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State of the Science Review

Impact of certified infection preventionists in acute care settings: A systematic review

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A B S T R A C T

Background: Health care-associated infection (HAI) is a common adverse event affecting patient safety. This review aims to (1) establish evidence for the impact of certified infection prevention and control (CIC) specialists on infection prevention and patient safety in acute care settings and (2) summarize study design and statistical modeling used for impact assessment to inform future studies.
Methods: We searched and reviewed full-text, quantitative studies assessing the impact of CIC. The studies used empirical data published in English between January 2000 and April 2021 in PubMed, PsycINFO, and EMBASE. We identified 8 articles for data extraction and analysis. All eight studies used a cross-sectional design and had a quality rating of good to high based on the Johns Hopkins Nursing Evidence-Based Practice rating scales.
Results: CIC infection preventionists (IPs) may have a stronger understanding than other practitioners of the evidence for certain infection prevention practices and are more likely to recommend implementing them in the hospitals where they work, especially when the lead IP is certified. The association between CIC and HAI rates was inconsistent in our results.
Discussion and Conclusions: Further studies are needed to explore the impact of CIC IPs on HAI rates.

Over the last fifteen years, the US health care system and its patients have paid an increasingly high price for adverse events. The health care system needs safe and reliable delivery systems to prevent common causes of patient harm.[1-4] Health care-associated infection (HAI) is among the most common adverse events affecting patient care. An estimated 648,000 patients in acute care hospitals across the United States develop HAIs annually, with 75,000 related deaths.[5]

Infection preventionists (IPs) play a significant role in preventing HAIs in US hospitals. Defined by the Association for Professionals in Infection Control and Epidemiology (APIC), IPs are "experts in identifying sources of infections and limiting their transmission in healthcare facilities." The Centers for Medicare and Medicaid Services (CMS) require that all hospitals designate at least one IP to conduct surveillance and develop and implement intervention strategies to prevent and control infections.[6] IPs must be familiar with the guidelines and literature on infection prevention and control (IPC) and recommend evidence-based practices. They may also lead organizational efforts of IPC practice implementation and improvement.

IPs can obtain certification in infection prevention and control, a designation that requires passage of a comprehensive examination to demonstrate mastery of 8 core competencies. The core competencies are (1) identification of infectious disease process; (2) surveillance and epidemiologic investigation; (3) prevention and control of the transmission of infectious agents and health care-associated infection; (4) occupational health; (5) communication and management; (6) education and research; (7) management of the health care environment; and (8) cleaning, sterilization, disinfection, and asepsis.[7] The Certification Board of Infection Control and Epidemiology (CBIC) is the sole organization offering certified infection prevention and control (CIC) specialist designation in the US. The CBIC provides standardized knowledge assessment for practicing IPC, encourages professional learning and growth, and recognizes individuals that

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achieve the certification requirements.[7] According to the APIC's MegaSurvey administered in 2015, 43% of the APIC-member IPs were CIC certified, and another 38% planned to obtain the certification in the near future.[8]

Better insight into the work and impact of CIC IPs on IPC and patient safety within hospitals is needed to assist hospital leadership and payers with resource deployment and policy making. Therefore, we conducted a systematic review to establish evidence of the impact of CIC on IPC and patient safety. The review focused on empirical, quantitative studies that aimed to quantify the impact in acute care settings. Our secondary objective was to inform future studies by collecting information on study design, frameworks, and statistical modeling used for impact assessment.

METHODS

We conducted the review with pre-specified protocols per the preferred reporting items for systematic reviews and meta-analyses (PRISMA).[9]

Search strategy

We searched studies published in English between January 1, 2000, and April 30, 2021, in the following scientific databases: PubMed, PsycINFO, and EMBASE. We tailored search terms to be inclusive and cover studies related to certification in infection prevention and control (see Table 1). The lead author (YJH) also manually searched articles to test the search terms and used the snowball approach for relevant articles. We then scanned references and citations from the included articles to further identify eligible papers.

Study inclusion and exclusion criteria

To be included, a study had to meet the following criteria: (1) English-language; (2) full-text published in a peer-reviewed journal; (3) assessing the impact of the certification or CIC IPs using empirical data; and (4) including at least one outcome measure related to IPC or patient safety. We excluded qualitative studies.

