and 68 cases (26.3%) of "negative." The remaining 53 persons (20.5%) replied, "not tested."

The antibody-positive conversion rate by uptake of hepatitis B vaccine was comparable between the group of doctors (52.1%) and the group of nurses (53.9%). All 19 HCWs who were exposed to a hepatitis B antigen-positive patient were already vaccinated and hepatitis B antibody-positive so that no postexposure prophylaxis was needed. Regular follow-up blood tests were received by 98 HCWs. As of October 2005, we found no cases of seroconversion in them.

Examination by job category

We analyzed the incidents among the doctors (51 cases) and the nurses (187 cases) separately. The source patients were found to be infection-negative among 16 doctors (31.4%) and 99 nurses (52.9%). When we consider the rate of the cases exposed to infection-positive patients in each group, we found that doctors were less likely than nurses to report incidents when the blood of a patient is infection-negative.

Among sharps injuries to the doctors, the largest number of incidents occurred during medical procedures (29 cases, 56.9%), followed by recapping (11 cases, 21.6%) (Table 5). Among the nurses, the largest number of cases occurred during clean-up (61 cases, 32.6%), followed by during medical procedures (40 cases, 21.4%) and during medical assistance (34 cases, 18.2%).

Examination by kind of instrument

We examined the incidents in relation to each of the main surgical devices that caused the injuries (Table 6). We considered separately 59 cases (22.8%) that occurred with a syringe-needle unit, 45 cases (17.4%) that occurred with a suture needle, and 41 cases (15.8%) that occurred with a winged steel needle, including winged-set type devices.
that occurred with a winged steel needle, 18 (43.9%) occurred after use but before disposal and 14 (54.1%) occurred during or after disposal. We found that the circumstances of the injuries varied with the kind of instrument. Furthermore, none of the disposable syringes that caused the injuries were provided with a protective mechanism. In addition, although winged steel needles with a protective mechanism were introduced in 2002, our study showed that more than half (53.7%) of the sharps injuries with a winged steel needle occurred in spite of the protective mechanism.

**DISCUSSION**

This 7-year study was the first long-term report showing the current situation of sharps injuries in Japan. Existing studies of sharps injuries tended to focus on the examination of their general trends. However, we considered that to seriously try to reduce sharps injuries, detailed analyses of the incidents by categorizing reported incidents are essential. We carried out this study using the data of EPINet JAPAN from our hospital compiled over a period of 7 years to find out whether factors in the incidents vary with job category, kind of work, or kind of instrument.

Compared with foreign countries, Japan has fewer HIV-positive patients and more HCV-positive patients. This study revealed that HCV-positive patients constituted the largest group with 52 cases, accounting for 20.1% of the total sharps injuries. The HBV-positive patients were involved in 19 cases (7.3%) and an HIV-positive patient was involved in one case (0.4%). It is reported that occupational transmission of HCV to HCWs after percutaneous exposure is 3% and that of HBV is 30%. In our hospital, as of October 2005, there has been no case of occupational infection. This study showed that 52.1% of the injured doctors and 53.9% of the injured nurses were anti-hepatitis B antigen-positive, with very little difference in the vaccination rate between the two groups. A higher vaccination rate should be preferably achieved when we consider the rate of occupational transmission of HBV.

The reliability of sharps injuries data is ambiguous because of under-reporting, so detailed analysis was limited. The surveillance conducted in Japan provides an estimated under-reporting rate of approximately 20%. Therefore, many incidents are expected to remain unreported in our hospital as well. Despite the possibility of under-reporting, we can still identify problems that need to be solved by analyzing the information collected. In fact, unlike nurses, doctors tended to report sharps injuries only when the blood of patients was found to be positive for infectious disease.

The characteristics of sharps injuries vary with the kind of instrument, which has important implications for planning measures to prevent sharps injuries. In the case of winged steel needles, for example, injuries tended to occur while putting the item into a disposable container (24.4%) or after use but before disposal. Because of its shape, the winged steel needle is one of the most difficult instruments to handle. When the needles are pulled out, they often become tangled with tape or drapes, or stick to fingers or vinyl gloves, increasing the risk of needlestick to HCWs. Although winged steel needles with a protective mechanism were introduced in 2002, our study showed that more than half of the sharps injury incidents with a winged steel needle occurred in spite of the protective mechanism. Unfortunately, the number and the rate of the incidents with winged steel needles among all the sharps injuries remain unchanged. Such cases mainly occurred because the protective mechanism was not perfectly put into action or the incidents happened at the time of activating the protective mechanism. Whereas protective shielded winged steel needles have been shown to reduce sharps injuries in one trial, they require conscious manipulation at the end of the procedure. We need to establish necessary measures for these events. Meanwhile, the incidents with a syringe-needle unit occurred chiefly while recapping the used needle (25.4%) or after use but before disposal (20.3%). Recapping remains one of the most common causes of sharps injuries in the world. This is also true in Japan, where syringe-needle units with protective mechanism are not pervasive yet. Introduction of syringes with a protective mechanism would contribute to the reduction of the incidents. Furthermore, the injuries with suture needles occurred at the time of suturing in 14 cases (30.4%), less frequently than the injuries that occurred during assisting in surgery in 20 cases (43.5%). This suggests a greater risk of needlestick when changing a thread with a needle carrier, so that those who assist in surgery need to be more cautious in handling the needle.

We cannot rely on the results of this study as they are. The introduction of EPINet JAPAN increased the reporting rate of sharps injury incidents, but is still not sufficient. Because medical circumstances vary from country to country, the literally translated version of the EPINet form and generated data cannot be easily applied in Japan. Moreover, there are some difficulties in answering the questions because of the diversity of the actual situations. However, we might be able to improve the accuracy of the data by interviewing every injured person and appointing an expert who inputs all the data related to EPINet for more detailed analysis. It is expected that accumulation of data like this report would be valuable for the prevention of sharps injuries in Japan as well as in other countries.
CONCLUSION

We examined the sharps injuries in our hospital registered with EPINet JAPAN over a 7-year period and reported the results in this paper. The problem of under-reporting aside, this detailed study comprising analyses by job category and by kind of instrument provides useful and effective information in terms of sharps injury prevention.

References

Prevalence of hospital-acquired infection in a Moroccan university hospital

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Background: Infection control and hospital-acquired infection (HAI) prevalence reports from developing countries are often not well established because of the lack of staff and resources. The aim of this study was to estimate the prevalence of HAI in a Moroccan hospital as well as to identify its predisposing factors.

Methods: A one-day prevalence survey was conducted in April 2005 at Ibn Sina University Hospital which included all inpatients who had been in the hospital for at least 48 hours.

