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Point prevalence of healthcare-associated infections and antibiotic use in three large Swiss acute-care hospitals

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Summary

BACKGROUND: The overall burden of healthcare-associated infections (HAIs) remains high, even in high-income countries. However, the current burden of HAI in Switzerland is unknown. Prevalence surveys have a long tradition in the field of infection prevention and control for measuring both HAI and antimicrobial use. The objective of this survey was to test the point prevalence survey (PPS) methodology of the European Centre for Disease Prevention and Control (ECDC) in acute-care hospitals in Switzerland.

METHODS: Two tertiary care hospitals and one secondary care hospital in central and western Switzerland participated in the survey. Patients from all wards except for emergency departments and psychiatric wards were included. Data were collected on a single day for every ward with a maximum time frame of 2 weeks for completing data collection. Methodology and definitions were based on the most recent ECDC PPS protocol.

RESULTS: Data on a total of 2421 patients were analysed. One hundred thirty-six patients had 153 HAIs, corresponding to a prevalence of 5.6% (95% confidence interval [CI] 4.7–6.5%). Rapidly fatal McCabe score, hospitalisation in the intensive care unit (ICU), and having a medical device in place were independent risk factors for HAI. Lower respiratory tract infection was the most frequent HAI type (24.8%), followed by surgical site infection (22.2%), bloodstream infection (17.0%) and urinary tract infection (13.7%). The highest HAI prevalence (26.2%) was observed in the ICU. In total, 60.8% of all HAIs were microbiologically confirmed. The most common microorganism was *Escherichia coli* (21.1%). Six hundred sixty-nine patients (27.6%, 95% CI 25.9–29.4%) received 893 antimicrobials for 705 indications. Community-acquired infections (39.0%) were the most common indication for antimicrobial use and amoxicillin-clavulanate was the most commonly prescribed antimicrobial (18.4%).

CONCLUSIONS: HAI prevalence and antimicrobial use in this survey were similar to findings of the past ECDC PPS. The ECDC methodology proved applicable to Swiss acute-care hospitals.

Key words: *point prevalence survey*, *Switzerland*, *multicentre*, *healthcare-associated infection*, *antibiotic use*

Introduction

The overall burden of healthcare-associated infections (HAIs) remains high, although efforts in infection prevention and control have resulted in HAI reduction in some countries [1]. According to the World Health Organization (WHO), 7% of patients in developed countries and 16% in developing countries have at least one HAI at any one time during hospitalisation, with a mortality rate estimated at 10% [2].

Prevalence surveys have a long tradition in the field of infection prevention and control [3]. In the early 1970s, the SENIC (study on the efficacy of nosocomial infection control) study in the United States used repeated point prevalence surveys (PPSs) to demonstrate the effect of infection prevention and control units in US acute-care hospitals [4]. As early as 1981, a group of WHO experts recommended use of national PPSs as a tool to estimate the global burden of HAI [5]. Although the response was below expectation at that time, a growing number of countries conducted national surveys in the following years. The last national prevalence surveys in Switzerland date back to 2003 and 2004 [6, 7]. HAI prevalence surveys have fallen into disuse until recently, when the US Centers for Disease Control and Prevention (CDC) and the European Centre for Disease Prevention and Control (ECDC) performed large-scale national (CDC PPS) and multinational (ECDC PPS) surveys to set HAI benchmarks [8, 9].

Although some Swiss hospitals continued doing periodical local prevalence studies after 2004, the global burden of HAI in Switzerland today is unknown, because current data are lacking and the former prevalence surveys did

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not use the “point” methodology, but rather the “period” methodology, which makes benchmarking with other surveys impossible [3]. In January 2013, the Swiss Federal Council approved its “Health 2020” plan, which set public health priorities for the coming years in Switzerland, and defined the reduction of HAIs as a first-order measure. For this purpose, the national strategy “Strategie NOSO” was established [10]. Within this strategy, measuring HAI is a priority. The objective of this survey was to pilot the ECDC PPS methodology in acute-care hospitals in Switzerland ahead of a national PPS.