Two researchers (YJH and EN, or YJH and ZZ) independently assessed the eligibility of the retrieved articles. We based the first assessment on title and abstract. We retrieved and reviewed the full text of an article if the title and abstract provided insufficient information to determine eligibility. A full-text review then helped determine whether an article fulfilled all the inclusion criteria for the final selection.

Data extraction and synthesis

We developed a standardized form for data extraction for the studies included in our review. The pre-specified elements extracted included study design, study sample (unit and size), measurement of the certification variable, outcome measure(s), and principal findings regarding the impact of the certification. To gather information to inform future studies, we also extracted covariates adjusted in the regression models, if any, and whether the study examined any mediating or moderating effects. One researcher (EN or ZZ) extracted the data from each included study, and a second researcher (YJH) examined the extracted data. We described and organized study characteristics (eg, study design) and outcome measures for all included studies. We also analyzed and grouped covariates included in the statistical analysis, if any. The categorization of covariates included respondent characteristics, facility structure, facility process, and external facility characteristics. We based the definition of structure and process on Donabedian's structure-process-outcome (SPO) categorization.[10] *Structure* refers to the physical, organizational, and human capacity of a health care facility (eg, equipment, personnel). *Process* refers to providing care (ie, practitioner activities) and receiving care (ie, patient activities). *Outcomes* are the effects of care described at a patient or population level.

We did not expect that studies examining the impact of CIC would adjust for outcomes as covariates. The external facility characteristics are covariates representing broad policy, regulations, and the community or patients a facility serves.

Rating of selected studies

We used the Johns Hopkins Nursing Evidence-Based Practice (JHNEBP) evidence rating scales[11] to appraise the level of evidence in this literature review. The JHNEBP tool assesses each study's study design, results, and conclusions and then assigns a quality grade of 'high quality,' 'good quality,' or 'low quality or major flaws' to help determine the strength of evidence.

RESULTS

Search results

The scientific database search yielded 2,141 articles (Fig 1). After excluding duplicates, the title and abstract review resulted in 12 articles for full-text review. Five articles met all inclusion criteria. We then identified 3 additional articles through citations in the included articles and hand search. Ultimately, we used 8 articles for data extraction and analysis.

Study characteristics

We summarized study characteristics and primary findings regarding the impact of CIC based on the included studies in Table 2.

Study design and measures

All 8 articles used a cross-sectional design to examine the association of certification with outcome measures. Based on the JHNEBP evidence rating scales, all articles had a strength of evidence rating of level II out of 5 and a quality rating of A/high or B/good. Two of the studies, both survey studies, were conducted at the individual IP level. One compared the perceived strength of evidence supporting infection prevention practices between certified and non-certified IPs[12]; the other compared a vaccine program score developed to measure self-reported adherence to the CDC's and ACIP's recommendations regarding vaccine handling and management.[13]

The other 6 studies were conducted at the hospital level. The certification-related independent variable was defined as whether the supervisory or lead IP was certified or whether there was a CIC IP in the hospital. Three studies examined self-reported adoption or use of specific infection prevention practices.[14-16] The remainder

Table 1
List of search terms

	Search term
1	Certification Board of Infection Control and Epidemiology
2	Certified infection preventionist(s)
3	Certified infection prevention and control professional(s)
4	Infection prevention certificate
5	CIC-certified
6	CIC certification
7	CIC credential
8	Certified in infection control
9	Certification examination AND infection control