Results: Among 658 patients surveyed, the prevalence of HAI was 17.8%. The prevalence was higher in intensive care units (50%). The most frequently infected sites were urinary tract (35%) and surgical wounds (32.5%). Microbiological documentation was available in only 31.6% of HAIs. The most frequently isolated organisms were Staphylococcus aureus (30%) and Proteus mirabilis (25%). Results of multiple logistic regression analysis indicated that HAI is linked to the surgical category, a hospital stay of more than 10 days, and the use of intravascular and urinary devices.

Conclusions: The prevalence of HAI is high at our center. This survey provided the principal information for future surveillance and prevention programs in Morocco. (Am J Infect Control 2007;35:412-6.)

Hospital-acquired infection (HAI) continues to be a major public health concern throughout the world because of the associated mortality and socioeconomic costs. The significant impact on the cost-effectiveness of health care provision is especially true in the developing world. Studies have shown that HAI prevalence varies from 3.8% to 18.6% depending on the population surveyed and the definitions used. Although eradication of HAI is impossible, a well-conducted surveillance and prevention program can help reduce the incidence; effective surveillance and infection control may significantly reduce HAI and associated costs. Unfortunately, prospective surveillance is costly, but point-prevalence studies are relatively inexpensive and are widely conducted in several countries.

Few studies have been reported in North-African countries. In Morocco, there is no published data on prevalence of HAI to date. To our knowledge, this is the first report of a point-prevalence study performed in a Moroccan hospital. The aim of this study was to estimate the prevalence of HAI in the Ibn Sina University Hospital as well as to identify its predisposing factors.

MATERIAL AND METHODS

Setting

Ibn Sina University Hospital in Rabat, Morocco is a 1028-bed tertiary-stage hospital that opened in 1955. The bed occupancy rate is of 76% to 85%. The hospital comprises 24 departments (12 surgical, 9 medical, and 3 intensive care units) and admitted adult patients. Gynecology-obstetric and pediatric patients are treated in other structures.

A one-day prevalence survey was conducted in the fourth week of April 2005.

Study population

All inpatients on the day of the survey who had been in the hospital for at least 48 hours were included in the study. Patients admitted at the time of the survey were excluded.

Data collection

Five trained investigators participated in the study, including an epidemiologist who served as the head of the team, a clinical microbiologist, a nurse, and two physicians.

The data included the patient’s age, gender, admission date, ward type (surgery, medicine, and intensive care unit), and duration of hospital stay. Patients were classified into three categories according to the severity of illness as proposed by McCabe and Jackson.
Conditions of immune deficiency as defined by Knaus et al\textsuperscript{19} were noted. Date and classification of surgical operations following Altemeier\textsuperscript{20} were also recorded. All surgical procedures during 30 days, and implants during 12 months prior to the survey were registered. Exposures to invasive devices (urinary catheter, central intravascular catheter, peripheral intravascular catheter, and mechanical ventilation) on the day of, or during the 7 days before the survey were noted. The HAI occurrence, HAI site, micro-organisms responsible for HAI, antimicrobial susceptibility patterns when available, and antibiotic therapy were identified.

Data were collected from clinical records, temperature charts, radiographs, laboratory reports, and information provided by ward personnel. Physical examinations were conducted by a trained physician. Evaluation notes on surgical wounds were examined from the doctor's notes.

Definitions

The HAI was defined according to Centers for Disease Control and Prevention standards:\textsuperscript{21} an infection was defined as nosocomial when it originated in the hospital environment, was not present or incubating on admission, and which appeared 48 hours or more after admission. The HAI was classified as urinary tract, surgical wound, pneumonia, bloodstream, and others (skin and soft-tissue infections, intravascular, and gastrointestinal system infections).

Antibiotic therapy was defined as prophylactic when it was prescribed in patients who did not have a progressive infection in order to prevent infection in traumatized or operated patients.

Statistical analysis

Data were analyzed using the statistical software SPSS version 13.0. Categorical variables were expressed as percentages, and continuous variables were expressed as means and SD. Percentages were compared using Chi-squared test, and means were compared using Student’s $t$ test. Prevalence of HAI (number of infected subjects per 100 admitted patients) and its 95% confidence interval (95% CI) were estimated. A $P$ value of .05 or less was considered to be statistically significant. To study risk factors, univariate analyses were first performed. All risk factors with a univariate $P$ value of less than .25 were included in a multivariate analysis using a stepwise forward multivariable logistic regression model. Adjusted odds ratios (OR) and their 95% CIs were derived.

RESULTS

On the day of the survey, 725 patients occupied a bed in the hospital (bed occupancy rate of 70%), 658 (91%) had been hospitalized for over 48 hours. Three hundred fifty-four patients (53.8%) were from general medicine, 282 (43%) from surgery, and 22 (3.2%) from intensive care units.

Patient characteristics

Of the 658 patients registered in the study, 339 (51.5%) were men and 319 (48.5%) were women. Mean age was 46 years (SD = 16; range, 15-92; median, 46), 23% were less than 30 whereas 22% were older than 60. The mean length of hospital stay from admission to study day was 15 days (range, 3-150; median, 10). According to McCabe index, 64.6% had no fatal disease, 16.4% had ultimately fatal disease (in 6 years), and 19% had rapidly fatal disease (in 6 months). Immune deficiency was reported in 24.3% of patients. A total of 177 patients (27%) underwent surgical intervention during the month before the survey. Surgical wounds were clean in 51%, clean-contaminated in 31%, contaminated in 9%, and dirty in 9%. Exposure to invasive devices is illustrated in Table 1. One hundred thirty-one patients (20%) received antimicrobials upon admission. There were curative in 81% and prophylactic in 19% of cases. The most frequently administered antibiotics were amoxicillin clavulanic acid (21%), ceftazidime (19%), and ciprofloxacin (16%).

Prevalence of HAI

The prevalence of HAI was 17.8% (95% CI: 17.1%-18.5%). None of the 117 infected patients had more than one infection. The prevalence of HAI was highest in intensive care units (50%). It was 19.5% on surgical and 12.8% on general medical wards. The frequency of urinary tract infections was the highest (35%), followed by surgical wound infection (32.5%), lower respiratory tract infection (16.3%), skin and soft tissue infection (8.5%), bloodstream infection (3.5%), gastrointestinal infection (2.5%), and intravascular infection (1.7%).

