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# Differences in Work Environment for Staff as an Explanation for Variation in Central Line Bundle Compliance in ICUs

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## Abstract

**Background—**Central line-associated bloodstream infections (CLABSIs) are a common and costly quality problem, and their prevention is a national priority. A decade ago, researchers identified an evidence-based bundle of practices that reduce CLABSIs. Compliance with this bundle remains low in many hospitals.

**Purpose—**To assess whether differences in core aspects of work environments–workload, quality of relationships, and prioritization of quality–are associated with variation in maximal CLABSI bundle compliance i.e., compliance 95–100% of the time in intensive-care units (ICUs).

**Methodology/Approach—**Cross-sectional study of hospital medical-surgical ICUs in the United States. Data on work environment and bundle compliance were obtained from the Prevention of Nosocomial Infections & Cost Effectiveness Refined (P-NICER) Survey completed in 2011 by infection prevention directors, and data on ICU and hospital characteristics from the National Healthcare Safety Network (NHSN). Factor and multi-level regression analyses were conducted.

**Findings—**Reasonable workload and prioritization of quality were positively associated with maximal CLABSI bundle compliance. High-quality relationships, although a significant predictor when evaluated apart from workload and prioritization of quality, had no significant effect after accounting for these two factors.

**Practice Implications—**Aspects of the staff work environment are associated with maximal CLABSI bundle compliance in ICUs. Our results suggest that hospitals can foster improvement in

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ensuring maximal CLABSI bundle compliance–a crucial precursor to reducing CLABSI infection rates–by establishing reasonable workloads and prioritizing quality.

### Keywords

Central line-associated bloodstream infection (CLABSI); work environment; maximal CLABSI bundle compliance; implementation; infection control

## Introduction

Central line-associated bloodstream infections (CLABSIs) are a common and costly quality problem (Berwick, Calkins, McCannon, & Hackbarth, 2006; Centers for Disease Control and Prevention, 2014; Institute of Medicine, 2001). In United States (U.S.) hospitals, 41,000 patients experience a CLABSI annually, with 1 in 4 affected patients dying as a result (Centers for Disease Control and Prevention, 2014; Weaver, Weeks, Pham, & Provonost, 2014). Caring for infected patients costs the healthcare system $2 to $3 billion annually (Warren et al., 2006). That so many patients and the healthcare system endure these health and financial costs respectively, is of great concern because CLABSIs are preventable (Berwick et al., 2006).

A decade ago, researchers identified and began disseminating information about an evidence-based bundle of practices aimed at reducing the CLABSI rate (Berwick et al., 2006; Mermel, Farr, & Sheretz, 2001; Provonost, 2008). The bundle, termed "the CLABSI bundle", consists of five practices: appropriate hand hygiene, use of chlorhexidine for skin preparation, full-barrier precautions when inserting central venous catheters, avoidance of femoral line placement, and removal of unnecessary lines (Provonost et al., 2006). In the most extensive study to date, National On the CUSP: Stop BSI Project, which involved more than 1,100 adult ICUs across 44 states, researchers calculated that use of the bundle was associated with a 43% decrease in CLABSI rates, 1,500 saved lives, and $175 million in reduced healthcare costs (Agency for Healthcare Research and Quality, 2012; Weaver et al., 2014). While on average the CUSP program succeeded (the median reported infection rate per 1,000 catheter days decreased to zero and was sustained for eighteen months), participants exhibited variation in the decrease of CLABSI incidence (Dixon-Woods, Bosk, Aveling, Goeschel, & Pronovost, 2011; Provonost, 2008). Researchers found maximal bundle compliance – defined as all practices in the bundle were used 95% or more of the time - is key for reduction: only when hospitals use practices in the bundle at this highest level of compliance does CLABSI incidence decrease (Furuya et al., 2011; Zachariah et al., 2014).

Despite the effectiveness of the CLABSI bundle and widespread promotion by federal agencies such as the Centers for Disease Control and Prevention (CDC) (Berwick et al., 2006), bundle compliance in the U.S. remains low. Having a written policy in place does not necessarily translate into high compliance (Zachariah et al., 2014). Maximal bundle compliance estimates range from 28% to 38% of U.S. hospitals (Provonost, 2008). Low compliance is puzzling given that the bundle's practices are evidence-based and do not require specialized expertise or equipment for implementation (Provonost, 2008). It is also puzzling because some hospitals achieve and maintain high compliance, indicating that it is attainable; something other than feasibility impacts compliance (Rangachari et al., 2015).

