ORIGINAL ARTICLE

Assessing the Burden of Healthcare-Associated Infections through Prevalence Studies: What Is the Best Method?

Walter Zingg, MD;[1] Benedikt D. Huttner, MD, MS;[1] Hugo Sax, MD;[1,a] Didier Pittet, MD, MS[1]

OBJECTIVE. To explore differences in the prevalence of healthcare-associated infections (HAIs) according to survey methodology.

DESIGN. Repeated point and period prevalence survey strategies.

SETTING. University-affiliated primary and tertiary care center.

METHODS. Analysis of data collected from 2006 to 2012 from annual HAI prevalence surveys using definitions proposed by the US Centers for Disease Control and Prevention. The study design allowed the analysis of the same data in the format of a point or a period prevalence survey.

RESULTS. Pooled point and period HAI prevalence was 7.46% and 9.84% (+32%), respectively. This additional 32% was mainly attributable to infections of the lower respiratory tract (2.42% vs 3.20% [+32%]) and the urinary tract (1.76% vs 2.62% [+49%]). Differences in surgical site infections (1.02% vs 1.20% [+19%]) and bloodstream infections (0.76% vs 0.86% [+13%]) were smaller. HAI prevalence for the point and period methodology in acute and long-term care were 7.47% versus 9.38 (+26%) and 8.37% versus 11.89% (+42%), respectively. Differences were stable over time. Focusing on the 4 major HAIs (respiratory tract, urinary tract, surgical site, and bloodstream infections) misses one-quarter of all HAIs.

CONCLUSIONS. More HAIs are identified by the period prevalence method, especially those of shorter duration (lower respiratory and urinary tract), which would make this method more suitable to be used in long-term care. Results of the 2 study methods cannot be benchmarked against each other.

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The pioneering Study on the Efficacy of Nosocomial Infection Control (SENIC) project, initiated in the 1970s by the US Centers for Disease Control and Prevention (CDC), unequivocally proved the benefit of healthcare-associated infection (HAI) surveillance.[1,2] The method was based on a stratified random sample of patients from 338 US hospitals, and HAIs were detected by thorough patient chart review. The HAI prevalence at that time was estimated at approximately 5.2%.[3-5] In 1970, the US National Nosocomial Infection Surveillance network was established to provide regular prospective outcome data on HAI in intensive care units (ICUs) in the United States.[6] In parallel, the CDC issued definitions of nosocomial infections.[7] Over the following decades, the CDC HAI definitions were continually updated and became the reference standard for the vast majority of HAI surveillance activities around the world.[7-14]

In 1981, the World Health Organization (WHO) convened an advisory group on the surveillance, control, and prevention of HAI.[15] The group specifically recommended the conduct of HAI prevalence surveys to assess the burden of the problem in different parts of the world. Later, WHO published prevalence data gathered between 1983 and 1985 from 47 hospitals in 14 countries.[15] At the same time, an increasing number of countries started to conduct national or regional prevalence surveys. Most recently, the European Centre for Disease Prevention and Control (ECDC), as well as the CDC, performed large point prevalence surveys in Europe and the United States based on the methodology published in 2 pilot studies, and the results of the ECDC point prevalence survey are now published.[16-18] Most local, regional, and national surveys used the point prevalence methodology, that is, only HAIs active on the day of the survey were taken into account. However, some studies in Italy,[19,20] Switzerland,[21-25] and the United States[26] used the period prevalence method, that is, not only were HAIs active on the day of the survey accounted for, but those active during a predefined period before the survey day were also assessed (Figure 1). Some surveys, such as the first Spanish prevalence survey of the Estudio de Prev-

Affiliations: 1. Infection Control Program and World Health Organization Collaborating Center on Patient Safety, University of Geneva Hospitals and Faculty of Medicine, Geneva, Switzerland; a. Present affiliation: Division of Infectious Diseases and Infection Control, University Hospital of Zurich and Faculty of Medicine, Zurich, Switzerland.

