Published in final edited form as:
Infect Control Hosp Epidemiol. 2008 July ; 29(7): 583–589. doi:10.1086/588701.

Detection of Methicillin-resistant *Staphylococcus aureus* and Vancomycin-resistant Enterococci by Healthcare Workers on Infection Control Gown and Gloves

Graham M. Snyder, MD, **Kerri A. Thom, MD**, **Jon P. Furuno, PhD**, **Eli N. Perencevich, MD, MS***, **Mary-Claire Roghmann, MD, MS**, **Sandra M. Strauss, BS, M(ASCP)**, **Giora Netzer, MD, MSCE**, and **Anthony D. Harris, MD, MPH**

From the Departments of Epidemiology and Preventive Medicine (G.M.S., K.A.T., J.P.F., E.N.P., M.R., S.M.S., A.D.H.) and Internal Medicine, Division of Pulmonary and Critical Care Medicine (G.N.), University of Maryland School of Medicine, Baltimore, Maryland, and the VA Maryland Health Care System, Baltimore, Maryland (E.N.P., M.R., A.D.H.)

Abstract

Objective—To assess the frequency of detection and risk factors for detection of methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococci (VRE) by healthcare workers on infection control protective gown and gloves.

Design—We observed interactions between healthcare workers and patients during routine clinical activities. Cultures were taken of healthcare workers' hands prior to entering the room, disposable infection control gown and gloves after completing patient care activities, and of hands immediately following removal of infection control protective gown and gloves.

Setting—A 29-bed medical intensive care unit at an urban tertiary-care academic hospital, the University of Maryland Medical Center.

Results—Seventeen percent (24/137, 95%CI ± 6.4%) of healthcare workers caring for a patient with MRSA and/or VRE acquired that organism on their gloves, gown or both. Contacting an endotracheal tube or tracheostomy ($P < 0.05$), contacting the head and/or neck of a patient ($P < 0.05$), and the presence of a percutaneous endoscopic gastrostomy/jejunostomy tube ($P < 0.05$) were associated with increased risk of detection of antibiotic-resistant organisms.

Conclusions—Gloves and gowns are frequently contaminated with MRSA and VRE during routine care duties. Contact with the head or neck, care for an endotracheal tube or tracheostomy, and the presence of an endotracheal tube or tracheostomy may increase the risk of detection of antibiotic-resistant organisms.

BACKGROUND

Nosocomial infections caused by methicillin-resistant *Staphylococcus aureus* (MRSA) and vancomycin-resistant enterococci (VRE) cause significant morbidity and mortality. The

Address correspondence and reprint requests to Anthony Harris, MD, MPH, Department of Epidemiology and Preventive Medicine, University of Maryland School of Medicine, 100 N. Greene Street, Lower Level, Baltimore, MD 21201; e-mail: aharris@epi.umaryland.edu.

*Primary affiliation is the VA Maryland Health Care System.

Preliminary data on detection frequency of antibiotic resistant bacteria presented at the 47th Annual Interscience Conference on Antimicrobial Agents and Chemotherapy (ICAAC); Chicago, Illinois; September 17, 2007 (Abstract K-463).

Potential conflicts of interest: All authors report no conflicts of interest relevant to this study.

Centers for Disease Control and Prevention and the Society for Healthcare Epidemiology of America recommend contact precautions (gloves and gown precautions) for healthcare workers (HCWs) caring for hospitalized patients colonized or infected with MRSA or VRE.[1,2] Although studies have demonstrated that gown and glove use[3–5] included as a component of a broader infection-control policy[6–10] in an epidemic or endemic setting reduces transmission of MRSA and VRE, the mechanisms for this benefit are not well understood.