The aim of this study is to assess whether differences in work environment for staff are associated with variation in maximal CLABSI bundle compliance. Work environment is the “inner setting” of the organization where staff interplay with the organization within which they work (Damschroder et al., 2009). The study of work environment facilitates understanding of how organizations can promote staff behavior change, and how staff behavior can result in organizational variation (Lukas et al., 2007). We focus on work environment because it creates opportunities or constraints on workers’ behavior (Johns, 2006) and has been shown to influence other aspects of patient safety outcomes (Stone et al., 2007), including CLABSI rates (e.g. Dixon-Woods et al. 2011; McAlearney et al. 2015). This past work that linked work environment to CLABSI rates found that aspects of the work environment were qualitatively linked to lower CLABSI rates, including for example, leader goal setting and support (McAlearney, Hefner, Robbins, & Garman, 2013) and inter-professional collaboration (McAlearney, Hefner, Robbins, Harrison, & Garman, 2015). An ex-post analysis of the CUSP project identified that cultural influences within the organization were the likely source of variation in CLABSI rates (Dixon-Woods et al., 2011). This prompted the CUSP team to add a cultural component to their intervention, with programs focused on quality at the unit, executive and community levels (Provonost, Marstellar, & Goeschel, 2011). Hospitals that have used this intervention have seen greater reduction in their CLABSI rates (Provonost et al., 2011).

Given that CLABSI bundle compliance is a precursor to lower CLABSI rates, we anticipate that work environment might also matter to CLABSI bundle compliance. This possibility has not yet been examined, nor tested empirically. Organizational scholars assert that three core factors construct work environments, also termed work contexts: the work to be performed (task context), relationships with co-workers (social context), and the setting where work occurs (culture and physical context) (Johns, 2006). We focus on a defining element of each: staff workload (amount of work to perform – task context), quality of staff relationships (social context), and hospitals’ prioritization of quality (culture and physical context). Past qualitative work by McAlearney et al. (2015, 2016) identified these elements as similar aspects of work environment to be important for reducing CLABSI incidence (e.g. resource discussions, staff communication with each other, leader alignment). In this manuscript, we provide a quantitative complement and extension to the past work by focusing on these aspects of work environment in relation to the preceding step of CLABSI bundle compliance.

Our study responds to the call for research on bundle compliance and the role of organizational factors (Hsu, Weeks, Yang, Sawyer, & Marstellar, 2014) as well as practitioner calls for insight that begets strategies to improve compliance (Rangachari et al., 2015; Zachariah et al., 2014). Improvement has become a greater priority for hospitals because CLABSIs are no longer reimbursable in many value-based payment systems (Bodily, McMullen, Walker, & Warren, 2011; Rangachari et al., 2015).

## Conceptual Framework: Why Work Environment Might Affect Compliance

Drawing on the organizations literature, there is logic for why each work environment factor –staff workload, quality of staff relationships, and hospitals' prioritization of quality (infection prevention, in particular) – may influence CLABSI bundle compliance.

**Staff workload—**Research shows that when workers have a reasonable workload (i.e., the amount of work they are expected to do can be accomplished in the time allotted (Nembhard & Edmondson, 2006), they are more likely to take time to perform all tasks as specified. When workload is excessive, they tend to forget steps and take shortcuts to accomplish their total work faster (Chong, Van Eerde, Chai, & Rutte, 2011). Excessive workload has been correlated with lower nurses' compliance with patient care plans (Daud-Gallotti et al., 2012; Pakyz et al., 2014) and hand hygiene mandates (Institute of Medicine, 2001). Similar to these tasks, CLABSI bundle compliance may be neglected when health professionals are overburdened. In contrast, we expect CLABSI bundle compliance to be higher when professionals have reasonable workloads, as it frees time and attention to devote to compliance.

**Quality of staff relationships—**Lower quality relationships are characterized by interactions that are limited to transactional exchanges (this-for-that), while higher quality relationships are characterized by trust, cooperation, and interpersonal concern (Carmeli & Gittell, 2009; Nembhard, Northrup, Shaller, & Cleary, 2012). According to social exchange theory, quality of relationships with others in the workplace is positively associated with workers' willingness to behave in ways that support colleagues and their task completion (Blau, 1986; Emerson, 1976). The higher the quality of the relationship, the more likely workers are to communicate and coordinate with each other, including about sensitive issues (Carmeli & Gittell, 2009). Comfort in communication is likely to aid CLABSI bundle compliance because it enables workers to feel safe reminding others about practices and asking for help to perform them. In high-quality relationships, neither party in the communication feels threatened by such conversation (Carmeli & Gittell, 2009). Past research has shown that staff relationships characterized by trust and collegiality were shown to facilitate the face-to-face communication needed for compliance with another type of bundle, the *Clostridium difficile* bundle (Pakyz et al., 2014). High-quality relationships between staff responsible for infection-related issues (e.g. providers, nurses or infection prevention specialists) should facilitate CLABSI bundle compliance as well, as some of the bundle's practices (e.g., removal of unnecessary lines) can involve communication and coordination between care team members.