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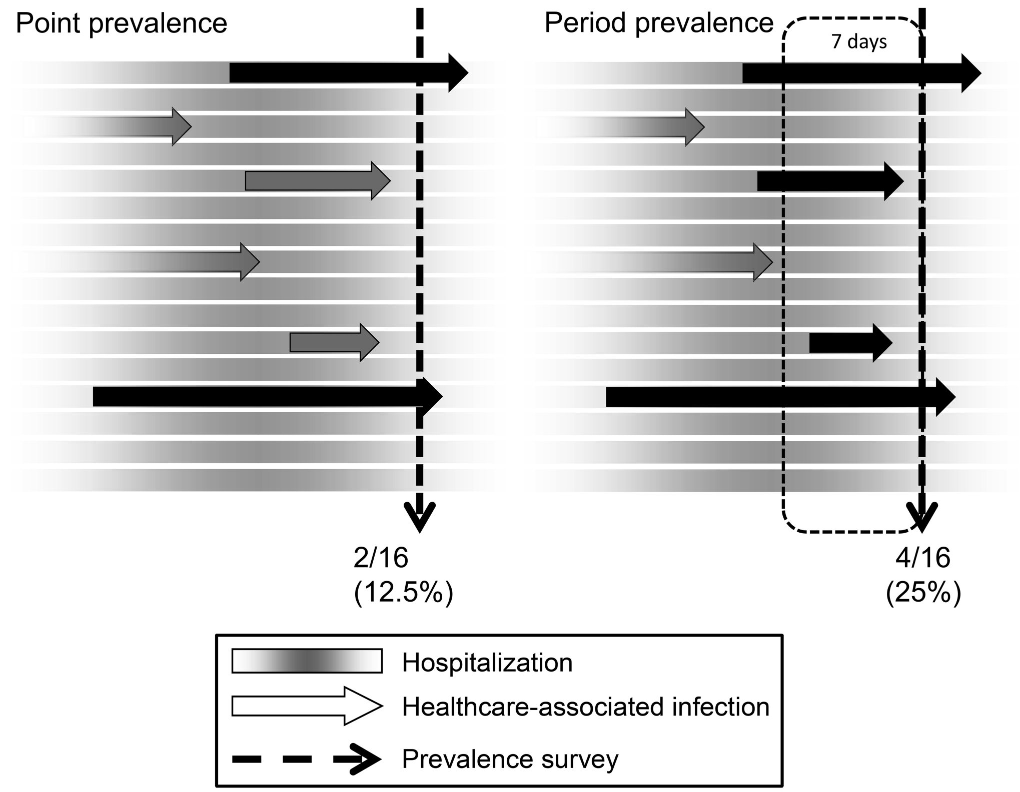

FIGURE 1. The concepts of point and period prevalence surveys. In point prevalence surveys, all patients present on the day of prevalence are eligible, and only healthcare-associated infections active at the time of the survey are included in the analysis. In this example, 2 of 16 patients have a healthcare-associated infection, for a prevalence of 12.5%. In period prevalence surveys, all patients present on the day of prevalence are eligible, and healthcare-associated infections active at the time of the survey or in the preceding 6 days (for a total of 7 days of study) are included in the analysis. In this example, 4 of 16 patients have a healthcare-associated infection, for a prevalence of 25%.

alencia de las Infecciones Nosocomiales en Espana (EPINE) network, combined point prevalence (active infection on the day of survey) with extrinsic risk factors present in the 7 days before the survey.[27] Both methodologies have advantages and disadvantages. While a period prevalence survey will allow capture of more HAIs, especially those of short duration, it is methodologically "less pure," since it mixes the concepts of prevalence and incidence, and it is also more time-consuming than a pure point prevalence survey.

To our knowledge, no study has analyzed the differences between the point and period methodology to assess the burden of HAI. We conducted this study to provide such an analysis from a large database and to place the findings in the context of the published literature.

