

# Hospital Staffing and Health Care–Associated Infections: A Systematic Review of the Literature

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In the past 10 years, many researchers have examined relationships between hospital staffing and patients' risk of health care–associated infection (HAI). To gain understanding of this evidence base, a systematic review was conducted, and 42 articles were audited. The most common infection studied was bloodstream infection ( $n = 18$ ; 43%). The majority of researchers examined nurse staffing ( $n = 38$ ; 90%); of these, only 7 (18%) did not find a statistically significant association between nurse staffing variable(s) and HAI rates. Use of nonpermanent staff was associated with increased rates of HAI in 4 studies ( $P < .05$ ). Three studies addressed infection control professional staffing with mixed results. Physician staffing was not found to be associated with patients' HAI risk ( $n = 2$ ). The methods employed and operational definitions used for both staffing and HAI varied; despite this variability, trends were apparent. Research characterizing effective staffing for infection control departments is needed.

Health care–associated infections (HAIs) are a serious patient safety issue. In the United States, it is estimated that nearly 90,000 patients who acquire HAIs die each year. This ranks HAIs as the fifth leading cause of death in acute care hospitals [1, 2].

In the past 10 years, there has been much interest in gaining an understanding of the relationship between health care–provider staffing and patient safety outcomes, such as HAIs. To examine these issues, a number of research projects have been funded by the Agency for Healthcare Research and Quality, the National Institutes of Health, the Robert Wood Johnson Foundation, and other agencies. There is a growing evidence base regarding working conditions in general (with staffing included as an important aspect of working conditions) and patient safety outcomes, such as HAI. In an effort to gain clarity and synthesize this evidence, a number of reports have been prepared [3–5]. However, none have focused specifically on the relationship between hospital staffing and HAI.

To associate an adverse event, such as a HAI, with the quality of the care the patient receives from nurses, physicians, infection control professionals, and/or other health care personnel, researchers should make certain that the patient's risk of developing complications is adjusted for and that both the staffing variables and the adverse events are defined and measured in a consistent manner [6].

According to Mark [7], the commonly used nurse staffing variables include the actual number of hours of nursing care and the registered nurse hours as a percentage of all nursing hours. The latter is frequently referred to as skill mix. Additionally, Mark [7] noted that some researchers operationalized the level of nurse staffing by use of the number of full-time equivalents. According to Human Capital Theory, which is used in labor economics, other staffing variables that could impact outcomes include the type of employee contract (e.g., full-time vs. part-time and/or temporary employee), absenteeism, use of overtime, and education/certification [8].

Standardized protocols for the identification and classification of HAI developed by the Centers for Disease Control and Prevention (CDC) [6] have been widely adopted by clinicians and researchers, both in the United States and in other countries [9, 10]. Identification of HAI with use of the CDC protocol requires that trained infection control professionals conduct HAI surveillance. Although never intended for clinical management, some researchers use codes of the *International Classification of Diseases*, 9th Revision (ICD), which allow for the

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identification of a patient diagnosis at discharge, including the diagnosis of an HAI.

The extent to which these different operational definitions impact research findings related to hospital staffing and patients' HAI risk has not been previously explored. The purposes of the present study are to provide a narrative review of the methods used in research examining relationships between hospital staffing and patient risk for HAI and to summarize findings of the recent studies.

## METHODS

A systematic search was conducted using the following methods. First, relevant data bases, including Medline and the Cumulative Index to Nursing and Allied Health Literature, were searched using the key words "staffing" cross-referenced with "infections." Additionally, reference lists of published reviews were searched for eligible studies [4, 5, 11–14]. Articles were considered eligible if they were published in peer-reviewed English-language journals in 1990 or later and if they reported original research in which investigators examined the relationship between staffing in hospital settings and HAI. Nonpublished dissertation results were not included.

The journal and year of publication of each eligible study was noted. Each eligible study was audited for the following elements: sample, setting (i.e., hospital wide, general unit, intensive care unit, or other specialty area), research design (i.e., cross-sectional, longitudinal, cohort, case-control, or before and after staffing changes), unit of analysis (i.e., patient, unit, or hospital), adjustments for confounding (yes or no), the personnel category studied (i.e., staff nurses, physicians, infection control professionals, or other health care providers), staffing variables (i.e., level of staffing, including clinician-to-patient ratio or clinician hours per patient day, skill mix, use of float or nonpermanent staff, absenteeism, and/or overtime), the type of HAI (i.e., bloodstream infection [BSI], pneumonia, urinary tract infection, nosocomial wound infection, organism specific, and/or unspecified). Within these broad infection types, we also abstracted the operational definition of the infection, such as device-associated infection (yes or no) and the method to identify each infection (i.e., consistent with CDC criteria, based on ICD codes, or other). If the HAI identified was organism specific, we noted whether the study was related to an outbreak. Finally, we abstracted the results presented in each published study.