Microbiological culture results were available in 31.6% of patients who had HAI. Forty-nine micro-organisms were isolated: \textit{Staphylococcus aureus} (30%), and \textit{Proteus mirabilis} (25%) were predominant, followed by \textit{Pseudomonas aeruginosa} (19%), \textit{Acinetobacter baumannii} (10%), \textit{Escherichia coli} (10%), and \textit{Klebsiella pneumoniae} (6%). Methicillin-resistant strains accounted for 40% of isolated \textit{Staphylococcus aureus}. \textit{Acinetobacter baumannii} was resistant to ceftazidime in all cases. \textit{Pseudomonas aeruginosa} was susceptible to ceftazidime in four cases (50%).

Risk factors

By using univariate analysis, patient characteristics (age, gender, immunodeficiency, McCabe index) did...
not increase the risk of HAI (Table 2). However, extrinsic factors associated with HAI were: longer duration of hospital stay (>10 days), being in surgical or intensive care units, undergoing surgery, exposure to intravascular or urinary catheter, and use of antimicrobials (Table 3).

In the stepwise forward logistic regression undertaken to control the effect of confounding variables, the variables found to be significantly associated with HAI were: hospital stay of more than 10 days (from 11–20 days: OR 4.43 95% CI 2.00–9.44; >20: OR 5.51 95% CI 2.50–12.00), surgery (OR 2.81 95% CI 1.81–4.32), urinary (OR 2.3 95%:1.04–5.37), and intravascular catheter (OR 2 95%:1.07–3.90) (Table 4).

**DISCUSSION**

Our investigation revealed an HAI prevalence of 17.8%. This finding is higher than that observed in almost all other point-prevalence studies but similar to that reported from some developing countries: 17.9% found in Tunisia, 14.8% found in Tanzania, and 13.9% found in Malaysia. This high prevalence rate can be explained on the one hand by the lack of infection control programs in Moroccan hospitals, and on the other hand by the high occupancy rate (70%) and the academic structure of our hospital whereby patients undergo advanced medical and surgical procedures. In addition, even though the prevalence surveys are a rapid, inexpensive, and easy way to estimate the HAI problems, they are less acceptable and less reliable than prospective surveillance studies. Moreover, the duration and conditions under point-prevalence studies, seasonal variations, and possible epidemic peaks can influence prevalence rates to an unknown extent.

Patients have had only one site infection even though the high HAI rate (17.8%) is contrary to what is commonly observed. A Tunisian study reported similar findings to ours. Two factors may explain the absence of more than one site infection in our study: the low percentage of microbiological documentation that may lead to an under-estimation in the diagnosis of some site infections, and the study sample included that is lower than other point-prevalence studies conducted in multiple hospital structures. The prevalence of HAI was highest in intensive care units (50%). This may be due to the high frequency of invasive procedure, high frequency of serious illness, and use of large therapeutic agents. The most frequently infected sites were urinary tract (35%) and surgical wounds (32.5%). Our results are similar to those reported in other studies and should call importance to the strong association between urinary tract infection and urinary catheter.
Bloodstream infection was low (3.5%) but comparable to other studies from countries with limited health care resources\textsuperscript{13-15,25} where bloodstream infection rates ranged from 0% to 4.5%. The low rate in our study reflects the limitation of microbiological documentation, as the microbiology reports are the primary source for detection. In addition, if bloodstream infection was much lower than urinary tract infection (35%) in our study, this may be explained by the obtainable urine analyses as vials for blood culture are often unavailable in our hospital.

The surgical site infection (SSI) rate appears to be higher than previous studies,\textsuperscript{12,15,26} but similar to Thai prevalence studies\textsuperscript{27,28} where SSI rates accounted for 19.6% and 16.6%, respectively. This can be explained by the lack of infection control programs and guidelines for SSI prophylaxis in a developing country such as Morocco. It may also reflect the fact that our hospital is a teaching institution to which complex surgical cases are referred. The design of our study cannot allow us to better understand the magnitude of the problem.

Microbiological documentation was available only for 31.6% of infected patients. This rate is lower than that reported in the literature (41-86%).\textsuperscript{6,8} and may lead to overestimation of the infection rate, overuse of broad-spectrum antibiotics, and increased mortality when the prescribed antibiotics are inadequate.\textsuperscript{15} Several factors may explain the low number of cultures in our study. Firstly, because of limited health care resources in Moroccan hospitals, cultures are often only taken in our hospital when empiric antibiotic therapy fails. It is then uncommon practice to obtain cultures when an infection is clinically suspected. Secondly, the study design did not allow us to analyze the actual number of specimens cultured; therefore, it is difficult to determine whether this low rate was due to insufficient laboratory capacity. Furthermore, other prevalence studies from developing countries conducted in university hospitals\textsuperscript{15,25} reported a similarly low availability of microbiology reports (28% and 29%, respectively).

Culture results were obtained mostly from orthopedic surgery and skin infected patients. This may explain the rate of \textit{Staphylococcus aureus} and \textit{Proteus mirabilis} isolated. The high percentage of \textit{Proteus mirabilis} (25%) suggests a possible epidemic episode because most infected patients were in communal surgery rooms. Moreover, the lack of both perisurgical prophylactic measures and education on the principles of asepsis for wound care may explain this peak, as the prevention of HAI in Moroccan hospitals is based only on individual efforts with no organized collective programs. No coagulase-negative staphylococci were identified even with the high SSI rate in our study. This is possibly due to the low microbiology reports that did not allow us to identify it. Other countries that have limited health care resources also did not isolate coagulase-negative staphylococci.\textsuperscript{12,15,26}

The most commonly isolated micro-organisms were multidrug-resistant; it is alarming that antimicrobial therapy administered in our study was considered inadequate and indicated the lack of antibiotic prescribing policy in our hospital.