**Prioritization of quality—**Organizational priorities are reflected in what the organization and its leaders supports, encourages and rewards, which in turn influences staff perception of priorities, and their behaviors (Johns, 2006). Staff perception of priorities is theorized to exert subtle control over staff by creating an environment ("organizational culture") that sets acceptable norms and behaviors. When an organization prioritizes quality, an emphasis on quality permeates the organization's mission and action (Nembhard et al., 2012) and facilitates staff actions in support of quality (Rangachari et al. 2015). Thus, with respect to CLABSI, organizations' and their leaders' prioritization of quality, and infection prevention specifically, is likely to affect bundle compliance because when quality is prioritized, organizations tend to take actions that support bundle compliance (e.g. placing handwashing stations in key areas), which cultivates and reinforces a culture of quality (Provonost, 2008), to which staff respond. A systematic review of healthcare associated infection (HAI) reduction strategies (e.g., ventilator-associated pneumonia interventions) – that did not include use of the CLABSI bundle - identified prioritization of safety efforts and organizational support as predictors of the use of these strategies (Mauger et al., 2014). A recent qualitative study of management practices to prevent HAIs identified top-level commitment to quality as the key management practice related to CLABSI outcomes (McAlearney et al., 2015). Thus, we hypothesize that reasonable workload, high-quality staff relationships, and prioritization of quality are each positively associated with CLABSI bundle compliance.

## Methods

### Sample and Data Collection

We examined the effect of staff workload, high-quality staff relationships and prioritization of quality on maximal CLABSI bundle compliance in ICUs, using data from 507 adult medical-surgical intensive care units (ICUs). These ICUs were located in hospitals that participated in the Prevention of Nosocomial Infections and Cost-Effectiveness Refined (P-NICER) study. The P-NICER survey was web-based and assessed the existence of evidence-based infection prevention policies for reducing HAIs including CLABSI, compliance with each evidence-based practice, and the work environment in U.S. hospitals. Work environment questions were drawn from the Leading a Culture of Quality-Infection Prevention Survey (LCQ-IP) (Pogorzelska-Maziarz, Nembhard, Schnall, Nelson, & Stone, 2015), an infection prevention-focused version of the LCQ survey, which has been used to assess the work environment for staff in other healthcare settings (e.g., primary care) (Nembhard et al., 2012).

As described in detail elsewhere (Furuya et al., 2011; Stone, Pogorzelska-Maziarz, Herzig, Furuya, & Dick, 2014; Zachariah et al., 2014), all nonveteran hospitals enrolled in the CDC National Healthcare Safety Network (NHSN) in 2011 (N= 3,374) were invited to participate in P-NICER. NHSN is the nation’s largest HAI surveillance system (Zachariah et al., 2014). Hospitals were invited to participate in the survey via an e-mailed invitation, followed by weekly reminders and a last chance letter (a modified Dillman technique), all of which occurred between October and December 2011. The invitation explained that participation entailed survey completion, and providing the research team with access to data from the NHSN annual survey and up to six years (2006–2011) of CLABSI rate data. Each participating hospital was entered into a lottery for 10 $100 prizes per week for 8 weeks.

Invitations were directed to the director or manager of each hospital’s infection prevention (IP) and control department, who was asked to complete the survey. IP directors were selected as informants because prior research has shown infection preventionists (IPs) to be valid informants on hospital work environments and infection-related issues in ICUs (Hazamy et al., 2013). In hospitals, IPs are often the designated leader of infection control programs and have been required to report HAI rates and other data to the NHSN, a task designated to IPs by the Centers for Disease Control and Prevention over 30 years ago, with the belief and after analysis showing that IPs are well-positioned to reliably report HAI-related performance (Bryant et al., 2016). In the course of their work, IPs work closely with other hospital staff on infection-related issues, as members of the clinical departments. They track infections in the ICU, provide consultation to ICU staff, and implement and monitor interventions and policies in the ICU – all of which makes them knowledgeable about the state of infection prevention practices such as bundle compliance. Because IPs' work requires them to spend considerable time in ICUs as "pseudo" team members, they are also able to provide an informed, evaluation of staff work environment. In using IPs as single informants in HAI research, we follow several national studies (Furuya et al., 2011; Krein et al., 2007; Saint et al., 2008) and the CUSP program, which has regarded their perspective as "providing a common unifying thread that ties activities at the front line of care to an organization's management" (pg. 571, (Goeschel, Wachter, & Provonost, 2010).