METHODS

The University of Geneva Hospitals (Geneva, Switzerland) is a primary and tertiary care center with 1,908 beds; in 2012, 47,000 admitted patients accumulated 670,000 patient-days. Located at 8 different sites, the hospital offers intensive, acute, and long-term inpatient care and also includes a pediatric hospital. Since 1994, the infection control team has conducted annual period prevalence surveys in May and early June.[28] The current study focused on data collected from 2006 to 2012 from all departments except psychiatry. All types of HAI as defined by the CDC were included apart from asymptomatic urinary tract infection (UTI).[11,12] No adjustments or modifications of the definitions or other aspects of the methodology were made during the study period, and all staff involved in the survey were trained in the methodology.

Every patient present in the ward on the day of the prevalence survey was included except those admitted on the calendar day of the survey. Infection control nurses and physicians screened patient charts for clinical symptoms and signs, laboratory data, microbiological results, and information from other diagnostics suggestive for infection within a 1-week period, ending with the day of the prevalence survey. HAIs were counted when they were active at any time within the 1-week period (Figure 1).[28] An infection was considered active when the patient had clinical symptoms and/or was still receiving treatment for that infection. Surgical site infections were documented as healthcare associated when they occurred within 30 days after the operation or 1 year in the case of infection associated with the insertion of a prosthetic

TABLE 1. Patient Characteristics with Annual Trends: Prevalence Surveys, University of Geneva Hospitals, 2006–2012

Characteristic	Pooled data	Trend, IRR (95% CI)
Age, median (IQR), years	72 (50–83)	1.01 (1.01–1.01)
Sex (female)	5,774 (56)	1.00 (0.99–1.02)
Charlson comorbidity index, mean ± SD	1.17 ± 1.68	1.01 (1.00–1.02)
McCabe score, mean ± SD	1.19 ± 0.46	1.01 (1.00–1.02)
Surgery	2,554 (25)	1.01 (0.99–1.03)
ICU stay at any time	853 (8)	1.07 (1.03–1.10)
Distribution of acute and long-term care		
Acute care at prevalence	5,717 (55)	1.00 (0.99–1.02)
Long-term care at prevalence	4,650 (45)	1.00 (0.98–1.01)

NOTE. Data are no. (%), unless otherwise indicated. CI, confidence interval; ICU, intensive care unit; IQR, interquartile range; IRR, incidence rate ratio; SD, standard deviation.

device.[21] The distinction between point and period prevalence was possible because the data set contained a variable indicating whether an HAI was active on the day of the prevalence survey. Annual prevalence surveys are part of a quality improvement program promoted by the directorate of the University of Geneva Hospitals. The institutional ethics committee waived informed consent related to the prevalence surveys. HAI duration was estimated from the pooled data by the difference of days between the date of HAI onset and the date of the point prevalence survey.

PubMed was searched for published prevalence surveys without restrictions of language up to June 30, 2013. The following search term was used: ("prevalence" [Title] OR "point-prevalence" [Title] OR "cross-sectional" [Title]) AND ("nosocomial" [Title] OR "hospital-acquired" [Title] OR "infection in hospitals" [Title] OR "hospital infection" [Title] OR "hospital infections" [Title] OR "healthcare-associated" [Title] OR "hospital-associated" [Title] OR "infections among hospitalized patients" [Title]). Further references were obtained by a full text sift of retrieved publications.

Statistical Analysis

The descriptive analysis was stratified by CDC infection categories (lower respiratory tract infection and pneumonia [LRTI], UTI, surgical site infection [SSI], bloodstream infection and clinical sepsis [BSI], gastrointestinal infection [GI], skin and soft-tissue infection [SST], and other infections, which included mostly eye, ear, nose, and throat infections) and care settings (acute [including intensive care] and long-term care). Descriptive statistics were used to express the difference between point and period prevalence surveys. No formal statistical test was used to quantify the differences because the same database was used to calculate outcomes for both point and period prevalence (the null hypothesis that the prevalence obtained by the different methodologies is equivalent can be rejected without a test since the period prevalence contains all infections counted in the point prevalence). Differences for the different HAIs between acute and long-term care were analyzed using a simple χ^2 test. Trends related to patient characteristics across the study years were determined using a nonadjusted Poisson regression analysis for each separate variable and reported as incidence rate ratios. Two-sided $\alpha < .05$ was used to determine statistical significance. All statistical analyses were conducted using Stata software, version 10.0 (StataCorp).