Materials and methods

A small number of acute-care hospitals in Switzerland were asked to participate in this multicentre cross-sectional study. Three acute-care hospitals accepted the invitation, among them two university hospitals (1954 and 957 beds, respectively) and one large regional hospital (825 beds). All patients (including children and neonates) were eligible to be included if admitted to the ward before or at 8 a.m. and not discharged (either home or to a different ward) during the day of the survey. All wards, regardless of specialty, were eligible. Patients staying in the emergency room for more than 24 hours and patients hospitalised in psychiatry were excluded. Long-term rehabilitation and other long-term care facilities were included in the survey if such wards were an integral part of an otherwise acute-care hospital. Data were collected in a single day for every ward, but a maximum time frame of 2 weeks was accepted to complete hospital-wide data collection.

Methodology and definitions were based on the most recent ECDC PPS protocol, but without hospital indicator data [11–13]. Indicator data from only three hospitals would not have been informative. An infection was considered active when signs and symptoms of the infection were present on the survey date or signs and symptoms were present in the past and the patient was (still) receiving treatment for that infection on the day of survey. In addition, one of the following conditions had to be fulfilled: (1) the onset of symptoms was on Day 3 or later (day of admission = Day 1) of the current admission or the patient presents with an infection but has been readmitted <48 hours after a previous admission to an acute care hospital; (2) the patient was admitted (or developed symptoms within 2 days) with an infection that met the case definition of an active surgical site infection, i.e. the infection occurred within 30 days after the procedure (or in the case of surgery involving an implant, was a deep or organ/space surgical site infection that developed within 90 days of the operation) and the patient either had symptoms that met the case definition and/or was on antimicrobial treatment for that infection; (3) the patient had been admitted (or developed symptoms within 2 days) with *Clostridium difficile* infection <28 days after a previous discharge from an acute care hospital; (4) an invasive device was placed on Day 1 or Day 2, resulting in an HAI before Day 3.

Investigators were trained on the protocol by the Swiss PPS coordination centre in Geneva. Spring and autumn were defined as steady-state periods with normal hospital activity and without seasonal outbreaks. Therefore, hospitals were asked to collect data either from April to June 2016 or from October to December of the same year.

Data from two hospitals were reported directly to the Swiss PPS coordination centre. The third hospital collected data within an electronic database later to be used for the national PPS. All patient data were anonymised. Rapidly fatal McCabe score (expected fatal outcome within 1 year) [14], age groups (0–17, 18–40, 41–60, 61–80, >80 years), hospitalisation in the intensive care unit (ICU) at survey, having a medical device (peripheral venous catheter, central venous catheter, urinary catheter, endotracheal tube) in place during survey, and having undergone NHSN (national healthcare survey network) surgery before survey, were tested in a univariable logistic regression analysis. Variables with a significance level of p = 0.2 were tested in a multivariable model. Observations were clustered on the hospital level, and a two-sided p-value of 0.05 was considered significant. Data analysis was performed using STATA version 13 (STATA Corporation).

Results

Two tertiary care centres and one secondary care centre in central and western Switzerland with >650 beds each agreed to participate in the pilot PPS. Two hospitals were university-affiliated, and one hospital was a cantonal hospital. One hospital performed the survey in May 2016, the two other hospitals in October 2016. The three hospitals collected data on a total of 2421 patients. Table 1 summarises the patients’ characteristics, including use of medical devices, and ward specialty for all patients, stratified by patients with HAI, and patients receiving one or more antimicrobials on the day of survey. Median (interquartile range) length of stay, defined as days between hospital admission and day of survey, was 5 (2–12) days.

One hundred thirty-six patients suffered from 153 HAIs, corresponding to a prevalence of 5.6% (95% confidence interval [CI] 4.7–6.5%). Rapidly fatal McCabe score (odds ratio [OR] 2.02, 95% CI 1.58–2.58), hospitalisation in intensive care (OR 3.80, 95% CI 2.58–5.61), and having a medical device in place (OR 4.43, 95% CI 3.49–5.63) were independent risk factors for HAI in the multivariable model (table 2). Lower respiratory tract infection was the most frequent HAI type (24.8%), followed by surgical site infection (22.2%), bloodstream infection (17.0%), and urinary tract infection (13.7%) (fig. 1). The highest HAI prevalence (26.2%) was observed in the ICU (fig. 2). HAI prevalences in other ward types were similar (5.5–8.3%), except in gynaecology and obstetrics, where no HAIs were identified (fig. 2). The highest HAI prevalence was observed in the age groups 41–60 years (6.3%, 95% CI 4.1–8.5%) and 61–80 years (6.6%, 95% CI 5.0–8.3%). However, age groups did not correlate with likelihood of having HAI (table 2). In total, 133 microorganisms were identified in 93 of the 153 HAIs (60.8%). The most common microorganisms of the 133 were *Escherichia coli* (21.1%), followed by *Enterococcus faecium* (9.8%), *Pseudomonas aeruginosa* (9.0%), *Klebsiella pneumoniae* (8.3%), *Candida albicans* (6.0%), *Staphylococcus epidermidis* (6.0%), *Clostridium difficile* (3.8%) and *Enterobacter cloacae* (2.3%). Figure 3 summarises the distribution of the different groups of microorganisms. The proportions of methicillin-resistant *Staphylococcus aureus*, vancomycin-resistant enterococci, and third generation cephalosporin-resistant Enterobacteriaceae were 16.7% (2/12), 5.3% (1/