All data were abstracted into a comprehensive evidence-base table. The evidence was synthesized and summary tables are presented. The summary tables are organized into studies that examined nurse staffing and single site-specific infection, nurse staffing and multiple types of infections, nurse staffing and organism-specific HAI, nurse staffing and unspecified HAI, and non-nurse staffing and HAI.

## RESULTS

A total of 354 titles and abstracts were identified and reviewed for relevance. All titles and abstracts were audited to determine eligibility for inclusion. Two hundred eighty-two titles were excluded because they were news articles and reprints, reviews, editorials, and expert opinions, no association was tested, or they had ineligible outcomes or settings or lack of information on staffing. A total of 72 studies were identified as potentially eligible and were fully reviewed. Of these, 30 were excluded because of inadequate data, ineligible outcomes, lack of information on staffing, no analysis was conducted, and/or ineligible setting.

The evidence-based table (table A1) describing the 42 studies and results is available as an appendix (online only). The majority of the studies were published in clinical journals, including both general medicine and nursing journals ( $n = 27$ ; 64%). Most of the studies were conducted in the United States ( $n = 27$ ; 64%), and the majority of researchers used multisite research designs ( $n = 24$ ; 57%). The most common infections studied were BSI ( $n = 18$ ; 43%), pneumonia ( $n = 17$ ; 40%), and urinary tract infection ( $n = 17$ ; 40%). There was a median of 3 studies published per year and maximum of 7 published in 2002. The majority of the studies examined nurse staffing and HAI ( $n = 38$ ; 90%). Of these, only 7 (18%) did not find a statistically significant association between nurse staffing variable(s) and HAI rates. Many ( $n = 17$ ; 45%) found a statistically significant association between the nurse staffing variable(s) studied and patient risk of HAI.

An overview of the reports that examined nurse staffing and a single site-specific infection is presented in table 1. Seven research teams focused on BSI [15–21], 1 team focused on urinary tract infection [22], and 1 team focused on ventilator-associated pneumonia [23]. The studies employed cross-sectional and cohort research designs, and the sample sizes ranged from 19 units to >13,000 patients. Most studies ( $n = 8$ ) measured the level of nursing, and more than one-half of these studies ( $n = 5$ ) determined statistically significant associations between higher staffing levels and a lower risk of patient HAI [15, 20–23]. Two teams investigated the amount of time a patient was cared for by float nurses [16, 20]. Both of these teams found that the increased use of float nurses was statistically significantly related to an increase in the risk of BSI; however, other results from these studies varied.

Seventeen reports were found that examined relationships between nurse staffing and multiple HAIs (table 2) [24–40]. Most of these studies ( $n = 15$ ) were multisite studies. Nine investigative teams aggregated data at the hospital level and used administrative ICD codes to define infections [24, 26, 27, 30, 31, 34, 35, 38, 39]. Only 2 of the research teams stated whether the identification of HAIs was consistent with CDC definitions [25, 40]. Four of the studies used longitudinal de-

**Table 1. Studies examining nurse staffing and single site-specific infection.**

Type of infection, reference, comparison	Unit of analysis	Sample	Setting	Multisite (no. of sites)	Design	Adjustment for confounding	Operational definition of HAI	Device associated	Staffing	Statistically significant association
Bloodstream infection										
Cimiotti et al., 2006 [15]	P	2675	NICU	Y (2)	C	Y	CDC	N	L	Y
Alonso-Echanove et al., 2003 [16]	P	4535	ICU	Y (6)	C	Y	CDC	Y (CL)	F	Y
Tucker, 2002 [17]	P	13,334	NICU	Y (186)	C	Y	Other	N	L	N
Whitman et al., 2002 [18]	U	95	Specialty	Y (10)	C	Not reported	CDC	Y (CL)	L	N
Pronovost et al., 2001 [19]	P	2606	ICU	Y (52)	C-S	Y	ICD	N	L	N
Robert et al., 2000 [20]	P	127	ICU	N	C-C	Y	CDC	N	L/F	Y/Y
Fridkin et al., 1996 [21]	P	1760	ICU	N	C-C	Y	CDC	Y (CL)	L	Y
Urinary tract infection										
Sujjantararat et al., 2005 [22]	U	19	H	N	C-S	Not reported	Other	N	L/SM	Y/N
Ventilator-associated pneumonia										
Hugonnet et al., 2007 [23]	P	2740	ICU	N	C	Y	CDC	Y (V)	L	Y