RESULTS

A total of 7 annual prevalence surveys including 10,367 patients were analyzed. Patient characteristics such as sex, age, Charlson comorbidity index, surgery, and distribution among the different care settings are summarized in Table 1. We observed moderate yearly trends toward higher age, higher McCabe classification[29] and Charlson comorbidity index[30] scores, and more frequent ICU stays. Proportions of acute and long-term care did not change during the study period (Table 1).

The point and period prevalence surveys identified a total of 816 and 1,089 HAIs among 773 and 1,020 patients, respectively. Estimated HAI durations (median [interquartile range]) for LRTI, UTI, SSI, BSI, GI, SST, and other infections were 6 (3–10) days, 5 (3–9) days, 14.5 (6–29) days, 7 (3–12) days, 6.5 (3–11) days, 6 (4–13) days, and 7.5 (5–15) days, respectively.

The pooled point and period prevalence (95% confidence interval) of all HAIs were 7.46% (6.96%–7.98%) and 9.84% (9.27%–10.42%), respectively. Figure 2 summarizes the differences of pooled HAI prevalence between acute and long-term care. Significantly higher proportions of UTI and LRTI were identified in long-term care, while the proportions of SSI and BSI were higher in acute care, irrespective of the prevalence methodology. Table 2 summarizes the differences between pooled point and period prevalence surveys for HAI, LRTI, UTI, SSI, BSI, GI, SST, and other infections stratified into acute and long-term care. Overall, HAI ratios were higher (+33.4%) when assessed by the period prevalence method in both acute (+25.6%) and long-term (+42.1%) care. There were particularly large differences between the 2 methodol-

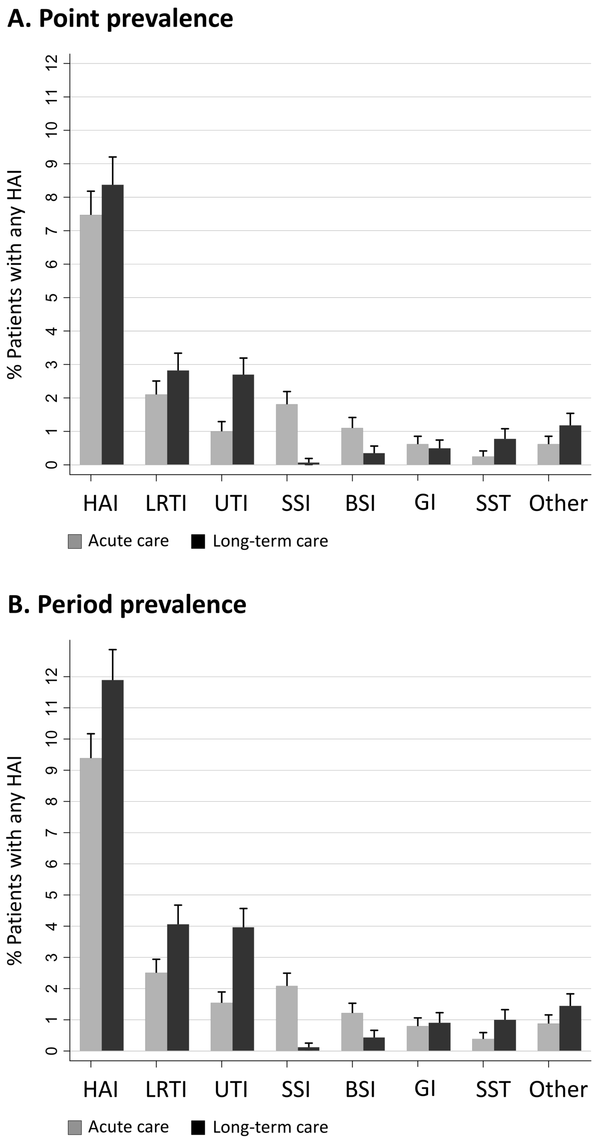

FIGURE 2. Pooled point and period prevalence of healthcare-associated infections (HAIs) with 95% confidence intervals stratified by clinical setting: prevalence surveys, University of Geneva Hospitals, 2006–2012. *A*, Point prevalence. *B*, Period prevalence. BSI, bloodstream infection; GI, gastrointestinal infection; LRTI, pneumonia/lower respiratory tract infection; SSI, surgical site infection; SST, skin and soft-tissue infection; UTI, urinary tract infection.

ogies for LRTI and UTI in long-term care where more of these infections were identified. SSIs and BSIs were identified mostly in acute care with little difference between point and period prevalence.

