WHY IS IT THAT INTERNISTS DO NOT FOLLOW GUIDELINES FOR PREVENTING INTRAVASCULAR CATHETER INFECTIONS?

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ABSTRACT

BACKGROUND AND OBJECTIVE: High morbidity of CVC-related infections has led to national guidelines for their prevention. Despite recommendations for the use of maximal barrier precautions (mask, sterile gloves, gown, and large drape) and skin antisepsis with 2% chlorhexidine gluconate during CVC insertion, internists in the United States are not implementing these practices frequently. This study sought to identify and characterize the obstacles to and potential opportunities for improving adherence.

DESIGN: Cross-sectional survey.

PARTICIPANTS: One thousand randomly selected physician-members of the American College of Physicians–American Society of Internal Medicine.

METHODS: Several potential determinants of adherence to maximal barrier precautions were assessed, including awareness of, agreement with, and ability to implement the recommendation, as well as the practice and training characteristics of the respondents. Factors influencing antiseptic selection were also recorded.

RESULTS: Of 526 respondents, 178 (34%) had recently inserted CVCs. Clinician experience and subspecialty, awareness of CDC guidelines, and external influences (eg, time to collect equipment) did not affect maximal barrier precautions adherence. The only independent predictor of adherence was high outcome expectancy for the use of large sterile drapes (OR, 5.3; CI_{95}, 2.2–12.6). Availability had the greatest influence on internists' selection of specific antiseptic agents, whereas cost was the least important determinant.

CONCLUSIONS: Despite established efficacy, use of maximal barrier precautions and chlorhexidine gluconate is low among internists. Because improved adherence to these practices will require increased outcome expectancy for maximal barrier precautions and availability of chlorhexidine gluconate, targeting these areas through focused education and systems modifications is essential (*Infect Control Hosp Epidemiol* 2005;26:525-533).

Primary bloodstream infections (BSIs) (ie, bacteremia or fungemia not due to infection at another site[1]) are the most common nosocomial BSIs in intensive care units (ICUs)[2,3] and are usually (87%) associated with central venous catheters (CVCs).[4] In ICUs in the United States, most patients have CVCs (pooled mean, 51%; range, 30% to 74%), and catheter-related BSIs occur at a rate of 5.9 per 1,000 CVC-days.[5] Approximately 80,000 critically ill patients are affected by catheter-related BSIs annually in the United States.[6,7] Catheter-related BSIs can prolong hospital stay by as many as 22 days,[8-11] expose patients to potential harm (eg, pneumothorax and vascular injury) when another CVC is required,[12,13] and increase hospital costs.[14,15] The continuing need for CVCs, the escalating prevalence of antimicrobial resistance,[5,16-18] and the growing number of ICU beds[19,20] necessitate the prevention of catheter-related BSIs.

It has been estimated that one-third of nosocomial infections are preventable.[21] An approach to prevention was promulgated by the Centers for Disease Control and Prevention's 1996 "Guideline for Prevention of Intravascular-Device–Related Infections."[22] This evidence-based guideline recommends practices regarding CVC insertion, including the use of maximal barrier precautions (mask, sterile gloves, sterile gown, and large sterile drape); skin antisepsis; "subclavian, rather than jugular or femoral, sites for central venous catheter placement unless medically contraindicated"; and "antimicrobial- or antiseptic-impregnated central venous catheter if, after full adherence to other catheter infection control measures (eg, maximal barrier precautions), there is still an unacceptably high rate of infection."[22] Despite publication of the guideline in two journals,[22,23] we recently reported that 28.2% of a sample of

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U.S. internists used full maximal barrier precautions, 17.0% inserted into the subclavian vein, and 16.7% used CVCs impregnated or coated with antimicrobial agents for at least 90% of their CVC insertions.[24]