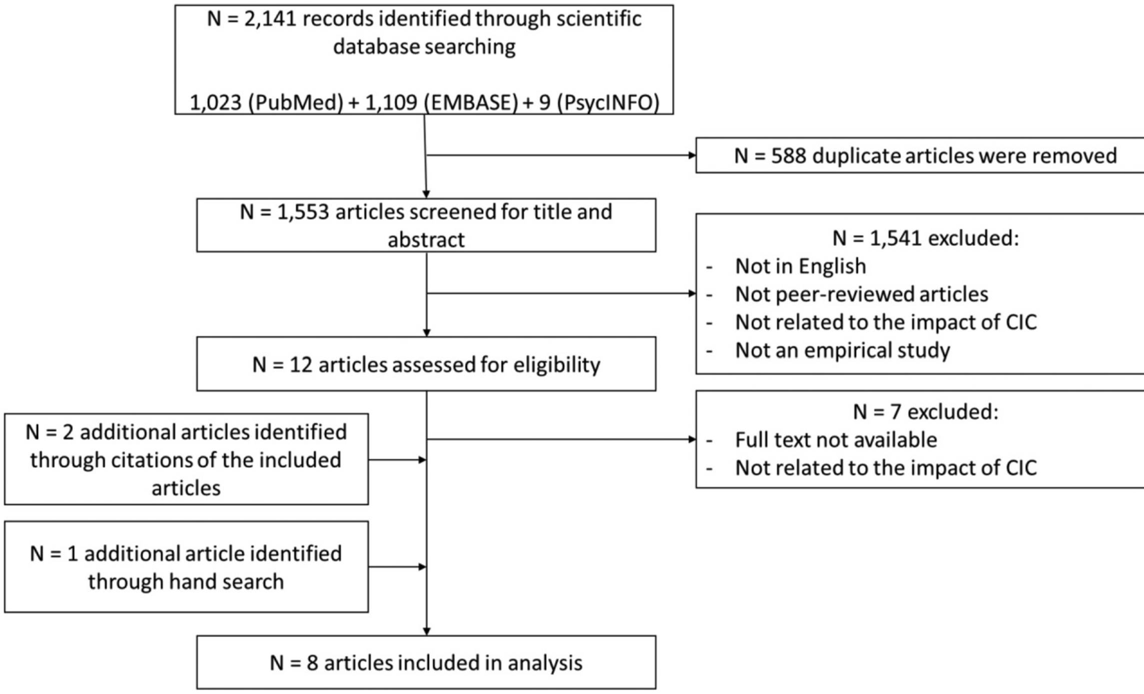

Fig 1. Flow chart of search and selection.

used HAI-related outcome measures, such as infection rates or CMS hospital-acquired condition domain scores.[17-19]

Covariate adjustment and analysis

None of the included studies examined mediating or modifying effects. One study (individual level) did not include any adjustments.[13] One study (hospital level) was a data brief, and it was unclear what covariates were included in the regression analysis.[18] The other individual-level study adjusted for IP individual characteristics (eg, length of time in current position) and hospital characteristics (eg, bed size, whether the hospital participates in a collaborative to reduce HAI).[12] In the hospital-level studies, 3 types of covariates were included:

1) *Hospital-level or unit-level structural variables*: Examples included bed size, teaching status, and academic affiliation. Most of the studies also included staffing, nurse staffing, and infection prevention staffing (eg, whether a hospital had a hospital epidemiologist, total infection control staffing hours).
2) *Process variables*: One study adjusted for infection control screening, contact precautions, and surveillance practices in health care facilities when examining the association between infection control department characteristics and multidrug-resistant infection rates.[19]
3) *External characteristics*: Region or geographic location.

Impact of certification

In the 2 individual-level studies that examined self-reported measures, CIC status was associated with higher self-assessed competency and greater perception of evidence strength for several IPC practices. These practices included antimicrobial stewardship programs, nurse-initiated urinary catheter discontinuation protocols, and sedation vacations.[12] CIC status was associated with better self-reported vaccine management and handling.[13] However, CIC status was negatively correlated with perceived strength of evidence for other practices, such as routine changes of central venous catheter, oscillating/kinetic beds, and antimicrobial mouth-rinse.

All 3 hospital-level studies that examined the use or adoption of infection prevention practices reported a positive impact on CIC status.[14-16] Hospitals with a lead certified IP or a greater proportion of certified IPs were more likely to implement certain practices, including subglottic secretion drainage to prevent ventilator-associated pneumonia (VAP), use of antimicrobial central venous catheters and avoidance of routine central catheter changes to prevent central-line associated bloodstream infections (CLABSIs) and screening new admissions.