### Table 3. Results of univariate analysis of association hospital-acquired infection–extrinsic risk factors

<table>
<thead>
<tr>
<th>Factor</th>
<th>Odds ratio</th>
<th>IC 95%</th>
<th>(P) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of hospital stay (days)\textsuperscript{1}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(&lt;6)</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-10</td>
<td>1.85</td>
<td>0.90-4.20</td>
<td>.08</td>
</tr>
<tr>
<td>11-20</td>
<td>4.57</td>
<td>2.20-9.34</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>(&gt;20)</td>
<td>6.50</td>
<td>3.00-13.80</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Wards</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medicine</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surgery</td>
<td>1.62</td>
<td>1.08-2.61</td>
<td>.019</td>
</tr>
<tr>
<td>Intensive care units</td>
<td>6.83</td>
<td>2.70-17.00</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Surgery</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>3.81</td>
<td>2.50-5.85</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Intravascular catheter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>2.50</td>
<td>1.45-4.31</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Urinary catheter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>5.00</td>
<td>2.50-10.70</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Antimicrobials</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>8.70</td>
<td>5.61-13.00</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

\(\textsuperscript{1}\text{95\% Confidence interval.}\)

\(\textsuperscript{1}\text{Stratified by interquartile range.}\)

### Table 4. Risk factors of hospital-acquired infection results of multivariate logistic regression

| Factor                     | Adjusted Odds ratio | IC 95%*  | \(P\) value |
|----------------------------|                     |          |             |
| Length of hospital stay (days)\textsuperscript{1} |            |          |             |
| \(<6\)                      | 1.00               |          |             |
| 6-10                       | 1.80               | 0.88-4.00| .100        |
| 11-20                      | 4.43               | 2.00-9.44| <.001       |
| \(>20\)                    | 5.51               | 2.50-12.00| <.001       |
| Surgery                    |            |          |             |
| No                         | 1.00               |          |             |
| Yes                        | 2.81               | 1.81-4.32| <.001       |
| Intravascular catheter     |            |          |             |
| No                         | 1.00               |          |             |
| Yes                        | 2.00               | 1.07-3.90| .02         |
| Urinary catheter           |            |          |             |
| No                         | 1.00               |          |             |
| Yes                        | 2.30               | 1.04-5.37| .03         |

\(\textsuperscript{*95\% Confidence interval.}\)

\(\textsuperscript{1}\text{Stratified by interquartile range.}\)
Statistical analysis showed that long length of hospital stay, surgery, and invasive devices are linked with an increased risk of HAI, which is in agreement with earlier investigations. Thus, infection control measures in our hospital should be focused on these parameters in the future.

In summary, the prevalence of HAI is high in our Moroccan hospital. This study provides baseline information for future surveillance that should be focused on patients with a long length of hospital stay and/or who have undergone surgery and/or invasive procedures. Infection control programs, appropriate national strategies for prevention, and repeated prevalence studies are needed in our institution in order to decrease the prevalence of HAI.

The authors thank Dr. Hmid for supplying bacterial strains, the hospital director for according logistic, and the head of departments for permission to study patients. A particular thanks to Sir Mohamed El Ahmed for his assistance.

References

Hand washing: Changes in the skin flora

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Minas Gerais, Brazil

Frequent hand washing may result in skin damage and increase the number of microorganisms that colonize the skin. The purpose of this study was to evaluate changes in total flora of healthy and damaged hands that were caused by the use of gloves, soap, and antiseptics. Samples were collected from the healthy and damaged hands of 30 health care professionals before and after washing with water and nonmedicated soap for the technique of sterile polyethylene bag. Fifteen additional volunteers (technicians and students) were asked to wash their hands 20 times with water and soap; those with complaints of irritation were evaluated separately. Damaged or healthy hands did not present statistically significant differences (P > .05) in terms of qualitative analysis of epidemiologically important microorganisms; however, washing with water and soap was effective only for healthy hands. In short, the water and soap washing of damaged hands was not effective in reducing their contamination. (Am J Infect Control 2007;35:417-20.)

For more than a century, skin hygiene, particularly of the hands, has been accepted as one of the primary mechanisms to control the spread of infectious agents. Nevertheless, the numbers of organisms spread from the hands of nurses who washed frequently with an antimicrobial soap actually may increase as a result of skin health compromise. One study showed that nurses with damaged hands were twice as likely to be colonized with Staphylococcus hominis, S aureus, gram-negative bacteria (GNB), enterococci, and Candida spp., and their hands had a greater number of species.

Presently recommended hand antisepsis takes the risk from the patient only to put the burden on the health care provider. This is neither acceptable nor prudent. Rather than fighting microorganisms at the expense of the skin’s health, the skin and its own defenses should be considered collaborators in combating infectious diseases.

Skin damage of hands also explains why those who must wash their hands very frequently (for example, several times per hour) actually shed more microorganisms those do those who wash less frequently.

The purpose of this study was to evaluate qualitative and quantitative changes when comparing total flora of damaged hands being washed or when the hygiene is associated with the irritant action of hygiene procedures or wearing gloves.

METHODS

Four groups of volunteers were selected. Fifteen nursing professionals from different units of the Hospital das Clínicas, Universidade Federal de Uberlândia (HC-UFU) who had evidence of dermatitis or other conditions that were related to the wearing of gloves or products for hand hygiene (“damaged hands”). None of these subjects was receiving antimicrobial agents nor had skin disease (eczema or psoriasis). Fifteen nursing professionals at the same institution with healthy hands without signs or symptoms of lesions or irritation were assigned to the second group (“healthy hands”). These 2 groups had their hands washed only once with water and 3 mL of nonmedicated liquid soap (Johnson Diversey, Sao Paulo, Brazil) for 30 seconds.

Fifteen students and laboratory technicians, divided into 2 sub-groups, performed 19 consecutive hand washings with nonmedicated liquid soap. After a 1-hour interval, the twentieth washing was performed according to the same protocol. After the repeated washing, this group was classified for irritation (“irritated hands”) or not (“normal hands”). As a rule, all 45 of the volunteers rubbed their hands in a standardized protocol and filled out a self-evaluation questionnaire (Hand Skin Assessment Form) by direct visual observation for redness, dryness, tingling, and scaling. The dominant hand of volunteers was sampled into a sterile polyethylene bag with 75 mL of soy tryptase.
broth (Difco, MD) added to 0.1% Tween 80,3 after a
1-minute massage.6 An inoculum of 0.1 mL of this
solution (in 1:10 and 1:100 dilutions in saline 0.95%)
was inoculated onto a plate containing soy tryptase
agar (Difco), MacConkey agar (Difco) with and without
ceftazidime 2 µg/mL (Glaxo, Rio de Janeiro, Brazil), salt
mannitol agar (Difco) with and without oxacillin 6 µg/mL
and agar bile esculine (Dignolab, Barcelona, Spain). All
were incubated at 37°C for 24 to 48 hours, dextrose
agar sabouraud (Difco), and then incubated at room
temperature for 48 to 72 hours. Identification of bacte-
rial species and yeasts was performed by standard

Table 1. Quantitative and qualitative evaluations of microorganisms with and without epidemiological significance
on healthy and damaged hands of health professionals