The detection rate of MRSA or VRE on the gowns or gloves of HCWs in either a standardized or routine setting has been reported from as low as 4% and as high as 67%.[11–15] To our knowledge, this is the largest study to date investigating the frequency of detection of MRSA or VRE on HCW gowns or gloves in a routine clinical study. Furthermore, to our knowledge no study has investigated risk factors for the detection of MRSA on HCW gowns or gloves, and only one study has investigated risk factors for the detection of VRE on healthcare worker gloves.[11]

In this study, we sought to evaluate the frequency of detection of MRSA and VRE by HCWs on infection control gown and gloves during routine clinical activities and to evaluate risk factors for the detection of these organisms on infection control protective gown and gloves.

METHODS

Study Population

This study was conducted in a 29-bed medical intensive care unit at an urban tertiary-care academic hospital, the University of Maryland Medical Center. HCWs were approached immediately prior to performing non-emergent, routine patient-care duties for patients infected or colonized with MRSA and/or VRE during randomly chosen days and times in February, August, and September of 2007. Patients were identified as MRSA- and/or VRE-positive by active surveillance cultures on admission, current clinical culture with either organism during their index hospitalization, or history of positive MRSA or VRE cultures at the index institution. The Medical Center's infection control policy includes: private room for patients identified to have MRSA or VRE, handwashing before entering and on exiting a room with antimicrobial soap or alcohol-based hand hygiene product (both are available), required disposable gloves and gown for entry into the room, patient-dedicated disposable patient care equipment (stethoscope, blood pressure cuff, digital thermometer), a ban on artificial nails or natural fingernails with tips longer than ¼ inch for HCW with direct patient contact and who handle patient-care supplies, and a standardized cleaning protocol with particular procedures for isolation rooms, germicidal cleaning products, and discharge room cleaning. The study was approved by the University of Maryland, Baltimore Institutional Review Board.

Observations

Cultures were taken of the HCWs' hands immediately prior to donning gowns and gloves. Routine HCW activities were then observed, and possible risk factors for detection of MRSA and VRE were collected, including provider type, time spent in the room, patient variables, and nature and location of HCW-patient contact. When uninterrupted routine activities were completed, the gloves and then gown were cultured and subsequently removed by the HCW. Hands were then cultured a second time immediately after removal of gloves and gown and before hand cleansing. An observation was excluded if the initial hand culture was positive for either MRSA or VRE. Hand hygiene prior to donning gloves and gown, method of removing gloves and gown, and hand hygiene after all cultures were collected were performed at HCW discretion, without documentation or instruction from study investigator.

Microbiological Methods

HCWs' hands, gloves, and gowns were sampled in a standardized fashion with sterile cotton-tipped applicators (Puritan Medical Products Co., LLC, Guilford, ME) moistened with sterile water. Hand and glove cultures were obtained using a standardized methodology with a single sample of both hands, first of the non-dominant hand and subsequently of the dominant hand. Hands and gloves were cultured by swabbing the dorsum of each finger three times and two circles of the palm, with a twirling motion of the swab. Gowns were cultured with two swabs of the forearm—non-dominant arm followed by the dominant arm—and then a "W" drawn on the beltline, all with one swab, performed with a twirling motion. When gloves or gowns were changed in the room (to either clean or sterile gloves, or over existing gloves), the gloves and gown worn exiting the room were cultured. Specimens were cultured on both blood agar plates and trypticase soy broth with 6.5% sodium chloride. Colonies consistent with MRSA were isolated on chrome agar (CHROMagar, BBL Microbiology Systems, Becton, Dickinson and Company, Sparks, MD) and/or Mueller Hinton agar with 4% sodium chloride and 6 μg/mL oxacillin (Becton, Dickinson and Company, Sparks, MD). Colonies consistent with VRE were isolated on bile esculin plates with 20 μg/mL vancomycin (Becton, Dickinson and Company, Sparks, MD).

Environmental cultures

To assess whether glove boxes and gowns were contaminated, the top glove from the first visible glove box was cultured on the same day from eight different rooms with a MRSA- or VRE-positive patient. Similarly, the first visible gown from the same eight rooms was cultured. Specimens were obtained by a sterile saline-moistened swab and cultures grown as described above.