**NOTE.** C, cohort; C-C, case-control; CDC, Centers for Disease Control and Prevention; CL, central line; C-S, cross-sectional; F, float nurse; H, hospital; HAI, health care-associated infection; ICD, *International Classification of Diseases*; ICU, intensive care unit; L, level of staffing; N, no; NICU, neonatal ICU; P, patients; SM, skill mix; U, unit; V, ventilator; Y, yes. Multiple statistical significance associations are presented for studies with multiple staffing scenarios.

signs [24, 26, 27, 31]. In all of the studies, some measure of nurse staffing (level, skill mix, overtime, or absenteeism) was statistically significantly associated with the risk of HAI ( $P \leq .05$ ), but the specific results varied.

Another body of evidence ( $n = 7$ ) focused on organism-specific infections in single institutions and nurse staffing (table 3) [2, 41–46]. Three of these analyses were related to outbreaks [2, 44, 46] and, therefore, were retrospective assessments of the staffing and risk of infection. The majority ( $n = 4$ ) of these researchers studied infections with methicillin-resistant *Staphylococcus aureus* [2, 41, 45, 46]. All but 1 investigative team observed statistically significant relationships between the level of staffing and the risk of infection. Both Dancer et al. [2] and Vicca [45] observed a statistically significant association between the use of float nurses and patient risk of methicillin-resistant *S. aureus* infection, but their findings conflicted with regard to staffing level.

Another group of researchers ( $n = 5$ ) did not identify the specific type of HAI being studied and/or grouped different types of infection together in a single analysis (table 4) [47–51]. The 3 investigative teams that used CDC protocols to identify infection demonstrated significant associations between nurse staffing and risk of infection [47, 48, 50].

Table 5 summarizes the 5 studies that focused on or included measures of non-nurse staffing [39, 52–55]. One study in which the investigators assessed the level of physician assistant staffing also measured nurse staffing and is therefore also listed in table 2 [39]. Three investigative teams examined the level of infection control staffing and patient risk of HAI [52–54]; 2 of these teams found that higher levels of infection control professional staffing were significantly related to lower rates of HAI [53, 54]. Physician staffing was not found to be associated with patient risk of HAI ( $n = 2$ ).

## DISCUSSION

This is a comprehensive compendium of the evidence that links hospital staffing variables and risk of HAI. The majority of the studies investigated nurse staffing. This may be because nurses are the largest workforce in hospitals, and although the number of nurses has grown in the past few years, a shortage still exists and is predicted to become worse in the coming years [56]. Also, nurses have the most direct and continuous role in performing the procedures and interventions on which the risk of infection often hinges, making them a critical component of infection prevention.

Although the limitations in the study designs make us unable to determine a specific evidence-based nurse staffing level benchmark that is associated with a decreased risk of HAI, trends are apparent from this body of research. For example, although only 2 investigators studied ventilator-associated pneumonia [23, 25], both reported that patients who were cared for in an intensive care unit with lower levels of nurse staffing had an increased risk of ventilator-associated pneumonia. Although the exact mechanism for this association was not studied, it is possible that when staffing levels are reduced, the nurses are unable to provide recommended care, such as keeping the head of the patient bed elevated [57]. Additionally, studies examining organism-specific HAI with single-site study designs all found that the level and/or the use of nonpermanent staff was statistically significantly related to a patient's risk of infection. It may seem surprising that care by float nurses versus full-time permanent staff nurses in intensive care units could put a patient at risk of HAI. However, this is consistent with Pronovost's description of the hierarchy in intensive care units and the importance of good communication channels and strong interdisciplinary team work [58]. Temporary staff may