<table>
<thead>
<tr>
<th>Microorganisms</th>
<th>Healthy hands (n = 15 (%))</th>
<th>Damaged hands (n = 15 (%))</th>
<th>P (95 %)</th>
<th>OR (CI)</th>
<th>Total (n = 30 (%))</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. aureus a</td>
<td>4 (27.3)</td>
<td>3 (20.0)</td>
<td>1</td>
<td>1.45</td>
<td>7 (23.3)</td>
</tr>
<tr>
<td>SCN</td>
<td>11 (73.3)</td>
<td>9 (60.0)</td>
<td>.69</td>
<td>1.83</td>
<td>20 (66.7)</td>
</tr>
<tr>
<td>GNB b</td>
<td>1 (6.7)</td>
<td>3 (20.0)</td>
<td>.59</td>
<td>0.29</td>
<td>4 (13.3)</td>
</tr>
<tr>
<td>GPB</td>
<td>-</td>
<td>1 (6.7)</td>
<td>-</td>
<td>-</td>
<td>1 (3.3)</td>
</tr>
<tr>
<td>Enterococci c</td>
<td>-</td>
<td>-</td>
<td>P</td>
<td>0.29</td>
<td>6 (13.3)</td>
</tr>
<tr>
<td>Yeast-form fungi d</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total Σ(a+b+c+d)</td>
<td>5 (33.3)</td>
<td>6 (40.0)</td>
<td>.70</td>
<td>0.75</td>
<td>11 (36.7)</td>
</tr>
<tr>
<td>CFU/mL ± SDa</td>
<td>3.47 ± 0.61</td>
<td>3.33 ± 1.01</td>
<td>.34</td>
<td>-</td>
<td>3.4 ± 0.80</td>
</tr>
</tbody>
</table>

SCN, Staphylococcus coagulase-negative; GPB, gram-positive bacilli; CFU, colony-forming unit; SD, standard deviation; OR, odds ratio.
aTotal number of S. aureus, bGNB, centerococci, and dyeast-form fungi.
aTotal count of CFUs ± standard deviation (t test).

Table 2. Quantitative and qualitative evaluation of microorganisms with and without epidemiological significance
on normal and irritated hands of volunteers, after repeated washing with water and soap

<table>
<thead>
<tr>
<th>Microorganisms</th>
<th>Normal hands (n = 6 (%))</th>
<th>Irritated hands (n = 9 (%))</th>
<th>P (95 %)</th>
<th>OR (CI)</th>
<th>Total (n = 15 (%))</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. aureus a</td>
<td>2 (33.3)</td>
<td>2 (22.2)</td>
<td>1.0</td>
<td>1.75</td>
<td>4 (26.6)</td>
</tr>
<tr>
<td>SCN</td>
<td>4 (66.6)</td>
<td>7 (77.7)</td>
<td>1.0</td>
<td>0.57</td>
<td>11 (73.3)</td>
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<td>GNB b</td>
<td>1 (16.6)</td>
<td>1 (11.1)</td>
<td>1.0</td>
<td>1.60</td>
<td>2 (13.3)</td>
</tr>
<tr>
<td>GPB</td>
<td>3 (50.0)</td>
<td>3 (33.3)</td>
<td>.62</td>
<td>2.0</td>
<td>6 (40.0)</td>
</tr>
<tr>
<td>Enterococci c</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Yeast-form fungi d</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total Σ(a+b+c+d)</td>
<td>3 (50.0)</td>
<td>3 (33.3)</td>
<td>.62</td>
<td>2.0</td>
<td>6 (40.0)</td>
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<tr>
<td>CFU/mL ± SDa</td>
<td>3.54 ± 0.46</td>
<td>4.43 ± 0.41</td>
<td>.01a</td>
<td>-</td>
<td>3.98 ± 0.43</td>
</tr>
</tbody>
</table>

SCN, Staphylococcus coagulase-negative; GPB, gram-positive bacilli; CFU, colony-forming unit; SD, standard deviation; OR, odds ratio.
aTotal number of S. aureus, bGNB, centerococci, and dyeast-form fungi.
aTotal count of CFUs ± standard deviation (t test).
aStatistically significant (P ≤.05).

Table 3. Comparison of total flora on healthy and damaged hands before and after hand washing

<table>
<thead>
<tr>
<th>Volunteers</th>
<th>Before CFU/mL ± SDa</th>
<th>After CFU/mL ± SDa</th>
<th>RF</th>
<th>P (95 %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health care workers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Healthy hands (n = 15)</td>
<td>3.47 ± 0.61</td>
<td>3.15 ± 0.63</td>
<td>0.32</td>
<td>.01*</td>
</tr>
<tr>
<td>Damaged hands (n = 15)</td>
<td>3.33 ± 1.01</td>
<td>3.29 ± 1.30</td>
<td>0.04</td>
<td>.40</td>
</tr>
<tr>
<td>Students and laboratory technicians</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal hands (n = 6)</td>
<td>4.39 ± 0.71</td>
<td>3.54 ± 0.46</td>
<td>0.85</td>
<td>.03*</td>
</tr>
<tr>
<td>Irritated hands (n = 9)</td>
<td>4.58 ± 0.50</td>
<td>4.43 ± 0.41</td>
<td>0.15</td>
<td>.27</td>
</tr>
</tbody>
</table>

CFU, colony-forming unit; RF, risk factor.
aTotal count of CFUs ± standard deviation (t test).
aStatistically significant (P ≤.05).
microbiologic techniques. Student’s t test was applied to compare counts of bacteria by using GraphPad Prism 4 version 2003 (Software MacKieu, San Diego, CA). The χ² tests were used to compare the proportions of different types of organisms; odds ratios (ORs) and corresponding 95% confidence intervals (CI) were calculated by using Epi Info version 2000 (CDC, Atlanta, GA). Statistical significance was defined by P ≤ .05.

The Ethics Committee of the UFU approved this study.

RESULTS

The greater number of the volunteers attribute damage in hands to hand hygiene and wearing gloves. In a total of 15 volunteers with damage, 5 (33.3%) were the result of wearing gloves, 1 (6.7%) was the result of using soap, 4 (26.7%) were the result of gloves and soap, 2 (13.3%) were the result of gloves and alcohol, 1 (6.7%) was the result of alcohol and soap, and 2 (13.3%) were the result of wearing gloves, using soap, and alcohol. The score of classification was 19.4, with redness and tingling being the most frequent signs. Table 1 shows similar means of 3.47 for those with healthy hands and 3.33 for those with damaged skin (P = .54). No group presented a significant qualitative difference in terms of S aureus, GNB, yeast, and enterococci. Isolated GNB were identified as Enterobacter agglomerans (2) and Escherichia coli (2); one of the samples was resistant to third-generation cephalosporin (Table 1). In volunteers who did not have contact with patients, the most frequent complaints were dryness (60%) and tingling (6.6%), classified as irritated; 6 of these volunteers did not report any signs or symptoms (normal hands). The score of classification was 26.6. After the repeated washing with water and soap, the count of colony-forming units was higher (4.43) on irritated hands (P < .05), but there were no qualitative differences among normal hands. The GNBs were identified as Enterobacter agglomerans and Escherichia coli (Table 2). In healthy hands and normal hands, there was a significant reduction in the amount of hand contamination after water and soap washing, with a reduction factor (RF) of 0.52 and 0.85 (P < .05), respectively. This was different from populations with damaged hands and irritated hands (RF: 0.04 and 0.15, respectively; Table 3).