Data analysis

All analyses were performed using SAS software, version 9.1 (SAS Institute Inc, Cary, NC). All p values are two-sided and were calculated using Fisher's exact test or chi-squared analysis as noted, except significance for time spent in room, which was calculated with the use of a Wilcoxon rank-sum test.

RESULTS

We approached 141 HCWs prior to patient interactions; one HCW refused participation, and three HCWs (2%) were excluded from the final analysis as hand cultures prior to HCW-patient interactions were positive for MRSA. Of the total 137 interactions, 38 were among patients co-colonized with MRSA and VRE, 43 were among patients with MRSA alone, and 56 were among patients with VRE alone. Interactions with co-colonized patients were evaluated as both an observation among a patient with MRSA and separately among a patient with VRE. For some interactions, gown or glove cultures could not be obtained, accounting for variation in the reported frequency denominators.

Of 175 HCW-patient observations in the final analysis, 96 were among registered nurses, 27 were among physicians or nurse practitioners, 18 were among patient care technicians, 16 were among respiratory therapists, 6 were among physical or occupational therapists, and 12 were among HCWs in miscellaneous fields.

Detection frequency

Detection frequencies of MRSA and VRE on hands, gloves, and gowns are reported in Table 1. Among 137 HCWs entering a room to provide care for a patient with MRSA, VRE, or both,

18% acquired the antibiotic-resistant organism on their gloves, gown, or both (24/137, 95%CI ± 6.4%).

Risk factors for detection

The frequency of presumed risk factors and a bivariate analysis of presumed risk factors for acquiring MRSA or VRE on gloves and/or gowns are presented in Table 2. These included the presence of a percutaneous endoscopic gastrostomy/jejunostomy tube ($P < 0.05$), HCW contact with a patient's endotracheal tube or tracheostomy ($P < 0.05$), and contact with the head and/or neck ($P < 0.05$). The duration of time spent in the room (rounded to the nearest minute during observation) ranged from 1 minute to 73 minutes, with a mean of 8.3 minutes and median of 5 minutes. The duration of time spent in the room was not statistically associated with detection of MRSA or VRE ($P = 0.27$). Table 3 describes bivariate analyses of presumed risk factors independently for MRSA and VRE. Among patients with MRSA, detection on gloves and/or gown was associated with the presence of an endotracheal tube, endotracheal tube or tracheostomy use or care, and contact with the head and neck as compared to table 2 overall analysis. In addition, contact with the right lower extremity was a significant risk factor. For VRE, the small number of positive findings limit the analysis, but catheter/drain care or use, contact with the trunk, and contact with the left lower extremity were significant factors to detection.

Environmental cultures

None of the sixteen environmental cultures from glove boxes or gowns grew MRSA or VRE.

DISCUSSION

Our study demonstrated that gloves and gowns were frequently colonized with MRSA and VRE during routine patient-care duties, with a detection frequency for MRSA and/or VRE on gowns and/or gloves of 18%. Detection frequencies of MRSA were noted to be higher than for VRE, and detection of either organism was more frequent on gloves than on gowns. We found that patient-associated risk factors for detection include the presence of gastrostomy/jejunostomy feeding tubes. Among risk factors related to the nature and location of contact between HCWs and patients, contact with the head or neck was associated with detection of organisms, as was care for an endotracheal tube or tracheostomy (although the presence of an endotracheal tube or tracheostomy as a patient variable was not strongly associated with detection of organism). The time spent in a patient's room was not significantly associated with an increased risk of acquiring antibiotic organisms. Hands were infrequently contaminated with VRE after routine clinical activities and removal of gloves, but a significant number of providers acquired MRSA on hands after removal of gowns and gloves on which MRSA had also been acquired.