Chlorhexidine gluconate, available in the United States since 2000, has been recommended as the preferred skin antiseptic for cleansing the CVC insertion site.[6,25,26] A recent meta-analysis demonstrated the superiority of chlorhexidine gluconate over povidone–iodine to reduce catheter-related BSIs.[27] Alcohol and povidone–iodine solutions were the most frequently used antiseptics among participants at a 1992 intravascular catheter conference,[28] and recently, less than 10% of U.S. internists reported regular use of chlorhexidine gluconate.[24]

Recognizing low adherence to guidelines is an essential step toward practice improvement. To prepare to improve clinical practice, it is also vital to understand the reasons why clinicians may fail to adhere to guidelines. A conceptual framework for determinants of clinician adherence to clinical practice guidelines can be used to identify obstacles to guideline implementation,[29] and there has been a call to apply this framework to the problem of nonadherence to intravascular catheter guidelines.[30] The purpose of this study was to identify the conceptual basis for obstacles to the use of maximal barrier precautions and chlorhexidine gluconate among internists, to establish a framework for improvement, and to define targets for intervention.

METHODS

Survey Participants

A survey was mailed to 1,000 internists in the United States who were randomly selected from the membership list of the American College of Physicians–American Society of Internal Medicine. To ensure adequate national representation, sampling was stratified by four geographic regions.

Because we sought to characterize current CVC insertion practices, the first question of the survey identified respondents who had inserted or supervised the insertion of a CVC in an adult ICU within the past 12 months. These respondents with recent CVC insertion experience were instructed to complete the entire survey, whereas those without recent experience were asked to provide information regarding their medical training only. Adherence to guideline recommendations for CVC insertion was assessed among the respondents with recent CVC experience and has been reported elsewhere.[24]

Obstacles to Use of Guideline Practices

Maximal Barrier Precautions. To understand reasons for nonadherence to the guideline, we focused on the two practices (maximal barrier precautions and skin antisepsis) that are always recommended (ie, ideal use, 100% of CVC insertions) rather than on those that are conditional (ie, subclavian vein insertion and antimicrobial-impregnated CVCs), whose ideal rate of use is unknown. Adherence to maximal barrier precautions (used during 90% or more of CVC insertions) was defined according to previously developed cutoffs.[29,31,32]

On the basis of a conceptual model of determinants of physician adherence to clinical practice guidelines,[29] we assessed obstacles to adherence in three major categories: (1) awareness of the guideline, (2) agreement with guideline recommendations, and (3) ability to apply the recommendations. Awareness included overall awareness of the guideline and familiarity with specific recommendations. We also assessed outcome expectancy (respondent believes the recommended action will reduce catheter-related BSIs) as a component of agreement.[29,33] Finally, we evaluated factors affecting the respondents' ability to use maximal barrier precautions (time, emergency access, reimbursement, and inconvenience to locate equipment). Likert-type scales were used for responses to the questions.

Skin Antisepsis. Respondents rated the importance of factors that affect their choice of skin antisepsis agent: (1) published evidence, (2) availability at their institution, (3) being provided within the CVC kit, (4) cost, (5) potential side effects, and (6) time required on skin prior to CVC insertion.

Respondent Experience, Subspecialty Training, and Practice Environment. The survey asked respondents about the number of CVCs inserted monthly and during their entire career, the academic status of their practice site, and whether their institutions report BSI rates to staff. All respondents, including those without recent CVC experience, were asked to provide training information (the year of graduation from medical school, the year in which residency training was completed, and their medical specialty).

Survey Mailing

We sent subjects a personalized pre-notification letter in June 2002, followed by the survey packet (personalized cover letter, survey, and stamped pre-addressed return envelope). A reminder letter was sent to nonrespondents, followed by up to two additional survey packets. We did not provide monetary incentives. Surveys received by September 20, 2002, were included in the analysis. The study was approved by the institutional review board of the Johns Hopkins Bloomberg School of Public Health.

To estimate the required sample size, we used the mean reported response rate (54%) for surveys of physicians,[34] and we anticipated that 40% of the internists would have recent CVC insertion experience. We planned to use multivariable logistic regression models with adherence to maximal barrier precautions (dichotomized) as the dependent variable and up to 10 independent predictors of adherence. Therefore, we desired at least 10 respondents who were highly adherent to maximal barrier precautions per predictor (100 high adherers in total).[35] We surveyed 1,000 physicians to guarantee an adequate number of respondents with recent CVC experience who were highly adherent to maximal barrier precautions.