Focusing on the 4 leading HAIs (LRTI, UTI, SSI, and BSI) misses a high proportion of infections in both the point (24.3%) and the period prevalence (25.0%), respectively. Differences are larger in long-term than acute care in both the point (33.0% vs 19.7%) and the period prevalence (28.0% vs 21.9%). The difference between the 2 settings is more pronounced in the point than in the period prevalence.

Results of the Literature Search

The search term identified 305 publications, of which 249 were prevalence surveys or complementary material. An additional 4 studies were identified by a search of the references of retrieved publications. A total of 97 international, national, or regional multicenter (more than 1 center) published surveys were identified with an upward trend over the decades.

DISCUSSION

Our study shows that benchmarking between point and period prevalence data is not possible, as the higher proportion of infections identified by the period methodology favors HAIs of short duration and infections in long-term care. Prevalence surveys are biased in favor of HAIs of longer duration compared with incidence surveys and are notably influenced by the duration of antimicrobial treatment and the propensity to discharge patients.[4] The period prevalence methodology counterbalances this to some degree, and the proportion of the different HAIs becomes more similar to the proportion of their incidence.

From a methodological point of view, the idea of the period prevalence may be challenged because it mixes the concepts of prevalence and incidence (J. Freeman, personal communication, 1999). However, the period methodology should not be considered inferior to the point prevalence methodology on the basis of this aspect alone, and our data suggest that it could be of particular interest for use in long-term care settings where HAIs of short duration, such as LRTI and UTI, are common and where the burden of these HAIs may be underestimated when using the point prevalence method. The difference between the 2 methodologies in acute care settings, where more SSIs and BSIs occur, is less important. Period prevalence data do not serve to estimate incidence rates using common algorithms.[31-33] The better approximation of HAIs of short duration by the period methodology could add value to such models, but further studies are needed to validate this hypothesis. Furthermore, focusing on the 4 leading (ie, most frequent) HAIs (LRTI, UTI, SSI, and BSI) may reduce workload but underestimates the proportion of infections (such as GI, SST, eye, and ear, nose, and throat infections) that are common in long-term care. This makes such an approach unsuitable for this type of setting, and prevalence surveys in long-term care should better focus on a more appropriate selection of HAIs, such as LRTI, UTI, SSI, and SST[34] or LRTI, UTI, BSI, GI, and conjunctivitis.[35]

HAI incidence data have become the gold standard of HAI surveillance over the past 2 decades. National and multinational networks, such as the US National Healthcare Safety Network, the German Krankenhaus Infektions Surveillance System, and the International Nosocomial Infection Control Consortium, have become success stories both in high-income table 2. Distribution of Pooled Point and Period Prevalence of Healthcare-Associated Infections (HAIs) Stratified by Clinical Setting: Prevalence Surveys, University of Geneva Hospitals, 2006–2012