**Table 2. Studies examining nurse staffing and multiple health care-associated infections.**

Reference	Unit of analysis	Sample	Setting	Multisite (no. of sites)	Design	Adjustment for confounding	Operational definition of HAI	Device associated	Staffing	Statistically significant relationship			
										BSI	Pnu	UTI	
Mark et al., 2007 [24]	H	286	H	Y (286)	Long	Y	ICD	N	L	NT	Y	N	NT
Stone et al., 2007 [25]	P	6385	ICU	Y (31)	C-S	Y	CDC	Y (CL, UC, V)	L/OT	Y/N	Y/N	N/Y	NT
Berney & Needleman, 2006 [26]	H	161	H	Y (161)	Long	Y	ICD	N	L/OT	Y/N	N/N	N/Y	NT
Mark et al., 2004 [27]	H	422	H	Y (422)	Long	Y	ICD	N	L/SM	Y/N	Y/N	N/N	NT
Cho et al., 2003 [28]	P	124,204	H	Y (232)	C-S	Y	ICD	N	L/SM	Y/Y	Y/Y	N/N	N/N
McGillis et al., 2003 [29]	U	77	Gen U	Y (19)	C-S	Y	Other	N	L/SM	NT	NT	N/N	N/Y
Needleman et al., 2003 [30]	H	3357	H	Y (799)	C-S	Y	ICD	N	L/SM	N/N	Y/Y	N/Y	NT
Unruh, 2003 [31]	H	Pennsylvania hospitals	H	Y (not reported)	Long	Y	ICD	N	L/SM	Y/Y	Y/Y	N/Y	N/N
Yang, 2003 [32]	U	21	Gen U	N	C-S	Y	Other	N	L/SM	NT	N/N	Y/N	NT
Barkell et al., 2002 [33]	P	96	Gen U	N	Pre-post	Not reported	Other	N	SM	NT	N	N	NT
Kovner et al., 2002 [34]	H	570	H	Y (528-570) <sup>a</sup>	C-S	Y	ICD	N	L	NT	Y	N	NT
Needleman et al., 2002 [35]	H	799	H	Y (799)	C-S	Y	ICD	N	L/SM	N/N	N/Y	Y/Y	N/N
Dimick et al., 2001 [36]	P	569	H	Y (25)	C	Y	ICD	N	L	N	N	N	NT
Amaravadi et al., 2000 [37]	P	366	Gen U	Y (35)	C	Y	ICD	N	L	Y	Y	Y	NT
Lichtig et al., 1999 [38]	H	478	H	Y (791)	C-S	Y	ICD	N	L/SM	NT	Y/Y	NT	Y
Kovner et al., 1998 [39]	H	589	H	Y (589)	C-S	Y	ICD	N	L	NT	Y	Y	NT
Taunton et al., 1994 [40]	U	Not reported	Gen U	Y (4)	C-S	Not reported	CDC	N	L/A	N/Y	NT	N/Y	NT

**NOTE.** A, absenteeism; BSI, bloodstream infection; C, cohort; C-C, case control; CDC, Centers for Disease Control and Prevention; CL, central line; C-S, cross-sectional; Gen U, general unit; H, hospital; HAI, hospital-associated infection; ICD, *International Classification of Diseases*; ICU, intensive care unit; L, level of staffing; Long, longitudinal; N, no; NICU, neonatal ICU; NT, not tested; OT, overtime; P, patients; Pnu, pneumonia; SM, skill mix; U, unit; UC, urinary catheter; UTI, urinary tract infection; V, ventilator; W, wound infection; Y, yes. Multiple statistical significance associations are presented for studies with multiple staffing scenarios.

<sup>a</sup> The number of hospitals analyzed varied per year.

**Table 3. Nurse staffing and organism-specific health care–associated infections.**

Reference	Unit of analysis	Sample	Setting	Multisite	Design	Adjustment for confounding	Organism	Staffing	Statistically significant relationship
Dancer et al., 2006 [2]	P	174	ICU	N	Outbreak	Not reported	MRSA	L/F	N/Y
Grundmann et al., 2002 [41]	P	331	ICU	N	C	Y	MRSA	L	Y
Stegenga et al., 2002 [42]	P	2929	Gen U	N	Retrospective	Not reported	Viral gastrointestinal	L	Y
Dorsey et al., 2000 [43]	P	52	ICU	N	C	Y	<i>Enterobacter cloacae</i> and <i>Serratia marcescens</i>	L	Y
Harbarth et al., 1999 [44]	P	60	NICU	N	C (outbreak)	Y	<i>E. cloacae</i>	L	Y
Vicca, 1999 [45]	P	50	ICU	N	C	Not reported	MRSA	L/F	Y/Y
Haley et al., 1995 [46]	P	10,943 <sup>a</sup>	NICU	N	Outbreak, before and after intervention	Y	MRSA	L	Y

**NOTE.** C, cohort; F, float nurse; Gen U, general unit; ICU, intensive care unit; L, level of staffing; MRSA, methicillin-resistant *Staphylococcus aureus*; N, no; NICU, neonatal ICU; P, patients; Y, yes. Multiple statistical significance associations are presented for studies with multiple staffing scenarios.