19) and 27.5% (14/51), respectively. Neither carbapenem-resistant Enterobacteriaceae nor carbapenem-resistant *Pseudomonas aeruginosa* were identified.

Six hundred sixty-nine patients (27.6%, 95% CI 25.9–29.4%) received 893 antimicrobials for 705 indications on the day of the survey (table 3). The highest proportion of antimicrobial use was identified in the ICU (62.0%, 95% CI 46.6–77.2%), followed by surgery (38.3%, 95% CI 34.6–42.0%) and mixed wards (37.0%, 95% CI 29.3–44.6%). A single antimicrobial was applied for 548 indications (77.7%, 95% CI 47.7–80.8%). Two or more concurrent antimicrobials were applied for 157 (22.3%, 95% CI 19.2–25.5%) indications. Community-acquired infections (39.0%) were the most common indication for antimicrobial use, followed by nosocomial infections (20.6%), surgical prophylaxis (17.7%), medical prophylaxis (16.2%) and other indications (6.4%). Antimicrobials were given for more than one postoperative day in more than half (52.8%) of surgical prophylaxis administrations. Amoxicillin/clavulanate was the most commonly prescribed antimicrobial (18.4%), followed by ceftriaxone (8.5%), sulfamethoxazole-trimethoprim (8.5%), cefuroxime (8.3%) and piperacillin-tazobactam (8.2%). The most common antimicrobial groups were penicillin combinations (25.9%), followed by third-generation

Figure 1: Distribution of healthcare-associated infections (n = 153) – multicentre point prevalence survey, Switzerland 2016.BSI = bloodstream infection; EENT = ear/eye/nose/throat infection; GI = gastrointestinal infection; LRTI = lower respiratory tract infection; NEO = neonatal infection; OTH = other infection; SSI = surgical site infection; SYS = systemic infection; UTI = urinary tract infection

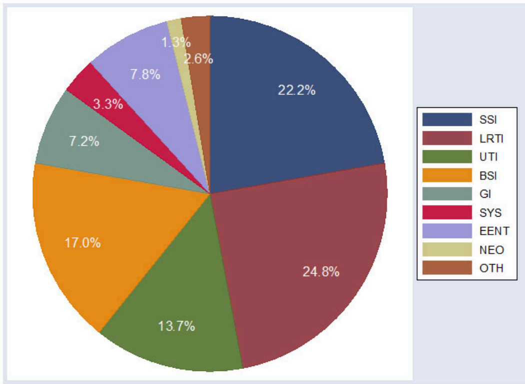


Table 1: Characteristics of patients – multicentre point prevalence survey, Switzerland 2016.