Of the 3,374 invited hospitals, 975 responded to the survey (29% overall response rate). Prior work found these hospitals did not differ significantly from those that did not respond to the survey, including on the hospital characteristics included in this study (Stone et al., 2014; Zachariah et al., 2014). In our study, we focused on the 2,768 hospitals with medical-surgical ICUs, of which 644 hospitals responded to the survey (23% response rate). Medical-surgical ICUs treat medical and surgical patients and are a high-risk setting for CLABSI due to the frequent use of catheters during critical care procedures (Provonost, 2008). They were the largest ICU type in the P-NICER sample (Stone et al., 2014), and are the most common type of ICU in U.S. hospitals (Stone et al., 2007). The 644 hospitals provided survey data on 703 ICUs. We excluded 196 of these ICUs (multiple reasons may apply): 135 because of incomplete data on the ICU and hospital characteristics used as covariates in our analyses, 75 because of incomplete bundle compliance responses, 2 because "don't know" was provided as the bundle compliance response, 17 because of incomplete work environment responses. Table 1 shows the characteristics of the 507 medical-surgical ICUs in our final sample (72% of the 703 ICUs), originating from 455 hospitals.

## Measures

**Maximal CLABSI Bundle Compliance—**We assessed the degree of compliance with the CLABSI bundle in each ICU by aggregating survey respondents' answer to the question: *"During the last period monitored, what proportion of the time was this policy correctly implemented?"* There was a question for each policy in the bundle: "Cleaning patient's skin with chlorhexidine at an insertion site", "Monitoring hand hygiene practices at insertion", "Checking the line daily for necessity", "Using maximal barrier precautions upon insertions for patients with a central venous catheter" and "Selecting an optimal catheter site" (Stone et al., 2014). Respondents indicated: no monitoring, we monitor but don't know proportion, rarely or never (<25%), sometimes (25%–74%), usually (75%–94%) and all of the time (95%–100%). "Don't know" responses (n=2) were excluded. We created a dichotomous variable to indicate whether an ICU complied all of the time with all practices, i.e. respondents selected all of the time for each practice, indicating maximal compliance that re-coded the categories (1= maximal compliance and 0=otherwise) to assess the effect of work environment on maximal (the highest level of) bundle compliance, which past work showed has the greatest association with CLABSI reduction (Furuya et al., 2011; Zachariah et al., 2014).

**Work Environment—**We assessed our focal work environment factors – staff workload, high-quality staff relationships and prioritization of quality in each ICU on a 5-point Likert response scale (1=strongly disagree; 5 = strongly agree). Table 2 shows the items used to assess each work environment factor. Exploratory factor analyses were conducted to determine the discriminant validity of each measure. The appropriateness of factor analysis was supported by the Kaiser-Meyer-Olkin Measure of Sampling Adequacy test value (0.93, $p < 0.001$) that exceeded the 0.90 threshold for Bartlett's Test of Sphericity (Hatcher & O'Rourke, 1994). We conducted an exploratory factor analysis on correlation matrices using the principal axis factor method with squared multiple correlation estimates as initial communality estimates, a Promax (oblique) rotation to account for significant correlations between factors ($r \geq 0.32$, $p < .05$), and item assignment to factors on which the item had a pattern loading greater than 0.40. As recommended by experts, we excluded two items because of cross-loading (Guttman, 1954). The presence of three factors/survey scales was supported by the discontinuity of the scree plot occurring at n=3, and eigenvalues for each factor (4.67, 1.41 and 1.02) exceeding Guttman's threshold criteria of 1 (Guttman, 1954). Cronbach's alpha for each measure (reported in Table 2) was above 0.70, indicating satisfactory reliability of the measures.

**ICU-Level Covariates—**We controlled for ICU characteristics that could be related to maximal CLABSI bundle compliance: central line utilization ratio, number of central line days, and number of ICU beds. We included ICU's central line utilization ratio, which is a ratio of the days in which central lines were used to patient days as an indicator of patients' illness severity (Stone et al., 2007) because sicker patients may be more susceptible to CLABSI. We included the number of ICU beds and number of central line days (i.e., how frequently central line insertion occurs) because they could impact the degree to which the ICU is familiar with central line prevention practices.