In the largest study to date, we provide further evidence for a significant detection rate of antibiotic resistant organisms on infection control protective gown and gloves, particularly for MRSA and on gloves in the routine care of patients. Given the general detection rate and low rates of hand contamination after removing gown and gloves, these infection control precautions likely serve as an important intervention in preventing transmission of these organisms. Although the population size is small, the thirteen percent of providers with acquired MRSA on gown and/or gloves who subsequently acquired it on hands after gown/glove removal reinforces the importance of handwashing after all patient-provider interactions, independent of contact precautions. It is also notable that even short durations of time in the room and limited activity or patient contact may result in detection of antibiotic-resistant organisms.

Furthermore, this study presents new information regarding risk factors for detection—including among patients with endotracheal tubes or tracheostomy—that may help guide further interventions in minimizing cross-patient transmission. Transmission associated with these sites may be due to contact with respiratory secretions which often have a high level of colonization with antibiotic-resistant organisms such as MRSA or VRE.[16] Although limited by the power of the study, independent analysis of risk factors for detection of MRSA remained very similar to the overall analysis, while factors for detection of VRE were limited to catheter/drain care or use and body contact sites. While focused studies are limited, several demonstrate a high rate of colonization of gastrostomy tubes with MRSA[17] and an association with infections at these sites.[18,19] In one study, colonization with MRSA was found to be more common among patients with enteral feeding tubes or indwelling devices in general than among those without (an effect not demonstrated with VRE).[20] While not the most common organisms isolated, endotracheal tube biofilm and tracheal aspirates have been associated with multiple potential pathogens, including *Staphylococcus aureus* and *Enterococcus*.[21,22] Taken together, this prior data and our current findings should encourage further investigation into the role of indwelling devices in the transmission of antibiotic-resistant organisms, particularly MRSA.

No prior study has investigated risk factors for the detection of MRSA on HCW gowns or gloves. Tenorio et al investigated risk factors for detection of VRE on gloves from 50 interactions among 5 HCWs and 10 patients: 39% of HCWs acquired VRE on gloves following interaction with a patient, and risk factors for detection on gloves included contacting a patient with diarrhea and increased number of colonization sites on the patient.[11]

There are several limitations to this study. Strain typing of MRSA and VRE isolates was not performed, thereby limiting our ability to ensure that the same strain colonizing a patient appears on the clinical cultures from the patients' HCW. The impact of this limitation was limited by excluding observations for which cultures of HCW hands prior to patient interaction was positive, likely limiting acquired MRSA or VRE to that acquired from the patient. Informal attempts were made to randomly collect data from all rooms with MRSA- and VRE-positive patients. However as patient-identifiable information was not collected, bias from repeat observations among the same patient cannot be excluded. Furthermore, some HCWs were observed more than once, and HCWs were aware their routine activities were being observed. Therefore, HCW-patient interactions may not be statistically independent, and while we feel observation is unlikely to have changed routine clinical activities as practiced, there may be an unrecognized impact on detection of organisms. While organism burden on patients may play a role in the detection and transmission of antibiotic-resistant organisms, this variable was not collected and thus not analyzed partially due to our desire to not have patient-identifying information. Selection bias due to inadequately sensitive sampling techniques may limit the ability to detect MRSA and VRE. However, while there may be some improvement in sensitivity using PCR to detect MRSA[23] and the Rodac imprint method to detect VRE,[24] the moistened swab method has been demonstrated superior to the Rodac method for Gram-negative bacteria and only slightly less sensitive than the Rodac method for detecting Gram-positive cocci when compared directly.[25] The enrichment broth method has been demonstrated similar or superior to other techniques for detection of both VRE[26] and MRSA[27] Our technique is cost effective, provides an optimal compromise for detection of both MRSA and VRE, and has been demonstrated successfully in a similar manner.[28] Lastly, risk factor analysis was limited by the power of the study given a relatively low number of cultures positive for acquired MRSA or VRE.

Gowns and gloves as infection-control protective barriers are frequently contaminated with MRSA and VRE particularly during the care of the patient's respiratory tract. As part of a larger infection control strategy, including high compliance hand disinfection, they likely

provide a useful barrier to transmitting antibiotic-resistant organisms among patients in an inpatient setting.