Clinical setting, type of infection	No. (%)	Point prevalence,[a] % (95% CI)	No. (%)	Period prevalence,[a] % (95% CI)
Hospital-wide (10,367 patients)				
LRTI	251 (31)	2.42 (2.13–2.74)	332 (30)	3.20 (2.87–3.56)
UTI	182 (22)	1.76 (1.51–2.03)	272 (25)	2.62 (2.32–2.95)
SSI	106 (13)	1.02 (0.84–1.24)	124 (11)	1.20 (1.00–1.42)
BSI	79 (10)	0.76 (0.60–0.95)	89 (8)	0.86 (0.69–1.06)
GI	58 (7)	0.56 (0.43–0.72)	87 (8)	0.84 (0.67–1.03)
SST	50 (6)	0.48 (0.36–0.64)	68 (6)	0.66 (0.51–0.83)
Other	90 (11)	0.87 (0.70–1.07)	117 (11)	1.13 (0.93–1.35)
All HAI	816 (100)	7.87 (7.36–8.41)	1,089 (100)	10.50 (9.92–11.11)
Acute care (5,717 patients)				
LRTI	120 (28)	2.10 (1.74–2.50)	143 (27)	2.50 (2.11–2.94)
UTI	57 (13)	1.00 (0.76–1.29)	88 (16)	1.54 (1.24–1.89)
SSI	103 (24)	1.80 (1.47–2.19)	119 (22)	2.08 (1.73–2.49)
BSI	63 (15)	1.10 (0.85–1.41)	69 (13)	1.21 (0.94–1.52)
GI	35 (8)	0.61 (0.43–0.85)	45 (8)	0.79 (0.57–1.05)
SST	14 (3)	0.24 (0.13–0.41)	22 (4)	0.38 (0.24–0.58)
Other	35 (8)	0.61 (0.43–0.85)	50 (9)	0.87 (0.65–1.15)
All HAI	427 (100)	7.47 (6.80–8.18)	536 (100)	9.38 (8.63–10.16)
Long-term care (4,650 patients)				
LRTI	131 (34)	2.82 (2.36–3.33)	189 (34)	4.06 (3.52–4.67)
UTI	125 (32)	2.69 (2.24–3.19)	184 (33)	3.96 (3.42–4.56)
SSI	3 (1)	0.06 (0.01–0.19)	5 (1)	0.11 (0.03–0.25)
BSI	16 (4)	0.34 (0.20–0.56)	20 (4)	0.43 (0.26–0.66)
GI	23 (6)	0.49 (0.31–0.74)	42 (8)	0.90 (0.65–1.22)
SST	36 (9)	0.77 (0.54–1.07)	46 (8)	0.99 (0.72–1.32)
Other	55 (14)	1.18 (0.89–1.54)	67 (12)	1.44 (1.12–1.83)
All HAI	389 (100)	8.37 (7.59–9.20)	553 (100)	11.89 (10.98–12.86)

note. CI, confidence interval; BSI, bloodstream infection; GI, gastrointestinal infection; LRTI, pneumonia/lower respiratory tract infection; SSI, surgical site infection; SST, skin and soft-tissue infection; UTI, urinary tract infection.

[a] Infections divided by the total number of patients.

and in low- and middle-income countries, thus serving as a reference for many similar undertakings.[36-38] Prospective hospital-wide HAI incidence surveillance is time-consuming and costly, and such programs are often restricted to the ICU or other high-risk settings, such as oncology or neonatology. However, HAI is not exclusively confined to such high-risk areas; it also occurs in regular wards. For example, it has been shown that central line–associated BSIs occur at similar incidence rate ratios both in and outside the ICU.[39]

Prevalence surveys help to assess the burden of hospital-wide HAI at a reasonable cost.[40-42] In the 1970s, many countries and regions in Europe and elsewhere began to conduct prevalence surveys, and the CDC and the ECDC have now followed this example by launching large point prevalence surveys in the United States and Europe.[18] Table 3 and Figure 3 show when countries and regions started to conduct international, national, or regional prevalence surveys, spanning a timeline of 4 decades. Only a few prevalence surveys used the period methodology,[19-26,43] and the vast majority in Africa,[44-50] Asia,[51-64] Australasia,[65-67] Europe,[34,40,42,68-110] North America,[17,111-113] and South America[114-117] used the point prevalence methodology. Although many surveys used some version of the CDC HAI definitions, methodological inequalities make direct comparison of prevalence results difficult.[118]

The history of HAI prevalence surveys is linked to the meticulous work of the SENIC project in the 1970s and the useful HAI definitions issued and regularly updated by the CDC and the ECDC, which have served the infection control community for many years. Today, time and budget restrictions force infection control programs to reestablish the concept of the prevalence survey, despite its methodological limitations. The recent commitment of the CDC and the ECDC to prevalence surveys sets the stage for future prevalence studies using comparable methodologies. More than 30 years after it was issued, the WHO call for action to perform HAI prevalence surveys to assess the size of the problem in different parts of the world is finally established.[15]