**Hospital-Level Covariates—**We also controlled for hospital-level characteristics that could be related to maximal bundle compliance: teaching hospital, geographic region, urbanicity of location, number of patient days, number of admitted patients and participation in HAI quality improvement initiatives. Teaching hospitals, which we considered all hospitals that were members of the Council of Teaching Hospitals, may have higher compliance because their educational efforts cause them to emphasize compliance. Geographic region (east, central, south or west) and urbanicity (urban, suburb, rural) may impact external resources available for infection prevention efforts (Furuya et al., 2011). The number of patient days and number of admitted patients indicates patient volume, which has been linked to experience implementing evidence-based processes of care (Williams, Koss, Morton, Schmaltz, & Loeb, 2008) and might impact the likelihood of maximal bundle compliance. Participation in one or more of the many quality improvement and demonstration programs aimed at reducing HAIs may also be related to bundle compliance. Hence, we included an indicator variable addressing whether the hospital participates in IHI, CUSP or other initiatives.

### Statistical Analysis

We began our analysis by calculating descriptive statistics for maximal bundle compliance to gain a sense of the range of compliance in our sample. Next, we conducted bivariate Spearman correlation analyses between work environment variables and covariates. Then we used a series of multivariate multi-level regression models to estimate the associations between the work environment variables, covariates, and maximal CLABSI bundle compliance. We accounted for the 507 ICUs nested in 455 hospitals with a multi-level model using SAS PROC GENMOD, with a logit link function to account for the binary outcome variable and a cluster indicator (REPEATED command) to model the effect of ICU membership. In the first model, we included covariates only, allowing us to assess how much these structural characteristics of the ICUs and hospitals alone account for the variation in compliance. In the next three models, we assessed the association between each work environment factor and maximal CLABSI bundle compliance separately, while controlling for ICU and hospital covariates. In the final model, all work environment variables were included to assess the robustness of results and ascertain the relative importance of these factors after controlling for hospital and ICU characteristics. We examined Odds Ratios and 95% CI to evaluate the significance of each factor. All analyses were conducted in SAS version 9.3.

## Findings

Maximal bundle compliance (95–100% compliance with all practices in the bundle) occurred in 17.64% of the ICUs in our sample; the remaining 82.36% of ICUs were below this benchmark.

As reported in Table 2, the average staff workload in the study ICUs was moderate (mean=3.06 on 5-point scale, S.D.=0.83), while quality of staff relationships and prioritization of quality were evaluated as high (mean=4.32, S.D.=0.68 and mean=4.00, S.D.=0.61, respectively). Correlations between these work environment factors were significant (p-values < .05), however, variance inflation factors were all less than 6 (under the standard threshold of 10), indicating that problematic multicollinearity was not present (Neter, Wassermann, & Kutner, 1989).

Table 3 presents our regression analyses results. Model 1, the covariates-only model, shows that none of the structural characteristics of the hospitals and their ICUs considered had a significant association with maximal bundle compliance (all p-values>0.2). Models 2, 3, and 4 show that the work environment for staff was associated with CLABSI bundle compliance. In sequence, the models show that reasonable workload (OR=1.67; 95% CI=1.27– 2.21; p<0.01), high-quality staff relationships (OR = 1.36; 95% CI=1.01–1.86; p=0.04), and prioritization of quality (OR = 2.27; 95% CI=1.58–3.25; p <0.001), were each positively associated with maximal CLABSI bundle compliance. When these three factors were included in the same model (Model 5), only reasonable workload and prioritization of quality were positively associated with maximal bundle compliance. In the study ICUs, for a one unit increase in reasonable workload (e.g., from agree to strongly agree), the odds of achieving maximal CLABSI bundle compliance increased by 1.34 (95% CI=1.30–1.84; p= 0.03). For a one unit increase in prioritization of quality (e.g., from agree to strongly agree), the odds of achieving maximal CLABSI bundle compliance increased by 2.04 (95% CI =1.34– 3.06;, p<0.001). High-quality staff relationships were not significantly associated with compliance (OR=0.99, 95% CI=0.70– 1.38, p=0.92).