Statistical Analysis

The relationships of obstacles, respondents' experience, subspecialty training, and practice environment to adherence to maximal barrier precautions were examined in bivariate analyses by chi-square tests for dichotomous

TABLE 1
CHARACTERISTICS OF THE SURVEY RESPONDENTS

Characteristic	All Respondents (N = 526)	Recent CVC Experience* (N = 178)	No Recent CVC Experience† (N = 348)	P
Completed residency	83.3%	57.7%	98.0%	< .001
If yes, median no. of years since completion (IQR)	15.0 (7–22)	12.0 (3–22)	15.5 (8–23)	.003
Internal medicine	99.6%	100%	99.4%	.55
Subspecialty‡				
General internal medicine	49.4%	50.6%	48.8%	.71
Critical care medicine	6.6%	16.1%	1.8%	< .001
Cardiology	5.9%	12.6%	2.4%	< .001
Infectious disease	5.9%	0.6%	8.6%	< .001
Nephrology	3.1%	5.8%	1.8%	.03
Gastroenterology	5.1%	2.3%	6.5%	.04
Hematology, oncology, or both	6.6%	0.6%	9.8%	< .001
Other	17.4%	16.1%	20.3%	< .001
ICU practice site§				
Community hospital without medical residency		30.1%		
Community hospital with medical residency		39.9%		
Academic medical center		41.6%		
Institutions reporting catheter-related BSI rates to staff		23.4%		
Catheter-related BSI rates reported for each physician inserter		15.0%		
Catheter-related BSI rates reported only as an aggregate ICU rate		8.4%		

CVC = central venous catheter; IQR = interquartile range; ICU = intensive care unit; BSI = bloodstream infection.
*Respondent has inserted ≥ 1 CVC in the ICU in the past 12 months.
†Respondents returned the survey but were instructed to provide data about their medical training only.
‡Percentages may not add to 100% because respondents may have had more than one specialty.
§Percentages may not add to 100% because respondents may have worked at multiple practice sites.

variables or Kruskal–Wallis tests for continuous variables ($P < .05$). Significant factors were subsequently included in a multivariable logistic regression analysis using maximal barrier precautions adherence as the dependent variable. Statistical significance was defined as a P value of less than .05 for all analyses. All statistical analyses were performed with Stata software (version 7.0 SE; StataCorp, College Station, TX).

Data from respondents who did not answer all of the solicited questions were still used for analysis if questions relevant to the particular analyses were completed. Respondents answered more than 95% of each question they were instructed to complete, so imputation of missing data was not undertaken. If respondents did not answer a question necessary for the calculation of adherence to maximal barrier precautions, they were withdrawn from the maximal barrier precautions adherence analysis but their responses regarding demographics and chlorhexidine gluconate were still analyzed. If respondents provided enough data for calculation of adherence to maximal barrier precautions but did not answer a question regarding a specific predictor of adherence, they were not included in that particular bivariate analysis. For the multivariable model, only those respondents who answered all of the survey questions regarding the use of a component of maximal barrier precautions as well as questions relevant to all predictors included in the model were evaluated in the final analysis.

RESULTS

Survey Respondents

The overall response rate was 52.9% (526 of 994 with correct address information) (Table 1). Half (49.4%) of the respondents were general internists and 6.6% were critical care specialists. Most (83.3%) of the respondents had completed residency training.

Of the total respondents, 178 (33.8%) had recent CVC insertion experience, and of this subset, trainees in residency were a substantial minority (42.3%). The majority of these respondents worked in academic centers or community hospitals with medical residencies. Less than one-quarter of the institutions (23.4%) reported BSI rates to physician staff.