One of 3 studies of the association between CIC status and HAI rates reported positive findings. Hospitals with a certified infection control director had lower rates of Methicillin-Resistant Staphylococcus Aureus (MRSA) infection after controlling for structure and process variables.[19] The other 2 studies did not find an association between CIC status and surgical site infection (SSI) rates or *Clostridium difficile* infection (CDI) rates at the hospital level.[17,18]

DISCUSSION

We systematically reviewed the literature for the impact of certification in infection prevention and control on HAI prevention and patient safety in the US. Our review suggested that CIC IPs may have a stronger understanding than other practitioners of the evidence for certain infection prevention practices. CIC IPs were also more likely to recommend implementing these practices in the hospitals where they worked, especially as the lead IP. The finding is consistent with core competencies that certification aims to build among CIC IPs. However, the association between CIC status and HAI rates was inconsistent. The 3 studies on the association between CIC status and HAI rates examined different types of infections, used different measures for the CIC status of acute care facilities (eg, whether any of the IPs were CIC versus whether a hospital's infection control director

Table 2
Summary of included studies

First author & publication year	Sample size	Study design	Outcome variable(s)	Primary independent variable(s)	Covariates	Summary of results
Saint, S et al. (2013)[12]	478 IPs	Cross-sectional design	Perceived strength of evidence for use of HAI[*] prevention practices	Whether the IP[†] is CIC[‡]	Number of years the respondent has been in their current position, number of full-time equivalent IPs, hospital bed size, hospital participation in a collaborative focused on reducing HAI	CIC status was significantly associated with stronger perceived strength of evidence for several practices, including antimicrobial stewardship programs, nurse-initiated urinary catheter discontinuation protocols, and sedation vacation. CIC status was also significantly associated with decreased perceived strength of evidence for other practices, including routine central venous catheter changes, oscillating/kinetic beds, antimicrobial month-rinse
Carrico, RM et al. (2013)[13]	1006 IPs	Cross-sectional design	Adherence to recommendations regarding vaccine selection and administration, vaccine handling and management, and training	Whether the IP is CIC	None	CIC IPs scored significantly higher in overall program performance than non-certified IPs
Krein, SL et al. (2007)[14]	516 hospitals	Cross-sectional design	Regular use of specific practices for preventing catheter-related bloodstream infections	Whether a hospital's supervisory ICP[§] is a CIC IP	Hospital characteristics: hospital type (non-federal vs. Department of Veterans Affairs medical centers), number of intensive care unit beds, registered nurse staffing, level of facility support for evidence-based practices, county population, and metropolitan location	Hospitals with a supervisory ICP that was CIC were more likely to use antimicrobial central venous catheters and avoid routine central catheter changes
Krein, SL et al. (2008)[15]	516 hospitals	Cross-sectional design	Use of following infection prevention practices: semirecumbent positioning, antimicrobial mouth rinse, subglottic secretion drainage, and oscillating or kinetic beds.	Whether the lead ICP is CIC	Whether the facility had a hospital epidemiologist, whether the facility was participating in a collaborative effort to encourage the use of infection control practices, academic affiliation, nurse staffing	If the ICP was CIC, the facility was significantly more likely to report regular use of subglottic secretion drainage
Pogorzelska, M et al. (2012)[16]	250 hospitals	Cross-sectional design	Adoption of screening and infection control interventions for multi-drug-resistant organisms	Proportion of CIC IPs	Screening practices, number of infection control staff, bed size, and region	Intensive care units in hospitals with a greater proportion of CIC IPs were less likely to report correct implementation of policy to screen new admissions after controlling for the number of infection control staff and region
Musuuza, JS et al. (2020)[17]	126 VA acute-care facilities	Cross-sectional design	Health care-associated Clostridioides difficile infection rates	Whether any of the IPs are CIC in a facility	Complexity of each facility (a surrogate measure of patient case mix)	Whether a facility's Clostridioides difficile infection rates were above or below the national Clostridioides difficile infection rate was not influenced by the certification of IPs in infection control. Clostridioides difficile infection rates were not influenced by infection control training and infection control certification
Wright, MO et al. (2017)[18]	120 hospitals	Cross-sectional design	Centers for Medicare and Medicaid Services hospital-acquired condition Domain 2 scores and surgical site infection rates for coronary artery bypass graft operations and knee prosthesis	IP staffing levels	Unknown	Board certification was not significantly associated with hospital-acquired condition Domain scores or surgical site infection rates
Pogorzelska, M et al. (2012)[19]	180 hospitals	Cross-sectional design	Hospital-associated methicillin-resistant Staphylococcus aureus bloodstream infections rates, hospital-associated vancomycin-resistant Enterococcus bloodstream	Whether a hospital's infection control director is a CIC IP	Structure variables: bed size, teaching status, setting (urban/suburban/rural), and participation in quality initiative. Structures of care (infection control department characteristics): IP staffing, presence of a full-time	Hospitals with a CIC director had significantly lower rates of methicillin-resistant Staphylococcus aureus bloodstream infections rates