## Discussion

To our knowledge, this study is the first to examine whether there is an association between the work environment for staff and maximal CLABSI bundle compliance in U.S. ICUs. Our results provide evidence of a link. Staff workload and hospitals’ prioritization of quality were positively associated with maximal CLABSI bundle compliance. The significance of these across models suggests that the overall work to be performed by staff (task context), which affects time and attention to compliance, and the setting where work occurs (culture context), which influences staff appreciation for the importance of compliance, persistently determines the extent to which staff comply with the CLABSI bundle. This observation is consistent with prior work that finds that workload and prioritization play a role in compliance with other bundles (Fakih et al., 2014; Pakyz et al., 2014). Our study adds to this evidence by identifying work environment as a key contributor to use of the CLABSI bundle specifically, which has been a challenge for many hospitals. It provides evidence that complements past qualitative work that has linked the work environment to CLABSI rates (e.g. (McAlearney et al., 2013; McAlearney et al., 2015).

This study provides evidence of the importance of two elements in the “inner work setting” in the implementation of evidence-based practice. Past implementation frameworks have theorized about their importance (Damschroder et al., 2009; Kitson et al., 2008). This study provides evidence in a national sample. Our study finds that the odds of maximal bundle compliance, an evidence-based practice for reducing CLABSI, can double if hospitals prioritize quality and increase by a third if they institute reasonable workload.

Our study also shows that not all work environment factors are equally influential on staff compliance with the CLABSI bundle, as the presence of high-quality staff relationships had limited relation to maximal CLABSI bundle compliance once we accounted for the other two factors. We had theorized that high-quality staff relationships influenced bundle compliance by facilitating communication and coordination. These actions are clearly important to patient safety and quality (Institute of Medicine, 2001) but may be less central for the CLABSI bundle. Some of the practices in the CLABSI bundle (e.g. hand hygiene, chlorhexidine use) are enacted independently by clinicians; communication and coordination are not required for successful completion. This contrasts with key practices in other infection prevention bundles. For example, compliance with the *Clostridium difficile* bundle requires communication between clinicians with different expertise (physicians, pharmacists, microbiologists, etc.) for practices such as preauthorization of antimicrobials, and coordination of assessments between clinicians is necessary to fulfill many of the bundles’ tasks. The difference in degree of communication and coordination required may explain why high-quality relationships are strongly associated with compliance with this bundle but not the CLABSI bundle. Despite the lower impact of high-quality relationships for the CLABSI bundle, we caution against dismissing their value. Certain practices, such as the removal of unnecessary lines, may still be facilitated by effective working relationships between clinicians, even if not deterministic of compliance. Given the contrast in findings between bundles, future work should examine how the nature of bundles affects which work factors influence compliance.

Notably, whereas the work environment factors studied had a significant association with maximal CLABSI bundle compliance, the ICU and hospital-level structural factors did not. Our analyses included ICU and hospital-level covariates found to have associations with CLABSI-infection rates (e.g. patient volume, geographic location) (Zachariah et al., 2014) as well as some not previously considered though seen as potentially important (e.g. patient severity) (Furuya et al., 2011). Our finding that none of these structural factors were significantly associated with maximal CLABSI bundle compliance suggests that broader structural factors have a weaker relationship to bundle compliance than to CLABSI rates, and that compliance may be influenced more proximately by work environment. More research is needed to understand how structural and work environment factors can be leveraged to achieve better compliance and infection rates.

As with all studies, this study has limitations. First, although based upon a national study, this analysis utilized cross-sectional data. Second, although the sample size is large, the response rate for this study is low (29%). Prior studies using this data demonstrated that respondents in our sample of medical-surgical ICUs resemble non-respondents on relevant infection-control related variables including the control variables used in our analyses (Furuya et al., 2011); nevertheless, our results may not generalize. Our study should be replicated with a larger sample and other types of ICUs. Third, compliance and work environment factors were both self-reported by a single informant, the infection preventionist (IP), which may raise the issues of validity and common-method bias, even though we did not rely on a single survey item for any of our measures, which increases the reliability of our measures (Neter et al., 1989). As noted earlier, past work has found IPs to be valid informants (Hazamy et al., 2013), especially regarding work environment and organizational issues (McAlearney & Hefner, 2014). A qualitative study of 8 organizations and 76 staff showed that the observations and themes discussed by IPs about their hospitals converge with those of frontline staff, although IPs discuss CLABSI prevention using organizational constructs such as leadership, processes and resources while frontline staff illustrate issues with patient examples (McAlearney & Hefner, 2014). Moreover, the low report of compliance suggests that our data was not subject to social desirability bias, a risk of self-report. Nevertheless, the possibility of differences in IP-staff reports and inaccurate reporting of compliance remains. We hope that future research will have access to objective data on compliance and multiple informants regarding work environment. Last, this study was limited to a few core characteristics of the work environment. There are promising avenues of research in the exploration of other work environment characteristics (e.g., unit leader role-modeling) and their impact on compliance (Hsu et al., 2014).