DISCUSSION

When frequent hand washing with water and soap leads to removal of the protective lipid external layer, followed by transepidermal loss of water as well as several cutaneous signs (e.g., roughness characterized by scaling and dryness, itch, dermatitis provoked by microorganisms and allergens penetrating the corneal layer) in addition to redness. Wearing gloves contributes to the problem, because this creates a humid environment that favors microbial growth, and they contain irritants (e.g., latex, talcum powder). The damage that is caused to the hands of health professionals is a result of hand washing and the use of irritating agents. In this study, however, the greatest proportion (86.6%) of skin damage was attributed to wearing gloves. Hand classification was based on the report of the volunteers and the Hand Skin Assessment Form—a self-rating scale to assess the condition of one’s hands. Previous studies have combined with objective clinical measures of skin irritation to provide valid and reliable measures of hand skin condition that are reproducible and have a high level of sensitivity and specificity. This investigation did not reveal differences in the qualitative microbiological analysis of damaged hands of volunteers with and without contact with patients. This was different from the report by Larson et al., which noted an increase in the colonization by microorganisms, such as S hominis, S aureus, and GNB, when hands are damaged.

This study has limitations because there was a small number of volunteers. We should note, however, that the decrease in the microbial count of colony forming units on healthy hands was significant when compared with irritated hands, including those with lesions from repeated washing. Other studies suggest that the numbers of organisms spread from the hands of nurses who washed frequently, actually increased after a period of time; this was associated with declining skin health that resulted in insufficient reduction of the contamination. All of this suggests that hand washing with soaps, antimicrobial products, and the use of gloves need careful reassessment of the damage that they cause to skin and the resultant increased risks for transmitting infectious agents.

Although hands that were damaged by the use of gloves or repeated washing with water and soap did not present more epidemiologically important microorganisms, the reduction of the total flora, when washed, was significantly lower.

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References


Contact investigation of a case of active tuberculosis in the community

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Jefferson and Ashtabula, Ohio

Background: Ashtabula County, Ohio, has been a low-risk county for tuberculosis (TB) based on the Centers for Disease Control and Prevention guidelines. The Ashtabula County TB clinic is provided through the Ashtabula County Health Department. Over the past 10 years, there has been an annual average of one to 2 active cases of TB seen and treated at the county TB clinic.

Contact investigation: In 2005, over a period of 3 months there were 6 cases of active TB identified in Ashtabula County. Contact investigation and follow-up were complicated by the fact that the suspected source case likely had active disease for more than 4 years and had some medical procedures performed at health care facilities in another county. This person was unaware of having TB and was identified through contact investigation by the county health department staff and sent for testing. The investigation was complicated further because the index case did not reveal contact with the suspected source case, although this was confirmed later through investigation. Contact investigation involved Ashtabula County and notification of other counties in Ohio. The Ohio Department of Health also was notified.

Discussion: Following identification of each case of active TB, contacts were identified through interviews with the clients, physicians, and health care facilities where clients were treated. Initially in Ashtabula County, 97 people were reviewed for follow-up, and 87 people were skin tested for TB. There were 7 conversions.

Conclusion: Although the overall incidence of TB has declined in the United States, increased awareness of TB, appropriate diagnostic work-up, treatment, and control measures among health care professionals in low-incidence areas is increasingly important. Contact investigation of a case of TB requires diligence and effective communication. (Am J Infect Control 2007;35:421-4.)

The Ashtabula County Health Department, located in Jefferson, OH, has the responsibility for the county tuberculosis (TB) clinic. The TB clinic operates under the recommendations and guidelines from the Centers for Disease Control and Prevention (CDC) and the Ohio Department of Health.1,2 Typically, Ashtabula County has an average of one or two active cases of TB treated and followed in the clinic per year. An active case is defined by the CDC guidelines.3,4 Patients who have active or latent TB are treated and followed through the TB clinic in Ashtabula County. Follow-up and treatment are provided according to guidelines of the CDC and the American Thoracic Society.5,6 All active cases are followed with directly observed therapy as recommended.7,8 A significant increase in the number of cases of TB was noted during the first part of the year 2005 (Table 1).

CASE REPORT

During the month of January 2005, the index patient, a 28-year-old white woman, presented at the Ashtabula County Health Department to have a tuberculin skin test (TST) performed for a pre-employment physical. This patient had no history of having a TST performed. Additionally, the patient did not have indication to be screened for TB except for the employment physical. The TST was administered and results were read as 10 mm induration. A history was conducted by a public health nurse. The patient denied symptoms of TB at that time and contact with anyone whom she knew to have TB or symptoms of TB. A chest radiograph and sputum samples were obtained (Table 1).

In February, the patient experienced dyspnea and discomfort in her left rib area. The patient was seen and evaluated by her primary care physician and admitted to a local hospital with a diagnosis of massive left pleural effusion. A left percutaneous pleural biopsy was done, which identified necrotizing granulomas and rare acid-fast bacilli (AFB). A sputum DNA probe was done and was positive for Mycobacterium tuberculosis complex. She was started on a 4-drug therapy for...
pulmonary and extrapulmonary active TB as recommended in the guidelines.\textsuperscript{3,9}

Over the next 3 months, the health department became aware of 5 additional cases of active TB in the county (Table 1).

**CONTACT INVESTIGATION**

Contact investigation is the responsibility of the health department to ensure that all persons who are suspected of having TB are identified and evaluated promptly and appropriate treatment is started and completed successfully.\textsuperscript{10,11} Ashtabula County Health Department nurses conducted contact investigation for all cases of identified active TB. Investigation was conducted according to the CDC recommendations using the traditional circle or ring method.\textsuperscript{1,6}

All contacts to the index case were baseline tested and all tested 0 mm. All contacts were tested again at 12 to 14 weeks and all tested 0 mm.