	All patients	Patients with HAI	Patients on AM
Patients, N	2421	136	669
Patient characteristics			
Age (years), median (IQR)	68 (48–80)	68.5 (56–79.5)	66 (48–76)
McCabe score*, % (95% CI)			
No fatal disease	75.3 (73.5–77.0)	61.2 (52.5–69.3)	72.9 (69.3–76.2)
Ultimately fatal disease	21.3 (17.9–23.0)	31.0 (23.5–40.0)	22.5 (19.4–25.9)
Rapidly fatal disease	3.4 (2.7–4.2)	7.8 (4.2–13.9)	4.6 (3.2–6.5)
Exposure			
Surgery†, % (95% CI)	30.0 (28.0–32.0)	43.4 (35–52)	44.2 (40.5–48.0)
Central venous catheter‡, % (95% CI)	12.0 (10.4–13.8)	38.5 (30.2–40.8)	27.2 (34.0–30.6)
Peripheral venous catheter‡, % (95%CI)	43.4 (41.4–45.4)	55.9 (47.5–64.3)	66.7 (63.3–70.4)
Urinary catheter‡, % (95% CI)	18.0 (16.6–19.7)	39.3 (30.9–47.6)	30.7 (27.3–34.3)
Mechanical ventilation‡, % (95% CI)	2.1 (1.6–2.8)	6.6 (2.4–10.8)	4.2 (2.9–6.0)
Length of stay§, median (IQR)	5 (2–12)	12 (5–21.5)	4 (2 –9)
Clinical settings			
Geriatrics, % (95% CI)	10.5 (9.4–11.8)	11.8 (7.3–18.4)	5.2 (3.7–7.2)
Gynaecology, % (95% CI)	1.8 (1.3–2.4)	0.0	0.9 (0.4–2)
Obstetrics, % (95% CI)	6.5 (5.6–7.5)	0.0	2.9 (1.7–4.2)
Intensive care, % (95% CI)	1.7 (1.3–2.3)	8 (4.5–14.1)	3.9 (2.7–5.7)
Long-term care, % (95% CI)	8.7 (7.9–10.2)	5.9 (2.9–11.4)	2.4 (1.5–3.9)
Medicine, % (95% CI)	24.6 (22.9–26.3)	24.3 (17.7–32.3)	30.2 (26.8–33.8)
Mixed¶, % (95% CI)	6.5 (5.6–7.5)	9.6 (5.6–15.9)	8.7 (6.8–11.1)
Paediatrics, % (95% CI)	4.5 (3.7–5.4)	4.4 (2.0–10.0)	5.1 (3.7–7.0)
Rehabilitation, % (95% CI)	7.4 (6.4–8.5)	8 (4.5–14.1)	2.7 (1.7–4.2)
Surgery, % (95% CI)	27.6 (25.8–29.4)	23.5 (21.6–25.6)	38.3 (34.6–42.0)

AM = antimicrobial; CI = confidence interval; HAI = healthcare-associated infection; IQR = interquartile range * 54 missing values † Yes/no in the hospitalisation before survey ‡ Yes/no on the day of survey § Days before and including the day of the prevalence survey ¶ Wards with less than 80% of patients belonging to one specialty

Table 2: Uni- and multivariable risk factor analysis – multicentre point prevalence survey, Switzerland 2016.

Variables	Univariable analysis			Multivariable analysis		
	OR	(95% CI)	p-value	OR	(95% CI)	p-value
Rapidly fatal McCabe score	2.51	(2.20–2.87)	<0.001	2.02	(1.58–2.58)	<0.001
Age group*	1.11	(0.93–1.32)	0.265			
Intensive care unit	6.40	(4.63–8.83)	<0.001	3.80	(2.58–5.61)	<0.001
Medical device†	5.08	(4.45–5.81)	<0.001	4.43	(3.49–5.63)	<0.001
NHSN surgery‡	1.77	(0.89–3.54)	0.106	1.41	(0.75–2.67)	0.288

CI = confidence interval; OR = odds ratio * Age groups: 0–17 years, 18–40 years, 41–60 years, 61–80 years, >80 years † Peripheral venous catheter, central venous catheter, urinary catheter, endotracheal tube – on day of survey ‡ NHSN surgery: surgery according to the NHSN (national healthcare safety network) definitions before survey cephalosporins (8.7%), sulphonamide-trimethoprim combinations (8.5%), second-generation cephalosporins (8.3%), and quinolones (7.5%). Figure 4 summarises the use of antimicrobial groups by ward specialty, revealing beta-lactam antibiotics to be the largest group of antimicrobials prescribed in the majority of ward specialties.

Figure 2: Prevalence of healthcare-associated infections by ward specialty – multicentre point prevalence survey, Switzerland 2016.GER = geriatrics; GO = Gynaecology; GOOBS = obstetrics; ICU = intensive care unit; MED = medicine; PED = paediatrics; REHA = rehabilitation; MIX = mixed unit; SUR = surgery