Acknowledgements

We thank all of the staff and clinicians of the MICU who participated in the study for their support and participation.

Financial support: This study was supported by Centers for Disease Control CI000369-01, National Institutes of Health (NIH) research grant R01 AI60859-01A1, 1 R01 CI000369-01 and NIH grant 1K12RR023250-01.

References

1. Siegel, JD.; Rhinehart, E.; Jackson, M.; Chiarello, L. Management of multidrug-resistant organisms in healthcare settings. Atlanta (GA): Centers for Disease Control and Prevention; 2006. Healthcare Infection Control Practices Advisory Committee.
2. Muto CA, Jernigan JA, Ostrowsky BE, et al. SHEA guideline for preventing nosocomial transmission of multidrug-resistant strains of *Staphylococcus aureus* and *Enterococcus*. Infect Control Hosp Epidemiol 2003;24:362–386. [PubMed: 12785411]
3. Puzniak LA, Leet T, Mayfield J, Kolleff M, Mundy LM. To gown or not to gown: the effect on acquisition of vancomycin-resistant enterococci. Clin Infect Dis 2002 Jul 1;35(1):18–25. [PubMed: 12060870]
4. Srinivasan A, Song X, Ross T, Merz W, Brower R, Perl TM. A prospective study to determine whether cover gowns in addition to gloves decrease nosocomial transmission of vancomycin-resistant enterococci in an intensive care unit. Infect Control Hosp Epidemiol 2002 Aug;23(8):424–8. [PubMed: 12186206]
5. Jernigan JA, Titus MG, Gröschel DHM, Getchell-White SI, Farr BM. Effectiveness of contact isolation during a hospital outbreak of methicillin-resistant *Staphylococcus aureus*. Am J Epidemiol 1996;143 (5):496–503. [PubMed: 8610665]
6. Montecalvo MA, Jarvis WR, Uman J, Shay DK, Petrullo C, Rodney K, Gedris C, Horowitz HW, Wormser GP. Infection-control measures reduce transmission of vancomycin-resistant enterococci in an endemic setting. Ann Intern Med 1999 Aug 17;131(4):269–72. [PubMed: 10454948]
7. Byers KE, Anglim AM, Anneski CJ, et al. A hospital epidemic of vancomycin-resistant *Enterococcus*: risk factors and control. Infect Control Hosp Epidemiol 2001 Mar;22(3):140–147. [PubMed: 11310691]
8. Ostrowsky BE, Trick WE, Sohn AH, et al. Control of vancomycin-resistant *Enterococcus* in health care facilities in a region. N Engl J Med 2002 May 10;344(19):1427–1433. [PubMed: 11346807]
9. Murray-Leisure KA, Geib S, Graceley D, et al. Control of epidemic methicillin-resistant *Staphylococcus aureus*. Infect Control Hosp Epidemiol 1990;11(7):343–350. [PubMed: 2376659]
10. Nicolle LE, Dyck B, Thompson G, et al. Regional dissemination and control of epidemic methicillin-resistant *Staphylococcus aureus*. Infect Control Hosp Epidemiol 1999 Mar;20(3):202–205. [PubMed: 10100549]
11. Tenorio AR, et al. Effectiveness of gloves in the prevention of hand carriage of vancomycin-resistant enterococcus species by health care workers after patient care. Clin Infect Dis 2001 Mar 1;32(5): 826–9. [PubMed: 11229854]
12. McBryde ES, Bradley LC, Whitby M, McElwain DLS. An investigation of contact transmission of methicillin-resistant Staphylococcus aureus. J Hosp Infect 2004 Oct;58(2):104–8. [PubMed: 15474180]
13. Zachary KC, Bayne PS, Morrison VJ, Ford DS, Silver LC, Hooper DC. Contamination of gowns, gloves, and stethoscopes with vancomycin-resistant enterococci. Infect Control Hosp Epidemiol 2001 Sep;22(9):560–4. [PubMed: 11732785]
14. Boyce JM, Potter-Bynoe G, Chenevert C, King T. Environmental contamination due to methicillin-resistant Staphylococcus aureus: possible infection control implications. Infect Control Hosp Epidemiol 1997 Sep;18(9):622–7. [PubMed: 9309433]
15. Grabsch EA, Burrell LJ, Padiglione A, O'Keeffe JM, Ballard S, Grayson ML. Risk of environmental and healthcare worker contamination with vancomycin-resistant enterococci during outpatient