TABLE 2
RESPONDENTS' EXPERIENCE WITH CENTRAL VENOUS CATHETER INSERTION

Experience	Respondents With Recent CVC Experience (N = 178)	Cardiologists, Critical Care Medicine Specialists, and Nephrologists (N = 57)	Other Internists (N = 121)	*P*
Median no. of CVC insertions in ICU per month (IQR)	2 (1–6)	3 (2–10)	2 (1–5)	.01
No. of CVC insertions in ICU during career				< .001
1 to 10	11.1%	1.8%	15.5%	
11 to 50	37.8%	10.7%	50.9%	
51 to 100	13.4%	8.9%	15.5%	
101 to 200	12.2%	17.9%	9.5%	
> 200	25.6%	60.7%	8.0%	

CVC = central venous catheter; ICU = intensive care unit; IQR = interquartile range.

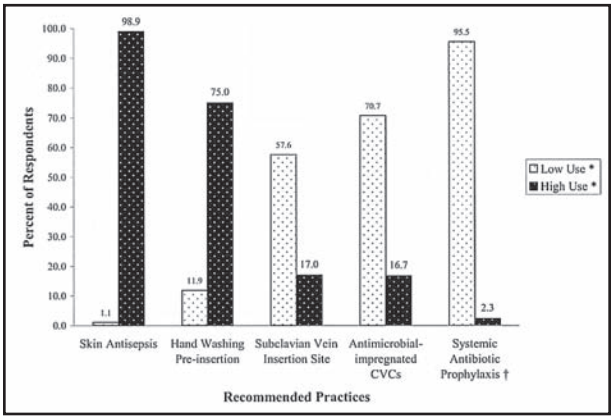

FIGURE 1. Self-reported use of recommended practices during central venous catheter (CVC) insertion. *Low use = using recommendation ⩽ 50% of CVC insertions; and high use = using recommendation ⩾ 90% of CVC insertions. Moderate use is not shown, but can be calculated from 100 (high use – low use). †Centers for Disease Control and Prevention guideline does not recommend the use of systemic antibiotic prophylaxis.

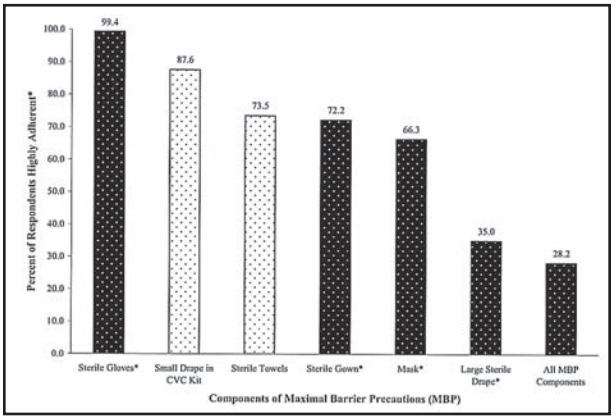

FIGURE 2. Rates of use of maximal barrier precautions components for central venous catheter (CVC) insertion. *Recommended component of maximal barrier precautions.

Respondents who specialized in critical care medicine, cardiology, and nephrology reported more experience inserting CVCs than did other respondents (Table 2). Career CVC insertion experience varied considerably, although more than 50% of the respondents with recent CVC insertion experience had inserted more than 50 CVCs.

Obstacles to the Use of Maximal Barrier Precautions

The frequencies of use of the guideline's recommendations were reported previously (Figs. 1 and 2).[24] Adherence to all components of maximal barrier precautions was 28.2%. Use of the large sterile drape (35.0%) was much lower than use of draping materials not specifically recommended (small drape provided in the CVC kit [87.6%] and sterile towels [73.5%]).[24]

Bivariate Analyses. Only 30.2% of the respondents were aware of the 1996 Centers for Disease Control and Prevention guideline. Adherence to maximal barrier precautions was not significantly different among physicians aware of the guideline (odds ratio [OR], 1.59; 95% confidence interval [CI_{95}], 0.79 to 3.24) (Table 3). However, physicians who were aware of the guideline and also familiar with the maximal barrier precautions recommendation were significantly more adherent (OR, 2.14; CI_{95}, 1.00 to 4.55).