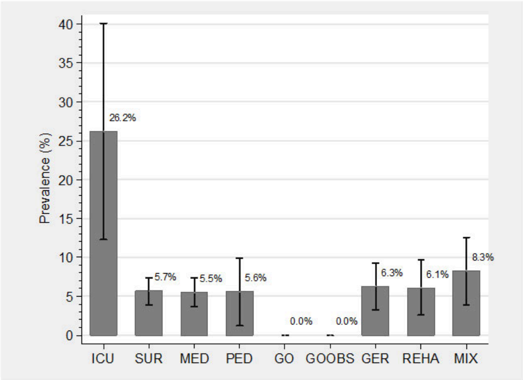


Figure 3: Groups of microorganisms (n = 133) – multicentre point prevalence survey, Switzerland 2016.anaerob = anaerobic bacteria; enterobac = Enterobacteriaceae; fungi = fungi; gramnegbac = Gram-negative bacilli (other than Enterobacteriaceae); gramnegcoc = Gram-negative cocci; gramposcoc = Gram-positive cocci

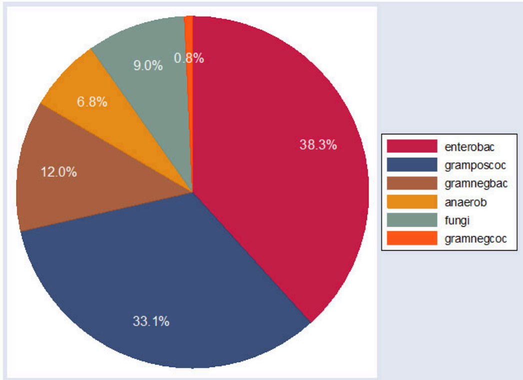
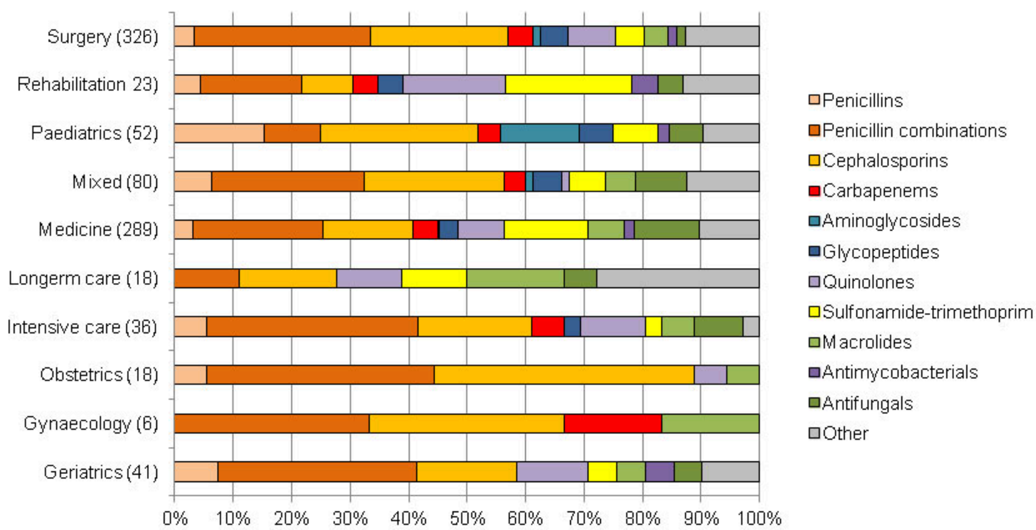


Table 3: Antimicrobial use – multicentre point prevalence survey, Switzerland 2016.

	Patients			Indications for antimicrobial use			
	All n	**on AM n**	**AM use % (95% CI)**	**All n**	**1 AM % (95% CI)**	**2 AM % (95% CI)**	**≥3 AM % (95% CI)**
Geriatrics	255	35	13.7 (9.5–18.0)	36	86.1 (74.2–98.0)	13.9 (2.0–25.8)	0.0
Gynaecology	43	6	14.0 (3.2–24.7)	6	100.0	0.0	0.0
Obstetrics	157	18	11.5 (6.4–16.5)	18	100.0	0.0	0.0
Intensive care	42	26	62.0 (46.6–77.2)	26	65.4 (45.8–85.0)	30.8 (11.8–49.8)	3.8 (0.0–11.8)
Long-term care	217	16	7.4 (3.9–10.9)	17	94.1 (81.6–100.0)	5.9 (0.0–18.4)	0.0
Medicine	595	202	33.9 (30.1–37.8)	221	74.7 (68.9–80.4)	20.8 (15.4–26.2)	4.5 (1.8–7.3)
Mixed*	157	58	37.0 (29.3–44.6)	61	72.1 (60.6–83.7)	24.6 (13.5–35.7)	3.3 (0.0–7.9)
Paediatrics	108	34	31.5 (22.6–40.4)	36	66.7 (50.5–82.8)	22.2 (8.0–36.5)	11.1 (0.3–21.9)
Rehabilitation	179	18	10.0 (5.6–14.5)	19	78.9 (58.8–99.1)	21.1 (0.9–41.2)	0.0
Surgery	668	256	38.3 (34.6–42.0)	265	80.0 (75.2–84.8)	16.6 (12.1–21.1)	3.4 (1.2–5.6)
Total	2421	669	27.6 (25.9–29.4)	705	77.7 (47.6–80.8)	18.6 (15.7–21.5)	3.7 (2.3–5.1)