In summary, our findings suggest that the additional portion of HAIs detected by the period methodology favors HAIs of short duration, which are less likely to be captured by the

TABLE 3. First International, National, or Regional Prevalence Surveys of Healthcare-Associated Infections: 1970–2010

Country/organization	Year(s) of survey	Hospitals	Patients	Setting(s)	CDC criteria	Method	Prevalence,[a] %
Sweden[69]	1975	5	4,246	All	Yes[7]	Point	17.0
Denmark[70]	1978	20/25	2,920	Acute	Yes[8]	Point	10.4
United Kingdom[75]	1979	43	18,163	Acute	Yes[10]	Point	19.1
Italy[68]	1983	130	34,577	Acute	Yes[8]	Point	19.3
WHO[15]	1983–1985	47	28,861	Acute	No	Point	8.7
Australia[65]	1984	269	28,643	Acute	Yes[10,119]	Point	6.3
Belgium[76]	1984	106	8,723	Acute	Yes[8]	Point[b]	9.3
Czechoslovakia[105]	1984	23	12,260	All	No[120]	Point	6.1
Thailand[53]	1988	23	6,805	Acute	No[121]	Point	11.7
Spain[27,122]	1990	123	38,489	Acute	Yes[11]	Point[c]	8.5
Norway[78]	1991	76	14,977	Acute	Yes[9]	Point[d]	6.3
Brazil[114]	1992	11	2,339	Acute	Yes[11]	Point	14.0
Europe[85]	1992	1,417	10,038	ICU	Yes[11]	Point	44.8
Mauritius[50]	1992	4	1,190	Acute	Yes[10]	Point	4.9
Germany[94]	1995	72	14,996	Acute	Yes[11]	Point	3.5
France[82]	1996[e]	830	236,334	All	Yes[14]	Point	6.7
New Zealand[66,67]	1996–1999	4	5,819	All	Yes[11]	Point	9.5
Switzerland[21]	1996	4	1,349	Acute	Yes[11]	Period	11.6
Cuba[116]	1997	28	6,152	Acute	Yes[11,14]	Point	6.8
Lebanon[62]	1997	14	834	Acute	Yes[119,123]	Point	6.8
Greece[102]	1999	14	3,925	Acute	Yes[11,14]	Point	9.3
Mexico[112]	1999[f]	21	1,183	Pediatric	Yes	Point	9.8
Slovenia[106]	2001	19	6,695	Acute	Yes[11,14]	Point	4.6
Turkey[103]	2001	22	236	ICU	Yes[11]	Point	48.7
Canada[113]	2002	25	5,750	Acute	Yes	Point[g]	10.5
Indonesia[63]	2001–2002	2	888	Acute	Yes[11,14]	Point[h]	8.3
Latvia[98]	2003[f]	2	1,291	Acute	NA	Point	5.6
Iran[60]	2004–2005	8	2,667	All	Yes[11]	Point	8.8
Finland[80]	2005	30	8,234	Acute	Yes[11]	Point	8.5
Scotland[91]	2005–2006	45[i]	11,608	Acute	Yes	Point	9.5
Ireland[87]	2006	44	7,541	Acute	Yes[13]	Point	4.9
China[61]	2007–2008	13	20,350	Acute	Yes[11,j]	Point	3.9
Netherlands[96]	2007–2008	41	26,937	Acute	Yes[k]	Point[l]	6.2
Argentina[117]	2008	39	4,249	Acute	Yes[124]	Point	11.3
Mongolia[58]	2008	2	933	Acute	Yes	Point	5.4
Vietnam[56]	2008	36	7,571	Acute	Yes[11]	Point	7.8
CDC[17]	2009	9	851	Acute	Yes	Point	6.0
ECDC[18]	2013	947	273,753	Acute	Yes[12,m]	Point	6.0

NOTE. BSI, bloodstream infection; CDC, US Centers for Disease Control and Prevention; CDI, *Clostridium difficile* infection; ECDC, European Centre for Disease Prevention and Control; ICU, intensive care unit; NA, not available; SSI, surgical site infection; UTI, urinary tract infection; WHO, World Health Organization.