(*continued on next page*)

Table 2 (*Continued*)

First author & publication year	Sample size	Study design	Outcome variable(s)	Primary independent variable(s)	Covariates	Summary of results
			infections rates, and Hospital-associated C difficile infection rates		and part-time physician hospital epidemiologist, total infection control staffing hours, number of IPs, proportion of IPs certified in infection control, use of electronic surveillance systems for tracking of HAI, whether the infection control director is a member of APIC¶ or SHEA#. Processes of care: screening all new patients upon admission, screening select patients upon admission, screening all patients after admission, implementing presumptive isolation/contact precautions pending results of a screen, implementing contact precautions for patients with positive screen, conducting surveillance of microbiology results for new cases	

*Hospital-acquired infection.
†Infection preventionist.
‡Certified infection prevention and control.
§Infection control professional.
¶The Association for Professionals in Infection Control and Epidemiology.
#The Society for Healthcare Epidemiology of America.

was a CIC IP), and were embedded in different settings (eg, Veterans Affairs hospitals versus California hospitals). All these differences may contribute to inconsistencies in reported findings.

All identified studies used a cross-sectional design. None used a longitudinal design that considered the cumulative effect of employing a CIC IP for a longer time period. A longitudinal design that observes and analyzes a group of health care facilities for a certain period of time may benefit the research by establishing temporality (eg, the impact of early employment of CICs on HAI rates later). Longitudinal studies could also assess cumulative effects (eg, short-term hiring of CICs versus long-term hiring). Future studies should consider a longitudinal design and seek to understand how a CIC IP's role may modify or mediate contextual factors that influence HAI and patient safety.

The included studies focused on HAI prevention, and only 1 of them examined vaccination.[13] We expected that CIC training on education, research, communication, and management of the health care environment would help HAI prevention and the facility's capacity to improve overall patient safety. This is another area future studies can investigate. Our review catalogued covariates included by previous studies to assist in building analytic frameworks for future studies.

Our initial search yielded 1,553 distinctive publications. The review included 8 articles in the analysis, with 5 identified using search terms, 2 cited by those 5 studies, and the remaining 1 from manual search. We believe the large exclusion from the initial search was due to our broad search strategy that aimed to include all studies related to CICs. We did not include search terms that specified quantitative studies nor any outcome measures. We also found inconsistencies in what a certified infection control professional is called and in the definition of the CIC acronym. The spell-out of CIC includes "certified in infection prevention and control," "certified in infection control," and "board certification in infection prevention and control" in the 8 included articles, which may have limited our ability to identify all the studies from the search words at the beginning.

Another limitation was that we only considered published studies and could not search for unpublished manuscripts. Hence, there may have been publication bias. Nor did we include qualitative studies. Specifically, qualitative studies that explore the role of CICs in the context of a multidisciplinary work environment and the challenges CICs face to implement best infection prevention practices could have been helpful. Such qualitative studies would have helped explain the findings of quantitative investigations reported in this study.

The coronavirus disease 2019 (COVID-19) pandemic poses a tremendous challenge to delivering health care worldwide. It has impacted and will continue to impact the organization and design of health care facilities and how they provide care. The role of infection preventionists and their training has grown in importance to prepare health care facilities for pandemics like the COVID-19 and to prevent other HAIs. There is increasing support for hiring certified professionals in infection prevention.[20] Therefore, it is critical to understand the impact of the certification. To our knowledge, this study is the first systematic effort to review the evidence of the impact of the certificate in infection prevention and control in the US. The study also points to research areas for future studies to consider.

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