AM = antimicrobial; CI = confidence interval * Wards with less than 80% of patients belonging to one specialty

Figure 4: Antimicrobial classes by ward specialty – multicentre point prevalence survey, Switzerland 2016.



Discussion

This survey identified a pooled HAI prevalence of 5.6% (95% CI 4.7–6.5%) in three large Swiss medical centres, antimicrobial use in less than a third of inpatients, and Enterobacteriaceae as the most common microorganisms isolated from patients with HAIs.

The HAI prevalence was comparable to the prevalence of 6.0% overall, and the prevalence of 5.9% among hospitals with more than 650 beds in the past ECDC PPS [9]. The most recent PPS in Switzerland in 2004 identified a HAI prevalence of 10.4% for the subset of large hospitals [7]. However, that survey measured HAI with the period prevalence methodology (which included HAI within a time frame of 7 days before the survey day). This methodology inflates the number of infections by a third (32%) compared with the point prevalence methodology used here for a case-mix of acute and long-term care [3]. Estimating point prevalence from period prevalence data would result in a HAI prevalence of 7.9% for large hospitals in 2004. Compared with this rate from a decade ago, the identified prevalence of the three participating hospitals in this survey was markedly lower. Similar to our findings, lower respiratory tract infection was the most common HAI type in the ECDC PPS (26%) [9], and the CDC PPS (26%) [1]. Also, surgical site infection was second in the CDC PPS (22%), but third in the ECDC PPS (16%). Surgical site infections were first in the past Swissnoso PPSs in 2003 (26%) and 2004 (29%) [6, 7]. This could have been an effect of the period methodology. However, recent prospective surgical site infection surveillance in Switzerland revealed that 47% of all surgical site infection occur after hospital discharge [15]. Thus, the true proportion of surgical site infection is most likely higher.

Interestingly, gastrointestinal infections were the third most common HAI group in the CDC PPS (17%), with *Clostridium difficile* causing 12% of all HAIs. *Clostridium difficile* contributed to only 3.7% of all HAI in our survey, but 27.8% of all gastrointestinal infections.

Antimicrobial use in the three large Swiss hospitals was lower than in similar hospitals in Europe (35.3%) [9]. The ECDC report did not stratify detailed antimicrobial use for the different hospital sizes. However, the most commonly prescribed antimicrobial was amoxicillin-clavulanate in both our survey and the ECDC PPS. Also, the other common antimicrobials were similar in both surveys, with ceftriaxone, cefuroxime and piperacillin-tazobactam among the first five. Sulfamethoxazole-trimethoprim ranked third in our survey but was rarely used in the ECDC PPS. Interestingly, more than a half of the patients received surgical prophylaxis for more than 24 hours, which the WHO recommends against. In our opinion, this finding should trigger antimicrobial stewardship activities addressing best practice in surgical prophylaxis.

This survey has limitations. First, data collection was done by local infection prevention and control professionals and not by the same study team. However, all participating data collectors had experience with performing local PPSs in the past, and were trained before data collection. Second, the data are not representative for Switzerland because only three large hospitals were included. However, the data are generalisable to other large hospitals. In addition, the overall number of patients included in this survey is similar to the number from large hospitals included in the CDC PPS (2214 patients). Third, data on antimicrobial resistance are limited because only a small number of microorganisms were tested as part of diagnosing HAI. This limits the estimation of the resistance prevalence among the isolated microorganisms.

Conclusion

This survey found similar numbers on HAI and antimicrobial use compared to the ECDC PPS. The ECDC methodology proved feasible in patients hospitalised in Swiss acute-care hospitals.

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Potential competing interests

The authors declare no conflict of interest in the context of the content of this manuscript.

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