[a] Proportion of patients with 1 or more healthcare-associated infections as defined in the survey.

[b] Only UTI, SSI, and BSI.

[c] Extrinsic risk factors were screened for 7 days before the survey.

[d] All diagnoses except UTIs were based on clinical criteria alone.

[e] A first study among 11,599 patients in 39 hospitals was performed in 1990.[125]

[f] Year of publication.

[g] Only UTI, BSI, SSI, and CDI.

[h] Only UTI, BSI, SSI, and phlebitis.

[i] Acute care only.

[j] With some modifications for infants.

[k] With some modifications.

[l] Only UTI, pneumonia, BSI, and SSI.

[m] European case definitions by HELICS or other European projects were used where available.

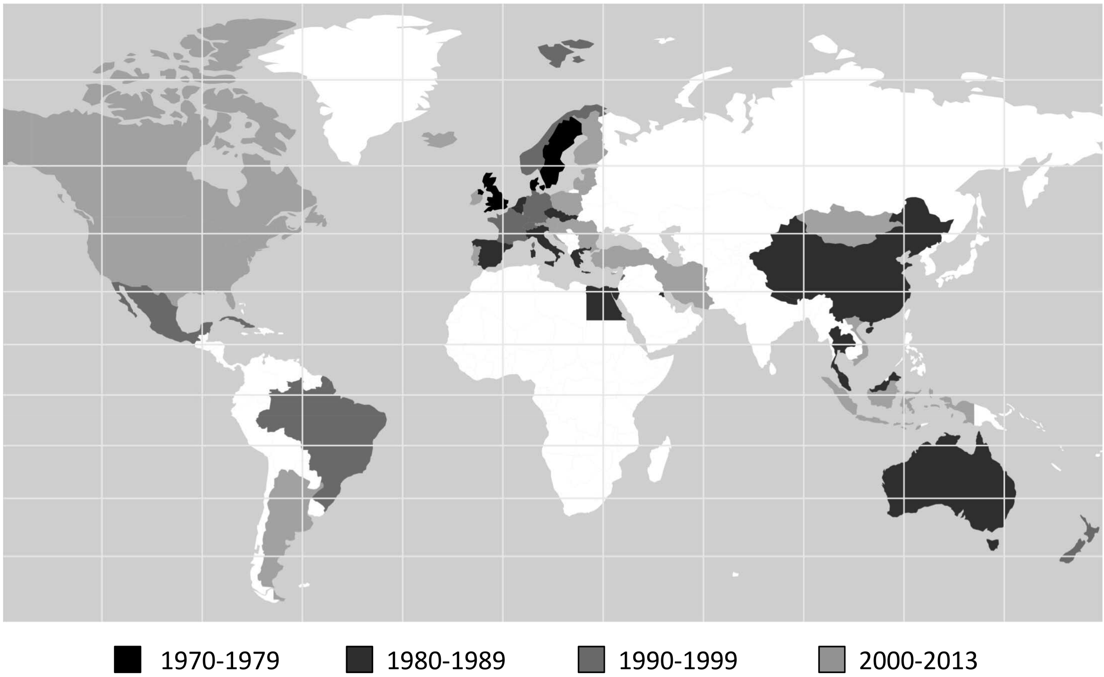

FIGURE 3. International, national, or regional prevalence surveys of healthcare-associated infections in acute or mixed care settings: 1970–2013.

point methodology. This would make the period strategy suitable to be used in long-term care, while the benefit in acute care is low. The results of the 2 concepts cannot be benchmarked against each other. Given the potential advantage of the period methodology in long-term care and the heterogeneity of care settings in our primary and tertiary care hospital, we will continue to use the period methodology with the opportunity to calculate point prevalence data in order to benchmark with other databases.

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Address correspondence to Walter Zingg, MD, Infection Control Program, University of Geneva Hospitals, 4 Rue Gabrielle Perret-Gentil, 1211 Geneva 14, Switzerland (walter.zingg@hcuge.ch).

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