<sup>a</sup> Patient days.

lack specific training and familiarity with institutional procedures and “best practices” for preventing HAIs, and they may not have the relationships needed for clear communication. Hospital administrators, nurse managers, and infection control professionals should be aware of the importance of interdisciplinary team work and the need for both consistent training and adequate nurse staffing in reducing the risk of HAI.

There is sparse evidence that examines the impact of staffing of infection control departments and availability of physicians in the prevention of HAI. More than 30 years ago, the CDC undertook the national Study on the Efficacy of Nosocomial Infection Control (SENIC) [59]. This study established a connection between elements of infection control programs and provided strong evidence that hospitals with more staffing and more intense infection control processes had lower rates of HAI. However, the study has not been updated, and evidence to inform current practice is seriously lacking [60]. For example, the investigators of the original study recommended that hospitals employ at least 1 full-time infection control professional for every 250 occupied beds; because of the lack of more-recent data, this outdated ratio is sometimes applied as the standard today. Although this ratio may have been adequate many years ago, there have been many changes in health care delivery, such as shorter lengths of stay, increased patient acuity, and an increased risk of HAI, including HAI due to multiple-drug resistant organisms [61–63]. Although there has been a number of reports that describe infection control staffing [64, 65], no researchers have updated this study. The use of the outdated ratio may be contributing to the persistent nature of the HAI problem.

Throughout this body of research, there were a number of methodological flaws. In many of the larger multisite studies, the research teams used administrative data sets to examine both staffing and infection variables. These studies have a number of limitations. First, in large data sets, the staffing measures are often determined using the hospitals’ reported full-time equivalents. This method is not precise, is not unit specific,

and is likely to introduce measurement error [66]. Another limitation in many of these studies is the identification of infections with use of diagnoses and procedure codes recorded in administrative data. Previous studies have found that ICD codes and other hospital administrative databases did not accurately identify patients who had a central line–associated BSI, as defined by the CDC [67]. Poor sensitivity (60%) and low positive predictive value (20%) for administrative data as a means of identifying HAIs was recently reported in a pediatric hospital [68]. When these issues are considered, it is likely that variability in the measurement of both staffing and HAI each contribute to the mixed results found in these studies. Indeed, because of the limitations of ICD codes and the identification of HAI, others may not have considered these studies for review. However, we chose to include this body of evidence, because these studies are often cited and often impact policy, such as the legislated minimum nurse-to-patient ratios in California hospitals.

More-precise measurements of staffing and HAI may be obtained directly from the institution. However, the burden of data collection often limits research to smaller studies from single institutions. Single-site studies often lack sufficient sample size and have limited statistical power.

Much of the reviewed research used cross-sectional or cohort design, which limits the interpretation to association, not causality. For example, 1 multisite study had many strengths, including the fact that all hospitals used the CDC protocols to identify HAI and multiple methods were used to control for patient severity of illness and differences among settings [67]. However, even though the researchers found significant associations between staffing and various HAIs, the interpretation was limited by the cross-sectional study design. It is possible that there were unmeasured organizational traits, besides staffing, that were responsible for the observed effect. Another group of researchers who used administrative data alone conducted a longitudinal study and analyzed variation over time within a setting using a fixed-effect statistical model [27]. An-

**Table 4. Studies examining nurse staffing and health care–associated infections, unspecified infection type.**

Reference	Unit of analysis	Sample	Setting	Multisite	Design	Adjustment for confounding	Operational definition of HAI	Staffing	Statistically significant relationship
Hugonnet et al., 2007 [47]	P	1883	ICU	N	C	Y	CDC	L	Y
Halwani et al., 2006 [48]	P	430	ICU	N	Long	Not reported	CDC	L	Y
Blegan et al., 1998 [49]	U	42	Gen U	N	C-S	Y	Not defined	L/SM	N/N
Archibald et al., 1997 [50]	P	782	PICU	N	C-S	Not reported	CDC	L	Y
Grillo-Peck and Risner, 1995 [51]	P	71	U	N	Pre-post	Not reported	Not reported	SM	N