procedures and hemodialysis. Infect Control Hosp Epidemiol 2006 Mar;27(3):287–93. [PubMed: 16532417]

16. Rohr U, Wilhelm M, Muhr G, Gatermann S. Qualitative and (semi)quantitative characterization of nasal and skin methicillin-resistant *Staphylococcus aureus* carriage of hospitalized patients. Int J Hyg Environ Health 2004 Jan;207(1):51–5. [PubMed: 14762974]
17. Trick WI, Weinstein RA, DeMarais PL, et al. Colonization of skilled-care facility residents with antimicrobial-resistant pathogens. J Am Geriatr Soc 2001 Mar;49(3):270–276. [PubMed: 11300237]
18. Hull M, Beane A, Bowen J, Settle C. Methicillin-resistant *Staphylococcus aureus* infection of percutaneous endoscopic gastrostomy sites. Aliment Pharmacol Ther 2001 Dec;15(12):1883–1888. [PubMed: 11736718]
19. Pien ECT, Hume KE, Pien FD. Gastrostomy tube infections in a community hospital. Amer J Infect Control 1996 Oct;24(5):353–358. [PubMed: 8902109]
20. Mody L, Maheshwari S, Galecki A, Kauffman CA, Bradley SF. Indwelling device use and antibiotic resistance in nursing homes: identifying a high-risk group. J Am Geriatr Soc 2007 Dec;55(12):1921–1926. [PubMed: 18081670]
21. Adair CG, Gorman SP, Feron BM, et al. Implications of endotracheal tube biofilm for ventilator-associated pneumonia. Intensive Care Med 1999 Oct;25(10):1072–1076. [PubMed: 10551961]
22. Feldman C, Kassel M, Cantrell J, et al. The presence and sequence of endotracheal tube colonization in patients undergoing mechanical ventilation. Eur Respir J 1999;13:546–551. [PubMed: 10232424]
23. Jonas D, Speck M, Daschner FD, Grundmann H. Rapid PCR-based identification of methicillin-resistant *Staphylococcus aureus* from screening swabs. J Clin Microbiol 2002 May;40(5):1821–1823. [PubMed: 11980967]
24. Hacek DM, Trick WE, Collins SM, Noskin GA, Peterson LR. Comparison of the Rodac imprint method to selective enrichment broth for recovery of vancomycin-resistant enterococci and drug-resistant *Enterobacteriaceae* from environmental surfaces. J Clin Microbiol 2000 Dec;38(12):4646–4648. [PubMed: 11101613]
25. Lemmen SW, Häfner H, Zolldann D, Amedick G, Lütticken R. Comparison of two sampling methods for the detection of gram-positive and gram-negative bacteria in the environment: moistened swabs versus Rodac plates. J Hyg Environ Health 2001 Mar;203(3):245–248.
26. Reisner BS, Shaw S, Huber ME, et al. Comparison of three methods to recover vancomycin-resistant *Enterococci* (VRE) from perianal and environmental samples collected during a hospital outbreak of VRE. Infect Control Hosp Epidemiol 2000 Dec;21(12):775–779. [PubMed: 11140913]
27. Safdar N, Narans L, Gordon B, Maki DG. Comparison of culture screening methods for detection of nasal carriage of methicillin-resistant *Staphylococcus aureus*: a prospective study comparing 32 methods. J Clin Microbiol 2003 July;41(7):3163–3166. [PubMed: 12843058]
28. Lemmen SW, Häfner H, Zolldann D, Stanzel S, Lütticken R. Distribution of multi-resistant Gram-negative versus Gram-positive bacteria in the hospital inanimate environment. J Hosp Infect 2004;56:191–197. [PubMed: 15003666]

Table 1

MRSA and VRE detection frequency on infection-control gown and gloves worn by healthcare workers caring for patients with MRSA and VRE.