## Practice Implications

Our results suggest that hospital leadership can foster improvement in ensuring maximal bundle compliance by establishing reasonable workloads and prioritizing quality. Excessive workload is associated with patient safety and worker stress problems in many hospitals and

ICUs (Daud-Gallotti et al., 2012). Our results show another area of quality that is affected by this factor, and provides additional impetus for pursuing reasonable workload. A number of effective strategies exist including increasing staff-to-patient ratios, reducing the length of workshifts, and reforming other scheduling practices – all of which can increase the time and attention available to staff to complete important tasks (Ernst, Jiang, Krishnamoorthy, & Sier, 2004). For those organizations with scarce financial resources that limits their ability to enact the aforementioned strategies for workload reduction, past research suggests that managers acknowledging staff's contributions in the face of excessive workload can provide some aid. Manager acknowledgement can lessen the experience of workload psychologically, making it more bearable for staff and minimizing frustration that distracts from task completion (Parker et al., 2008).

With respect to prioritizing quality, past work suggests that leader behavior is key as staff attend to their actions (Morrison & Phelps, 1999; Yukl, 1981). A key behavior is to be cognizant of the artifacts, signals, and messages propagated about the importance of quality and specifically infection control in their hospitals (Rangachari et al., 2015). Proven leadership strategies for conveying prioritization include creating strategic goals (e.g., centered on quality) with milestones, enacting related initiatives throughout the organization (e.g., zero-CLABI campaign), and communicating periodically (e.g., about infection prevention practices) (Mauger et al., 2014; Rangachari et al., 2015).

## Conclusion

Ensuring maximal bundle compliance is a crucial precursor to reducing CLABSI infection rates, making the study of bundle compliance an important endeavor. We found that differences in staff workload and hospitals' prioritization of quality were central work environment factors associated with variation in maximal CLABSI bundle compliance. This work provides a basis for further research to evaluate more aspects of work environment that may contribute to variation in compliance with CLABSI and other bundles, and for interventions focused on the work environment for staff.

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**Table 1**

Characteristics of ICUs in Sample (N = 507)

| Characteristic | Mean (S.D)/ N (%) |
|---|---|
| ***ICU-level characteristics*** | |
| Central line utilization rate | 0.40 (0.21) |
| Number central line days/yr | 1514.25 (1453.18) |
| Number of ICU Beds | 32.13 (38.81) |
| ***Hospital-level characteristics*** | |
| Teaching hospital | |
| No | 327 (65%) |
| Yes | 180 (35%) |
| Geographic region | |
| Northeast (9 states) | 102 (20%) |
| Midwest (12 states) | 175 (35%) |
| South (17 states) | 138 (27%) |
| West (11 states) | 92 (18%) |
| Urbanicity | |
| Urban | 121 (24%) |
| Rural | 386 (76%) |
| Number of hospital beds | 237.25 (209.64) |
| Number of admitted patients | 12,124.64 (10,615.51) |
| Infection preventionists per bed | 1.13 (1.13) |

Summary statistics are reported as means with standard deviations in parentheses for continuous variables and sample sizes with percentages in parentheses for categorical variable.

**Table 2**

Measures for Work Environment with Item Loadings from Exploratory Factor Analysis (N=507)

| | Measures | | |
|---|---|---|---|
| | **Staff Workload** | **High-quality Staff Relationships** | **Prioritization of Quality (Infection Prevention)** |
| **Survey Items** | | | |
| The quality of work suffers because of the amount of work staff are expected to do (Reverse-scored) | **0.70** | 0.26 | 0.32 |
| Most people in this organization are so busy that they have little time to devote to infection prevention efforts (Reverse-scored) | **0.71** | 0.24 | 0.39 |
| I observe a high level of cooperation among all members of my work unit or department | 0.32 | **0.95** | 0.39 |
| There is a climate of trust in my department or work unit | 0.29 | **0.84** | 0.40 |
| Results of our infection prevention efforts are measured and communicated regularly to staff | 0.34 | 0.35 | **0.65** |
| HAI prevention goals and strategic plan of our organization are clear and well communicated | 0.34 | 0.35 | **0.65** |
| Employees are encouraged to become involved in infection prevention | 0.39 | 0.20 | **0.60** |
| There is good information flow among departments to provide high quality patient safety and care | 0.49 | 0.29 | **0.69** |
| People here feel a sense of urgency about preventing HAI | 0.39 | 0.29 | **0.72** |
| **Cronbach's Alpha** | **0.75** | **0.88** | **0.83** |
| **Mean (S.D.)** | **3.06 (0.83)** | **4.32 (0.68)** | **4.00 (0.61)** |