Contact investigation for all additional cases was conducted in the same manner. It was during the interview with the third patient that the suspected source patient was identified. This patient revealed to the public health nurse that her son had a persistent cough for a prolonged period and had recently begun experiencing hemoptysis. It also was discovered during the interview that the third patient was a sister to the second identified case, and that the sister had visited the home of the third patient.

The fourth case and the suspected source case is the son of case number three. During the interview with case number four, the public health nurse discovered that he had been symptomatic for more than 4 years with a cough and began experiencing hemoptysis, malaise, loss of appetite, and loss of weight. The patient revealed that he had always been tall and thin and was told that this was the reason for a spontaneous collapsed lung he experienced in 1987. The patient had been followed by his local primary care physician and had received treatment with antibiotics several times for chronic bronchitis. Records obtained from his primary care physician’s office for the TB clinic file showed that the patient had a chest radiograph done in 1999 that identified an abnormal area in the left lung. The report stated the abnormality could represent pneumonia, but TB could not be excluded and a follow-up chest radiograph was needed after

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**Table 1. Cases of tuberculosis reported to the Health Department**

<table>
<thead>
<tr>
<th>Case number</th>
<th>Date health department notified</th>
<th>Date &amp; results of TST</th>
<th>Date &amp; result of CXR</th>
<th>Date of collection &amp; results of sputum smear</th>
<th>Date of collection &amp; results of sputum cultures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. (index case)</td>
<td>January 5, 2005</td>
<td>01/05/05 (10 mm)</td>
<td>Left upper lobe nodular density</td>
<td>02/06/05</td>
<td>02/07/05 MTB INH resistant</td>
</tr>
<tr>
<td>2.</td>
<td>March 11, 2005</td>
<td>03/11/05 (32 mm)</td>
<td>Nodule left lung base</td>
<td>03/14/05</td>
<td>03/15/05 MTB complex from bronch</td>
</tr>
<tr>
<td>3.</td>
<td>March 17, 2005</td>
<td>03/25/05 (30 mm)</td>
<td>Right lung mass or infiltrate</td>
<td>03/18/05</td>
<td>03/19/05 Negative (already on medications at time of collection)</td>
</tr>
<tr>
<td>4. (suspected source case)</td>
<td>March 31, 2005</td>
<td>03/18/05</td>
<td>Extensive disease</td>
<td>04/01/05</td>
<td>04/02/05 MTB complex</td>
</tr>
<tr>
<td>5.</td>
<td>March 12, 2005</td>
<td>03/15/05 (15 mm)</td>
<td>Right upper lobe mass or infiltrate</td>
<td>03/10/05</td>
<td>2+ AFB (needle biopsy) MTB complex (needle biopsy)</td>
</tr>
<tr>
<td>6.</td>
<td>April 2, 2004</td>
<td>07/10/04 (30 mm)</td>
<td>Negative for disease</td>
<td>04/05/05</td>
<td>04/05/05 Negative (already on medications at time of collection)</td>
</tr>
</tbody>
</table>

CXR, chest radiograph; MTB, Mycobacterium tuberculosis; INH, isoniazid; AFB, acid-fast bacilli.

*Started medications for latent TB in July of 2004. Patient completed only 1 month of medications and made the choice to stop medications.
treatment. The patient was treated for pneumonia with antibiotic therapy, but no follow-up chest radiograph was done at that time.

In February of 2004, the patient went to an out-of-county facility for back surgery. The patient’s surgery was cancelled because the anesthesiologist was suspicious of TB and refused to administer anesthesia until further evaluation was completed. The chest radiograph at that time revealed an extensive abnormal density in the left upper lobe. The patient was seen by a pulmonologist at the facility. A CT scan was performed; it showed extensive consolidation and numerous nodular densities in both lungs that were highly suspicious for TB or other atypical infection. Further evaluation with a pulmonary consultation was recommended. The patient was seen by a pulmonologist and cleared for surgery at that time, with no further work-up for TB. The patient had back surgery done a few weeks later. After surgery the patient was again seen and treated for chronic bronchitis by his primary care physician. Results of the patient’s chest x-ray and CT scan were requested for the TB clinic file and received.

In March of 2005, the patient’s chest radiograph demonstrated extensive disease with cavities and nodular infiltrates in the mid and right lower lung. Further investigation was recommended to exclude TB. Sputum specimens for AFB smears and cultures were obtained through the Ashtabula County TB clinic. A TST was administered, and results measured 20 mm induration. The patient was started on a 4-drug TB regime as recommended. The AFB smears showed 4+ and 3+ AFB. Cultures revealed MTB.

In review of the past and present chest radiographs, the TB clinic physician believes that this patient began developing active TB in 1999.

Follow-up with the Infection Control Practitioner (ICP) at the facility where this patient had surgery identified the fact that the physician who evaluated the patient believed that the abnormal chest findings were due to the collapsed lung that the patient had experienced years previously. The physician did not consider the possibility of TB at that time. The ICP conducted follow-up in the facility. There were no positive results on baseline or follow-up testing.

In addition to the contacts in the out-of-county facility, contact investigation for the suspected source case involved TB skin testing a total of 56 people in Ashtabula County. Because the patient was residing in the same home as his mother, and she had already skin tested positive, the circle investigation was expanded to include other family members, friends, and coworkers.

Through the investigation by the public health nursing staff, connection was made between the first, second, third, and fourth cases. It was found that the second reported case was an aunt of the fourth reported case and a sister of the third case. Public health nurses visited the plant where the fourth reported case worked, because many coworkers had concerns. Fortunately, the area where this person worked was open and well ventilated. As interviewing contacts continued it was found that the first reported case (index case) and the suspected source patient, case number four, had lived in the same residence for a few months approximately 1 year previously. Neither the index case nor the suspected source patient initially identified each other on contact lists. This relationship was revealed by other contacts and verified by the index case and the suspected source case when questioned by the public health nurse.

Contact investigation for the fifth and sixth case was conducted. No connection was made between these cases and any of the other cases.

RESULTS

The investigation of all 6 cases involved skin testing a total of 81 people. All people who tested positive had some type of contact with the suspected source case. A total of 7 people who had contact with the suspected source case tested positive. In addition to his mother, his aunt, and the index case, 72 additional possible contacts were interviewed by public health nurses. Fifty-six contacts were TB skin tested, which resulted in a total of 4 additional positive skin tests. This included only one coworker who confirmed that she also spent time with the suspected source case outside of the work setting. Additionally the patient’s current girlfriend, her daughter, and the daughter’s boyfriend skin tested positive. The patient reported spending a significant amount time around these individuals in his girlfriend’s home.

Follow-up with repeat TST was done in 3 to 4 months from the initial date of testing for contacts of all active patients whose skin test was 0 mm at baseline test. Follow-up testing did not result in any additional positive skin tests.