	Among Patients with MRSA, %	Among Patients with VRE, %
Number of observations	81	94
Gloves	17.7 (14/79) 95%CI ± 8.4	7.7 (7/91) 95%CI ± 5.5
Gown	6.2 (5/81) 95%CI ± 5.2	4.3 (4/94) 95%CI ± 4.1
Gloves or Gown	18.5 (15/81) 95%CI ± 8.5	8.5 (8/94) 95%CI ± 5.6
Hands after removing gloves and gown	2.6 (2/78) 95%CI ± 3.5	0 (0/94)

MRSA = methicillin-resistant *Staphylococcus aureus*

VRE = vancomycin-resistant enterococci

CI = confidence interval

Table 2

Frequency and univariate analysis of risk factors for detection of MRSA and/or VRE on gloves and/or gown.

Variable		Number of observations	No. with exposure and positive cultures (% of all positive glove or gown cultures)	No. with exposure and negative cultures (% of all negative glove or gown cultures)	P value
Patient Variables	Ventilated	99	11 (52.4)	88 (57.1)	0.68
	Endotracheal tube	49	8 (38.1)	41 (26.6)	0.27
	Tracheostomy	71	11 (52.4)	60 (39.0)	0.24
	Foley Catheter	133	16 (76.2)	117 (76.0)	0.98
	Percutaneous endoscopic gastrostomy/ jejunostomy tube	67	13 (61.9)	54 (35.1)	< 0.05
	Other drain[§]	97	8 (38.1)	89 (57.8)	0.09
	Vascular catheter (central venous, arterial line, or dialysis catheter)	140	16 (76.2)	124 (80.5)	0.58[*]
	Femoral catheter	42	7 (33.3)	35 (22.7)	0.29
Nature of contact	Physical exam	80	11 (52.4)	69 (44.8)	0.51
	Wound dressing	12	2 (9.5)	10 (6.5)	0.64
	Bathing/hygiene	9	2 (9.5)	7 (4.6)	0.29[*]
	Catheter/drain care or use	39	5 (23.8)	34 (22.1)	0.79[*]
	Endotracheal tube or tracheostomy use or care	38	13 (61.9)	25 (16.2)	< 0.05
	Vital signs	27	2 (9.5)	25 (16.2)	0.54
	Enteral medications	21	4 (19.1)	17 (11.0)	0.29[*]
	Activity with intravenous pump or lines	56	7 (33.3)	49 (31.8)	0.89
Location of patient contact	Head and/or neck	77	19 (90.5)	58 (37.7)	< 0.05
	Trunk	116	17 (81.0)	99 (64.3)	0.13
	Right upper extremity	79	11 (52.4)	68 (44.2)	0.48
	Left upper extremity	75	12 (57.1)	63 (40.9)	0.16
	Groin	18	3 (14.3)	15 (9.7)	0.46[*]
	Right lower extremity	53	10 (47.6)	43 (27.9)	0.07
	Left lower extremity	38	6 (28.6)	32 (20.8)	0.41[*]

MRSA = methicillin-resistant *Staphylococcus aureus*

VRE = vancomycin-resistant enterococci

[*] All p values obtained by Chi-squared analysis except those noted that were calculated using Fisher's Exact Test.

[§] Among all observations, other drains include: abdominal, 14; chest, 24; nasogastric or orogastric tube, 58; rectal tube, 35; surgical hip drain, 1. Patients may have had more than one drain.

Infect Control Hosp Epidemiol. Author manuscript; available in PMC 2008 November 4.