**Table 3**

Associations of Maximal CLABSI Bundle Compliance and Work Environment in United States ICUs in 2011 (N=507)

| | Model 1: Covariates Only | Model 2: Reasonable Workload | Model 3: High-Quality Staff Relationships | Model 4: Prioritization of Quality | Model 5: All Work Environment Factors |
|---|---|---|---|---|---|
| **Independent variables** | **Odds Ratio (95% CI)** | **Odds Ratio (95% CI)** | **Odds Ratio (95% CI)** | **Odds Ratio (95% CI)** | **Odds Ratio (95% CI)** |
| Reasonable workload | | 1.67 (1.27, 2.21)** | | | 1.34 (1.30, 1.84)* |
| High-quality staff relationships | | | 1.36 (1.01, 1.86)* | | 0.99 (0.70, 1.38) |
| Prioritization of quality | | | | 2.27 (1.58, 3.25)** | 2.04 (1.34, 3.06)** |
| **ICU and hospital covariates** | | | | | |
| Central line utilization rate | 0.73 (0.15, 2.46) | 0.74 (0.14, 2.01) | 0.79 (0.15, 2.04) | 0.80 (0.14, 2.20) | 0.82 (0.15, 2.36) |
| Number of central line days per year | 1.00 (0.99, 1.03) | 1.00 (0.98, 1.02) | 1.00 (0.99, 1.03) | 1.01 (0.99, 1.03) | 1.00 (0.99, 1.03) |
| Number of ICU beds | 0.99 (0.98, 1.01) | 1.00 (0.99, 1.02) | 0.99 (0.98, 1.01) | 1.00 (0.99, 1.02) | 0.98 (0.97, 1.00) |
| Teaching hospital | 0.98 (0.97, 1.00) | 0.99 (0.98, 1.01) | 0.99 (0.98, 1.01) | 0.99 (0.98, 1.01) | 0.99 (0.98, 1.01) |
| Region: Northeast | 0.40 (0.30, 1.51) | 0.39 (0.29, 1.49) | 0.40 (0.30, 1.50) | 0.43 (0.31, 1.52) | 0.44 (0.35, 1.58) |
| Region: Midwest | 0.22 (0.02, 1.60) | 0.18 (0.01, 1.18) | 0.20 (0.02, 1.57) | 0.20 (0.02, 1.57) | 0.23 (0.02, 1.79) |
| Region: South | 0.18 (0.15, 1.90) | 0.17 (0.14, 1.80) | 0.18 (0.15, 1.91) | 0.20 (0.16, 2.02) | 0.21 (0.18, 2.06) |
| Region: West | 0.30 (0.02, 1.40) | 0.27 (0.02, 1.37) | 0.35 (0.25, 1.42) | 0.40 (0.31, 1.43) | 0.41 (0.32, 1.46) |
| Rural setting | 1.17 (0.86, 1.53) | 1.15 (0.84, 1.50) | 1.10 (0.80, 1.45) | 1.11 (0.81, 1.47) | 1.15 (0.84, 1.49) |
| Urban setting | 1.03 (0.57, 1.88) | 1.09 (0.62, 1.93) | 1.05 (0.59, 1.90) | 1.05 (0.59, 1.91) | 1.02 (0.56, 1.85) |
| Number of beds | 1.00 (0.99, 1.01) | 1.00 (0.99, 1.01) | 1.00 (0.99, 1.01) | 1.00 (0.99, 1.01) | 1.00 (0.99, 1.01) |
| Number of admitted patients | 1.00 (0.99, 1.01) | 1.00 (0.99, 1.01) | 1.00 (0.99, 1.01) | 1.00 (0.99, 1.01) | 1.00 (0.99, 1.01) |
| Participation in IHI or CUSP | 1.20 (0.96, 1.41) | 1.17 (0.88, 1.33) | 1.16 (0.90, 1.30) | 1.16 (0.92, 1.32) | 1.13 (0.87, 1.27) |

* $p < 0.05$;

** $p < 0.01$