All highly adherent physicians agreed with the guideline's recommendation for the use of maximal barrier precautions, but agreement alone was not enough to ensure adherence because agreement was common among low adherers (76.2%) (Table 3). Physicians who believed that wearing a sterile gown during CVC insertion had a major effect on reducing catheter-related BSIs (high outcome expectancy) were significantly more likely to be high adherers to maximal barrier precautions (OR, 2.60; CI_{95}, 1.27 to 5.32). High outcome expectancies for use of a mask and a large sterile drape were also strong predictors of high adherence to maximal barrier precautions (OR,

TABLE 3
CENTRAL VENOUS CATHETER INSERTION–RELATED FACTORS AND USE OF MAXIMAL BARRIER PRECAUTIONS

Potential Obstacle to Use of MBP	No. of Respondents With Recent CVC Experience: High Adherence (≥ 90% of CVC Insertions; N = 49)*	No. of Respondents With Recent CVC Experience: Non–High Adherence (< 90% of CVC Insertions; N = 125)*	Bivariate OR† (CI_{95})	Multivariable OR‡ (CI_{95})
Awareness of guideline (vs no awareness)	18 (36.7%)	32 (25.6%)	1.59 (0.79–3.24)	
Familiarity with MBP recommendation (vs no familiarity)	16 (32.7%)	22 (18.5%)	2.14 (1.00–4.55)	1.74 (0.72–4.23)
Agreement with MBP recommendation	49 (100%)	93 (76.2%)	-§	
Outcome expectancy (belief that use will reduce infection rates)				
Sterile gloves	46 (95.8%)	113 (94.2%)	1.42 (0.28–7.11)	
Sterile gown	34 (70.8%)	58 (48.3%)	2.60 (1.27–5.32)	0.63 (0.21–1.91)
Mask	28 (58.3%)	38 (31.7%)	3.02 (1.51–6.03)	1.95 (0.70–5.42)
Large sterile drape	15 (68.7%)	32 (27.4%)	5.84 (2.81–12.17)	5.31 (2.23–12.63)
Presence of external obstacles				
Lack of equipment	17 (35.4%)	58 (47.9%)	0.60 (0.30–1.20)	
Inconvenience	13 (27.1%)	45 (37.2%)	0.63 (0.30–1.31)	
Requires too much time	9 (18.8%)	26 (21.5%)	0.84 (0.36–1.96)	
Low reimbursement	2 (4.2%)	10 (8.3%)	0.48 (0.10–2.26)	
Emergency intravascular access	28 (58.3%)	82 (67.8%)	0.67 (0.33–1.33)	

CVC = central venous catheter; OR = odds ratio; CI_{95} = 95% confidence interval; MBP = maximal barrier precautions.
*Numbers for bivariate analyses may be slightly different due to respondents not answering 100% of questions of the survey.
†OR should be interpreted as odds of being highly adherent to MBP use for those having a particular characteristic compared with the odds of being highly adherent for those not having the characteristic (eg, odds are 1.59:1 of being highly adherent for physicians who were aware of the guideline compared with those who were unaware of the guideline).
‡Adjusted for all statistically significant predictors of MBP adherence in bivariate analyses (familiarity with MBP recommendation; outcome expectancy for use of sterile gowns, masks, and large sterile drapes; and practicing at a community hospital without a medical residency).
§OR cannot be calculated because division by zero would be required (because 100% of highly adherent internists agree with the MBP recommendation).

3.02; CI_{95}, 1.51 to 6.03; and OR, 5.84; CI_{95}, 2.81 to 12.17, respectively).

Physicians tended to be less adherent if their ability to use maximal barrier precautions was influenced by any of the following: lack of equipment, inconvenience to locate equipment, too much time to use maximal barrier precautions, lack of reimbursement, and need for emergent intravascular access. None of these potential obstacles was statistically significant (Table 3).