Table 3

Independent frequency and univariate analysis of risk factors for detection of MRSA and VRE on gloves and/or gown.

Variable		MRSA No. with exposure and positive cultures (% of all positive glove or gown cultures)	MRSA No. with exposure and negative cultures (% of all negative glove or gown cultures)	MRSA P value	VRE No. with exposure and positive cultures (% of all positive glove or gown cultures)	VRE No. with exposure and negative cultures (% of all negative glove or gown cultures)	VRE P value
Patient Variables	Ventilated	8 (53.3)	38 (57.6)	0.76	3 (37.5)	50 (58.1)	0.29*
	Endotracheal tube	7 (46.7)	14 (21.2)	0.05*	2 (25.0)	26 (30.2)	1.00*
	Tracheostomy	6 (40.0)	28 (42.4)	0.86	2 (25.0)	35 (40.7)	0.47*
	Foley Catheter	12 (80.0)	47 (71.2)	0.75*	6 (75.0)	68 (79.1)	0.68*
	Percutaneous endoscopic gastrostomy/jejunostomy tube	7 (46.7)	21 (31.8)	0.28	2 (25.0)	37 (43.0)	0.46*
	Other drain§	7 (46.7)	33 (50.0)	0.82	7 (87.5)	50 (58.1)	0.14*
	Vascular catheter (central venous, arterial line, or dialysis catheter)	11 (73.3)	49 (74.2)	1.00*	7 (87.5)	73 (84.9)	1.00*
	Femoral catheter	4 (26.7)	11 (16.7)	0.46*	4 (50.0)	23 (26.7)	0.22*
Nature of contact	Physical exam	7 (46.7)	28 (42.4)	0.76	4 (50.0)	41 (47.7)	1.00*
	Wound dressing	1 (6.7)	5 (7.6)	1.00*	2 (25.0)	4 (4.7)	0.08*
	Bathing/hygiene	1 (6.7)	2 (3.0)	0.46*	1 (12.5)	5 (5.8)	0.42*
	Catheter/drain care or use	4 (26.7)	10 (15.2)	0.28*	5 (62.5)	20 (23.3)	< 0.05*
	Endotracheal tube or tracheostomy use or care	8 (53.3)	9 (13.6)	< 0.05*	0	21 (24.4)	0.19*
	Vital signs	2 (13.3)	9 (13.6)	1.00*	3 (37.5)	13 (15.1)	0.13*
	Enteral medications	3 (20.0)	7 (10.6)	0.38*	1 (12.5)	10 (11.6)	1.00*
	Activity with intravenous pump or lines	5 (33.3)	22 (33.3)	1.00	1 (12.5)	28 (32.6)	0.43*
Location of patient contact	Head and/or neck	13 (86.7)	22 (33.3)	< 0.05	4 (50.0)	38 (44.2)	1.00*
	Trunk	13 (86.7)	42 (63.6)	0.12*	8 (100)	53 (61.6)	< 0.05*
	Right upper extremity	9 (60.0)	30 (45.5)	0.31	6 (75.0)	34 (39.5)	0.07*
	Left upper extremity	8 (53.3)	29 (43.9)	0.51	6 (75.0)	32 (37.2)	0.06*
	Groin	2 (13.3)	3 (4.6)	0.23*	3 (37.5)	10 (11.6)	0.08*
	Right lower extremity	8 (53.3)	15 (22.7)	< 0.05*	5 (62.5)	25 (29.1)	0.11*
	Left lower extremity	5 (33.3)	12 (18.2)	0.29*	5 (62.5)	16 (18.6)	< 0.05*

MRSA = methicillin-resistant *Staphylococcus aureus*

VRE = vancomycin-resistant enterococci

*All p values obtained by Chi-squared analysis except those noted that were calculated using Fisher's Exact Test.

§Among all observations, other drains include: abdominal, 14; chest 24; nasogastric or orogastric tube, 58; rectal tube, 35; surgical hip drain, 1. Patients may have had more than one drain.