DISCUSSION

Although the suspected source patient is believed to have had active TB for approximately 5 years before he was diagnosed properly, and he resided and worked in Ashtabula County during that entire time, only people who had spent time in the same residence as he did on a routine basis developed latent or active TB. This is consistent with many previous studies; however, there also are documented cases of TB transmission from casual contact.
Tuberculosis continues to be a devastating disease worldwide; it is believed to be present in about one third of the world’s population. Although the overall incidence of TB is declining in the United States, increased awareness of the disease, appropriate diagnostic work-up, and appropriate treatment among physicians and other health care professionals in low-incidence areas is increasingly important. Primary care physicians provide the critical first steps in reducing the incidence of active cases and detecting drug resistance.

In the cases reported in the paper, many of the physicians were not considering TB. The suspected source case had TB for a prolonged period of time before it was diagnosed properly, which resulted in a small outbreak in a community. Additionally, the mother of the suspected source patient was started on TB medications before sputum smears or cultures were obtained. The physician did not believe that she had TB, but started her on TB medications as a “precaution” because of her positive TST and abnormal chest radiographs. The physician who suspected a malignancy of the lung did not report this case to the health department. He told the patient—although he did not believe that she had TB—that she should call and just make the health department aware that she had started on TB medications as a precaution.

The decrease in TB incidence creates challenges for public health. Since cases of TB have decreased, fewer primary care providers or even specialists have diagnosed and treated TB. Training and education are crucial for maintaining provider competence.

According to the CDC, providers need training so they will “think TB” in the first place and become familiar with the advantages of collaborating with the health department. Public health staff must find more effective strategies to assure that providers are current and remain current with new guidelines for the diagnosis and treatment of TB.

Contact investigation of a case of TB requires diligence and effective communication among providers, public health staff, and patients.

References
The general public’s awareness, knowledge, and perceptions of “staph”—with a focus on community-associated methicillin-resistant Staphylococcus aureus

To the Editor:

Methicillin-resistant Staphylococcus aureus (MRSA), recognized as a cause of health care–associated infections since the late 1960s, has emerged as a cause of skin, soft tissue, and invasive infections in healthy persons in the community.\(^1^\)\(^-\)\(^2^\) Factors that have been associated with community-associated MRSA (CA-MRSA) can be categorized into the five “C” framework of general infection control principles: Compromised (nonintact) skin, Contact with a person colonized or infected with MRSA, contact with Contaminated environmental surfaces or shared items, Lack of Cleanliness and personal hygiene, and Crowding.\(^3^\)\(^-\)\(^6^\) Little is known about the public’s awareness, knowledge, and perceptions about CA-MRSA infections. Therefore, we conducted focus groups with members of the public to assist in the development of educational and other interventions to reduce the incidence of this emerging public health and infection control challenge.

Eight focus groups, two each in New Orleans, Louisiana; Atlanta, Georgia; Houston, Texas; and Phoenix, Arizona, were conducted in July 2005. Market research firms recruited participants using a convenience sample of parents or legal guardians of at least one child under the age of 12 residing within each of the metropolitan areas. Quotas for recruitment were established for the following variables: age, ethnicity, gender, and income. Individuals were excluded if they or their relatives worked in the medical field. One trained moderator conducted all of the focus groups using a standardized script. All focus groups were tape recorded and transcribed, and responses were coded for themes, which were aggregated into standardized categories using qualitative methods. The Kruskal-Wallis test was used to determine significance between responses.

Sixty-three individuals participated in the focus groups; 57% female, 54% Caucasian, 27% African American, 16% Hispanic, 2% Asian, and 2% were of other racial/ethnic groups. Nearly 90% (range: 78%–100% among cities) had heard of Staph (\(S.\) aureus); only 22% (17%–33%) and 8% (6%–11%) had heard of MRSA and CA-MRSA, respectively. Participants reported hearing about staphylococcal infections from: person(s) with Staph or MRSA (27%), a health care provider (22%), a lay person (20%), the news/media (18%), a class or work-related training (8%), and/or personal experience (4%).

When asked what they know about Staph, MRSA, or CA-MRSA, participants most frequently reported that these organisms caused blood disease (35%); a rash, impetigo, or “big sores” (30%); were “flesh eating” (20%); or caused heart disease (15%). Participants also described person-to-person transmission of these infections as occurring through cuts or broken skin (63%); “being dirty” (21%); sneezing (8%); scratching (8%); environmental transmission as occurring in the hospitals (50%), through touching doorknobs or other shared surfaces (17%), being related to surgery (17%); and by swimming pool water (17%). Other described transmission modes included bug bites and fish juice; the latter was mentioned in the context of food preparation.

Participants were asked to rate how common Staph, MRSA, and CA-MRSA are using a 5-point rating scale from 1, meaning “not at all common,” to 5, meaning “very common.” Overall, perceived frequency of these diseases had a mean rate of 3.5 (2.5 in Houston, 3.2 in Atlanta, 3.4 in Phoenix, and 4.4 in New Orleans; \(P = .005\)).
Finally, participants were asked what they could do to keep Staph, MRSA, and CA-MRSA from spreading. Sample responses included: stay at home and limit contact with others, wash your hands, and sanitize cuts and clean wounds properly (Table 1).

Preferred formats for learning about diseases such as CA-MRSA included: TV (75%), magazines (63%), brochures (54%), Internet (54%), newspapers (52%), radio (57%), and posters (33%). Participants identified health care providers (98%), health departments (76%), the Centers for Disease Control and Prevention (75%), friends, relatives, or coworkers (27%), and community or religious leaders (14%) as the most trusted sources for health information.

These qualitative findings, gathered in a series of eight focus groups, were drawn from a convenience sample and therefore may not be representative of the public at large. However, this was the first assessment of this type, and the data provide initial insight into the general public’s awareness, knowledge, and perceptions of staphylococcal infections. Overall, awareness of Staph was high (89%), much higher than awareness of either MRSA or CA-MRSA. Awareness and knowledge of the type of infections Staph, MRSA, or CA-MRSA cause, how they are transmitted, and perceptions of how common these infections are varied among cities. The public’s knowledge of general infection control strategies was consistent with, and could be categorized according to, the five “C” framework of factors associated with transmission of Staph or MRSA.6 These data suggest that national and local communication and educational efforts are needed to promote awareness and recognition of all staphylococcal infections. These efforts should be delivered using preferred formats and through the sources considered most trusted to improve the dissemination of information and adoption of preventive health and infection control measures by the general public.

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