The practice environment of the respondents was associated with adherence (Table 4). Physicians who practiced in a community hospital without a residency were less likely to be high adherers compared with all other physicians (OR, 0.44; CI_{95}, 0.19 to 0.99). Institutional reporting of catheter-related BSI rates to the respondents was not associated with adherence.

Adherence to maximal barrier precautions was not different between those who had and those who had not finished residency training (Table 4). Intensivists, cardiologists, and nephrologists, who on average had more experience inserting CVCs in ICUs than did other respondents, did not have higher adherence to maximal barrier precautions. Even the most experienced (career CVC insertions, > 200) among these specialists did not have better adherence to maximal barrier precautions (30.3% vs 28.7% for all other respondents; $P = .85$).

Multivariable Analysis. The only independent predictor of adherence to maximal barrier precautions was high outcome expectancy for use of a large sterile drape (Table 3). High outcome expectancy for use of a mask and a sterile gown (Table 3) as well as practicing at a non-teaching community hospital (Table 4) were important predictors of adherence in bivariate analyses but were not statistically significant in the multivariable analysis.

Skin Antisepsis

We previously reported that almost all (98.9%) of the respondents used a skin antiseptic: povidone–iodine was used most frequently (89.5%) and chlorhexidine gluconate was used less frequently (9.8%). Because use of agents other than povidone–iodine was so infrequent, predictors

TABLE 4
PRACTICE AND OPERATOR FACTORS AND USE OF MAXIMAL BARRIER PRECAUTIONS

Factor	High Adherence (≥ 90% of CVC Insertions; N = 49)*	Non–High Adherence (< 90% of CVC Insertions; N = 125)*	Bivariate OR† (CI_{95})	Multivariable OR‡ (CI_{95})
Academic medical center	20 (40.8%)	52 (43.0%)	0.92 (0.47–1.80)	
Community hospital with medical residency	22 (44.9%)	46 (38.0%)	1.33 (0.68–2.60)	
Community hospital without medical residency	9 (18.4%)	41 (33.9%)	0.44 (0.19–0.99)	0.43 (0.17–1.06)
Catheter-related BSI rates reported for each physician inserter	10 (20.4%)	16 (13.2%)	1.68 (0.70–4.02)	
Catheter-related BSI rates reported only as an aggregate ICU rate	4 (12.5%)	12 (16.4%)	0.73 (0.22–2.45)	
Operator-related factors				
> 2 CVC insertions per month	25 (52.1%)	56 (47.1%)	1.22 (0.63–2.40)	
> 50 CVC insertions during career	22 (44.9%)	64 (53.3%)	0.71 (0.37–1.39)	
Completed residency	27 (56.3%)	66 (56.9%)	0.98 (0.49–1.92)	
Intensivists, cardiologists, and nephrologists	20 (40.8%)	36 (28.8%)	1.70 (0.86–3.40)	
General medicine physicians	28 (57.2%)	58 (47.9%)	1.45 (0.74–2.82)	

CVC = central venous catheter; OR = odds ratio; CI_{95} = 95% confidence interval; BSI = bloodstream infection; ICU = intensive care unit.
*Numbers for bivariate analyses may be slightly different due to respondents not answering 100% of questions of the survey.
†OR should be interpreted as odds of being highly adherent to use of maximal barrier precautions for those having a particular characteristic compared with the odds of being highly adherent for those not having the characteristic (eg, odds are 1.59:1 of being highly adherent for physicians who were aware of the guideline compared with those who were unaware of the guideline).
‡Adjusted for all statistically significant predictors of adherence to maximal barrier precautions in bivariate analyses (familiarity with the recommendation for maximal barrier precautions; outcome expectancy for use of sterile gowns, masks, and large sterile drapes; and practicing at a community hospital without a medical residency).

TABLE 5
FACTORS INFLUENCING CHOICE OF A SKIN ANTISEPTIC AGENT

Factor	% of Respondents Reporting This Factor
Availability at institution	91.2
Provided in CVC kit	74.3
Published evidence	49.7
Potential side effects	38.0
Time on skin required prior to insertion	29.9
Cost	14.5

CVC = central venous catheter.

of agent preference could not be analyzed in multivariable models. The most commonly cited factor affecting choice of skin antiseptic was whether it was available at their institution (91.2%) (Table 5). Whether the agent was provided in the CVC kit also influenced many (74.3%) of the respondents. Cost of the agent was rarely important (14.5%).