**NOTE.** C, cohort; CDC, Centers for Disease Control and Prevention; C-S, cross-sectional; Gen U, general unit; HAI, health care–associated infection; ICU, intensive care unit; L, level of staffing; Long, longitudinal; N, no; P, patients; PICU, pediatric ICU; SM, skill mix; U, unit; Y, yes. Multiple statistical significance associations are presented for studies with multiple staffing scenarios.

alytically, this is a much stronger design than a cross-sectional study, because it controls for differences in the setting that are time invariant (e.g., patient population served). Although these researchers found that nurse staffing had a diminishing marginal effect on reducing inpatient mortality, they did not find a similar significant effect on HAI. This may be attributable to the use of the administrative data to identify HAI.

More-rigorous research is needed. Both the staffing and infection variables should be operationalized with the use of reliable and valid measures. The strongest design would be a multisite, randomized, controlled trial; however, this may not be feasible or pragmatic. A study that uses a cluster randomization may be possible. At the very least, researchers should use longitudinal fixed effect and/or instrumental variable research designs (both of which help control for underlying unmeasured differences in setting).

This review has limitations. Only English-language articles published after 1990 were included in the audit. The language limitation was necessary because of resources. With the changes in the health care system over the past 20 years, we believe that limiting the search to publications after 1990 is justified. Besides the SENIC study [61], we do not know of another seminal study examining other personnel categories that was omitted from the present review. Every attempt was made to be comprehensive in the search strategy; however, we may have missed

eligible articles. Different researchers may have chosen different elements to abstract from the articles and/or may have categorized the data elements differently. To ensure that the abstraction was consistent and accurate, 2 readers abstracted each data element and compared abstractions. Any discrepancies were discussed. Although we attempted to report the studies in a consistent manner (e.g., defining level of staffing as both clinician-to-patient ratio and clinical hours per patient-day) and report statistical significance of associations tested, with the varying definitions and data sources for the measurement of both the staffing and HAI variables as well as varying quality of the analyses and diverse settings, we did not report specific point estimates and SEs, and we did not conduct a meta-analysis. Although it is tempting to pool the data and compute weighted averages, with the methodological flaws we observed, we did not believe this to be prudent.

This review examining hospital staffing and HAI was comprehensive. Although nurse staffing was most thoroughly studied, additional rigorous research is warranted with use of standard CDC definitions of HAI and more-accurate and consistent measures of nurse staffing. With the increased use of hospitalists, physician assistants, and other health care providers, more research is needed that incorporates the many disciplines of staffing. Finally, the role and scope of practice of epidemiologists and infection control professionals is changing and

**Table 5. Studies examining non-nurse staffing and health care–associated infections.**

Reference	Unit of analysis	Sample	Setting	Multisite (no. of sites)	Design	Adjustment for confounding	Operational definition of HAI	Device associated	Staffing type	Staffing	Type of infection	Statistically significant relationship
Geubbels et al., 2005 [52]	H	36	H	Y (36)	C	Y	CDC	N	ICP/Phy	L/L	W/W	N/N
The UK Neonatal Staffing Study Group, 2005 [53]	P	13,334	NICU	Y (186)	C	Y	Other	N	ICP	L	BSI	Y
Richet et al., 2003 [54]	H	90	H	Y (90)	C-S	Not reported	Other	N	ICP	L	MRSA	Y
Dimick et al., 2001 [55]	P	366	H	Y (35)	C	Y	ICD	N	Phy	Other	BSI/Pnu/ not specified	N/N/N
Kovner and Gergen, 1998 [39]	H	589	H	Y (589)	C-S	Y	ICD	N	PA	L	Pnu	Y

**NOTE.** BSI, bloodstream infection; C, cohort; CDC, Centers for Disease Control and Prevention; C-S, cross-sectional; H, hospital; HAI, health care–associated infection; ICD, *International Classification of Diseases*; ICP, infection control professional; ICU, intensive care unit; L, level of staffing; MRSA, methicillin-resistant *Staphylococcus aureus*; N, no; NICU, neonatal ICU; PA, physician assistant; Phy, physician; Pnu, pneumonia; W, wound infection; Y, yes. Multiple statistical significance associations are presented for studies with multiple staffing scenarios and/or types of infection.

increasing. Rigorous research characterizing infection control departments that are effective in preventing HAI in different settings and hospital types is needed.

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