DISCUSSION

Although evidence and expert opinion support the use of maximal barrier precautions and 2% chlorhexidine gluconate to prevent catheter-related infections, U.S. internists rarely use these practices during CVC insertion. The key reasons for nonadherence are that most internists do not believe that the use of maximal barrier precautions is effective and they have limited access to chlorhexidine gluconate.

Each of the proven interventions can alter the pathogenesis of BSI. Skin contamination at the insertion site of a short-term (indwelling time, 1 to 10 days), non-tunneled CVC with subsequent migration of pathogens along the extraluminal surface of the catheter has a major role in the development of a catheter-related BSI.[36-40] Greater numbers of organisms at the skin insertion site increase the likelihood of catheter-related BSI. Use of maximal barrier precautions is believed to reduce skin contamination by the CVC inserter, whereas chlorhexidine gluconate likely reduces the impact of colonizing organisms.

Use of maximal barrier precautions reduces CVC colonization[38] and catheter-related BSI rates (sixfold reduction in septicemia)[41] when compared with CVC insertion with use of only sterile gloves and the small drape provided in the typical CVC kit. Because no study has examined the effects of individual components of maximal barrier precautions for the prevention of catheter-related BSI, transfer of the current published evidence into practice necessitates use of all components of maximal barrier precautions. Our study revealed that respondents used components of maximal barrier precautions at variable rates and had differing opinions about the effectiveness of each component. Nearly all of the respondents

believed that sterile gloves were effective, but fewer believed that using a mask, a sterile gown, or a large sterile drape prevented catheter-related BSIs. Variable use of maximal barrier precautions components was also reported in a study that directly observed clinicians inserting CVCs.[42]

Physician experience with CVC insertion did not affect adherence to maximal barrier precautions. Increasing experience, potentially associated with higher technical skill at CVC insertion, did not ensure "best practices." Housestaff were included in our sample (16.3% of all respondents and 42.3% of those with recent CVC experience) because they insert many of the CVCs at their institutions. Low adherence to maximal barrier precautions was independent of whether physicians had completed residency training, suggesting that behaviors practiced by educators are adopted by trainees. Interestingly, specialists in critical care medicine, cardiology, and nephrology were not more likely to adhere to maximal barrier precautions. Accordingly, optimum practices cannot be assumed on the basis of the provider's experience or specialty designation, and all groups need to be targeted by educational efforts. Disappointingly, physicians from hospitals where rates of catheter-related BSI are reported to physician staff were not more likely to use maximal barrier precautions. Hence, current audit and feedback methods (catheter-related BSI rates aggregated by ICU or by individual CVC inserter) are not sufficient to increase adherence, although this does not exclude the potential benefit of these methods when included as part of multimodal interventions to modify physician behavior.[43]

The primary obstacle to use of maximal barrier precautions was low outcome expectancy for the large sterile drape. Many physicians thought it fine to use the drape (agreeing with the maximal barrier precautions recommendation) but that this practice was unlikely to have a meaningful impact on patient outcomes (low outcome expectancy). This finding suggests that further interventions are needed to target outcome expectancy, such as academic detailing or use of opinion leaders,[44,45] and that additional investigation is needed to demonstrate the specific effect of the large sterile drape to underscore its role in maximal barrier precautions. Novel instruction of physicians-in-training regarding CVC placement has been associated with an increased perceived need for (and documented use of) large sterile drapes and a decreased rate of catheter-related BSIs.[46] Interestingly, physicians from institutions without medical residencies used maximal barrier precautions even less frequently, but our study did not define which aspects of the residency training environment account for better adherence.

There was remarkably little awareness of the Centers for Disease Control and Prevention's 1996 guideline despite publication in two peer-reviewed journals[22,23,47] and the previous availability of the guideline on the Centers for Disease Control and Preventions's web site. Moreover, only a minority (36.7%) of the participants who were aware of the guideline were highly adherent to the use of maximal barrier precautions. Guideline familiarity, which requires more specific knowledge of the recommendations, was associated with adherence to maximal barrier precautions only in bivariate analyses. Although a plan to increase familiarity with the recommendations would appear to be necessary to augment the use of maximal barrier precautions, our findings suggest that this approach alone would be insufficient to alter physician behavior. Since our initial survey mailing, an update of the Centers for Disease Control and Prevention guideline has been published in several peer-reviewed journals.[48-51] This updated document is comprehensive, yet, as with the 1996 version, it is unlikely that passive dissemination of the guideline alone will optimize CVC insertion practices.

Our data indicate that choice of the specific skin antiseptic agent is influenced largely by what is immediately at hand in one's institution. Although dissemination of the advantages of chlorhexidine gluconate to physicians may be an important component of an intervention to change practice, our findings suggest a major role for administrative or other systems changes that ensure timely availability of chlorhexidine gluconate to all who insert CVCs. For example, use of chlorhexidine gluconate might be promoted by increasing its availability by stocking it routinely in ICUs and other settings of CVC insertion and by providing it in CVC kits. Such relatively simple interventions to improve the availability of chlorhexidine gluconate at the institutional level may help prevent thousands of catheter-related BSIs annually.

One potential limitation of this study, as with any survey that has a response rate of less than 100%, is that the respondents may not accurately represent the entire sampled population. We did not design the survey collection process to assess response bias, and the American College of Physicians–American Society of Internal Medicine membership database had limited information on the nonrespondents. The response rate for this survey (52.9%) is consistent with published rates of surveys of physicians,[34] and a recent report has suggested that response bias may not strongly influence results of physician surveys.[52] Although we cannot be fully certain that the determinants for the use of maximal barrier precautions and chlorhexidine gluconate identified in this study are representative for all internists, low use of the large sterile drape has been reported in another study, albeit in a heterogeneous physician population.[42]

Because most ICU care in the United States is not provided by intensivists,[53] we designed our sample to include a broad range of internists, and our expectation that 40% of internists would have recent experience was close to the study findings (33.8%). When our study was conceived and designed, there were no published data regarding the use of maximal barrier precautions in practice. Largely because of low self-reported use of a large sterile drape,[24] only 49 (27.5%) of the internists with recent CVC experience were highly adherent to maximal barrier precautions components. We anticipated that approximately 100 (50%) of the internists with recent CVC experience would be highly adherent to use of maximal

barrier precautions when inserting CVCs, which would allow us to evaluate approximately 10 potential predictors of adherence to maximal barrier precautions in a multivariable logistic regression model. Only 4 significant predictors of adherence to maximal barrier precautions were identified from the bivariate analyses, so 49 highly adherent internists were sufficient to test the independent effects of these in a multivariable model.

With a larger sample of internists we may have been able to identify additional determinants of adherence to maximal barrier precautions. Hence, some of the predictors that were not shown to have independent effects on adherence to maximal barrier precautions may still have some influence on their use. We are interested in the most important predictors of adherence because we hope that, based on these data, interventions could be designed and initiated in many medical ICUs, especially those with limited resources, to overcome the most important obstacles to the use of maximal barrier precautions and chlorhexidine gluconate and thus reduce catheter-related BSIs.

Simple interventions that are optimized for the prevention of catheter-related BSIs without major resource expenditures might have the broadest impact on critically ill patients in the United States. Findings such as ours can guide such approaches to increase adherence to the best practice standards for CVC insertion and reduce the burden of catheter-related BSIs for patients in ICUs. We strongly encourage more active dissemination of the recommendations by the Centers for Disease Control and Prevention, Agency for Healthcare Research and Quality, and specialty societies, along with the development of institution-specific strategies to improve outcome expectancy for maximal barrier precautions and administrative changes to increase the availability of chlorhexidine gluconate.

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