



ELSEVIER

Available online at www.sciencedirect.com

Journal of Hospital Infection

journal homepage: www.elsevier.com/locate/jhin



Multi-centre point-prevalence survey of hospital-acquired infections in Ghana

A-K. Labi^a, N. Obeng-Nkrumah^{b,*}, E. Owusu^b, S. Bjerrum^c,
A. Bediako-Bowan^d, G. Sunkwa-Mills^e, C. Akufo^f, A.P. Fenny^g, J.A. Opintan^e,
C. Enweronu-Laryea^h, S. Debrahⁱ, N. Damale^j, C. Bannerman^f, M.J. Newman^e

^a Department of Microbiology, Korle-Bu Teaching Hospital, Accra, Ghana

^b Department of Medical Laboratory Sciences, School of Biomedical and Allied Health Sciences, College of Health Sciences, University of Ghana, Accra, Ghana

^c Department of Public Health, Global Health Section, University of Copenhagen, Copenhagen, Denmark

^d Department of Surgery, School of Medicine and Dentistry, College of Health Sciences, University of Ghana, Accra, Ghana

^e Department of Medical Microbiology, School of Biomedical and Allied Health Sciences, College of Health Sciences, University of Ghana, Accra, Ghana

^f Institutional Care Division, Ghana Health Service, Accra, PMB, Ministries-Accra, Ghana

^g Institute of Statistics, Social and Economic Research, University of Ghana, Accra, Ghana

^h Department of Child Health, School of Medicine and Dentistry, College of Health Sciences, University of Ghana, Accra, Ghana

ⁱ Department of Surgery, Cape Coast Teaching Hospital, Cape Coast, Ghana

^j Department of Obstetrics and Gynaecology, Korle-Bu Teaching Hospital, Accra, Ghana

ARTICLE INFO

Article history:

Received 16 February 2018

Accepted 26 April 2018

Available online 3 May 2018

Keywords:

Hospital-acquired infection

Prevalence

Ghana



SUMMARY

Background: There is a paucity of data describing hospital-acquired infections (HAIs) in Africa.

Objective: To describe the prevalence and distribution of HAIs in acute care hospitals in Ghana.

Methods: Between September and December 2016, point-prevalence surveys were conducted in participating hospitals using protocols of the European Centre for Disease Prevention and Control. Medical records of eligible inpatients at or before 8am on the survey date were reviewed to identify HAIs present at the time of the survey.

Findings: Ten hospitals were surveyed, representing 32.9% of all acute care beds in government hospitals. Of 2107 inpatients surveyed, 184 HAIs were identified among 172 patients, corresponding to an overall prevalence of 8.2%. The prevalence values in hospitals ranged from 3.5% to 14.4%, with higher proportions of infections in secondary and tertiary care facilities. The most common HAIs were surgical site infections (32.6%), bloodstream infections (19.5%), urinary tract infections (18.5%) and respiratory tract infections (16.3%). Device-associated infections accounted for 7.1% of HAIs. For 12.5% of HAIs, a micro-organism was reported; the most commonly isolated micro-organism was *Escherichia coli*. Approximately 61% of all patients surveyed were on antibiotics; 89.5% of patients with an HAI received at least one antimicrobial agent on the survey date. The strongest

* Corresponding author. Address: Department of Medical Laboratory Sciences, School of Biomedical and Allied Health Sciences, College of Health Sciences, University of Ghana, P.O. Box 143, Accra, Ghana. Tel.: +233 0548394763.

E-mail address: successfulnoahforchrist@yahoo.com (N. Obeng-Nkrumah).

independent predictors for HAI were the presence of an invasive device before onset of infection and duration of hospital stay.

Conclusion: A low HAI burden was found compared with findings from other low- and middle-income countries.

© 2018 The Authors. Published by Elsevier Ltd on behalf of The Healthcare Infection Society. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Introduction

Globally, hospital-acquired infections (HAIs) are the most common adverse events to occur during hospitalization [1,2], and are the cause of extended admissions, increased medical costs, and marked morbidity and mortality [3–5]. Continued improvements in patient safety depend on a comprehensive understanding of the local epidemiology of HAIs. Reliable data on HAIs is scarce in low-resource countries, and it is likely that existing data underestimate the true burden [6]. Available data describe an HAI prevalence rate of 15.5 per 100 patients in developing countries [6]. In sub-Saharan Africa, these infections are suspected to be widespread [1]. High rates of HAIs persist due to lack of national infection prevention and control (IPC) policies, lack of IPC personnel, and poor adherence to existing HAI guidelines [1].

Elimination of HAIs is a priority of the Ministry of Health in Ghana, as has been demonstrated recently by an update of the IPC policy and guideline document [7]. The Ghana Health Service emphasizes the importance of IPC through campaigns on water, sanitation and hygiene. Despite these efforts, there is currently no existing surveillance system to provide estimates of the burden of HAIs across acute care patient populations in Ghana. The most recent estimate of HAI prevalence of 6.7% was derived from a single-centre study published in 2009 [8]. To address this knowledge gap, the authors conducted a large-scale multi-centre HAI point-prevalence survey to determine the prevalence and distribution of HAIs in acute care hospitals. The findings provide a global picture of the epidemiological situation in the country, and serve as a baseline for the evaluation of future IPC interventions in Ghana.

Methods

Study design and settings

A country-wide point-prevalence study was conducted at 10 acute care hospitals, surveying all units/departments at each facility. The hospitals were selected from 10 geographically distinct regional health directorates in the country. In Ghana, there are three teaching hospitals, 10 regional hospitals and approximately 162 district hospitals [9,10]. The Ghana Health Service reported a bed occupancy rate of 60.4% ($N=8195$) for a total bed capacity of 12,806 beds for all government hospitals in 2017 [9]. Representative samples of acute care hospitals were drawn across Ghana (Figure 1) by applying systematic random sampling to the national list of hospitals ranked according to size and hospital type (teaching hospitals, regional hospitals and district hospitals) as per the guidelines of the European Centre for Disease Prevention and Control (ECDC) [11]. The ECDC protocol provides a validated and standardized Europe-wide consensus tool that can be implemented in settings with

limited network connectivity, and is thus suitable for use in resource-constrained settings. Briefly, the hospital list for each directorate was ranked in ascending order of the number of beds. A sampling interval k was obtained by dividing the total number of hospitals within each category by the number to be sampled. One hospital was surveyed per directorate. A random number i was selected between 1 and k . For each regional health directorate, the $i^{\text{th}}+k$ hospital in the ascending order list of hospitals was selected to constitute the survey site for that region. The invitation for hospitals to participate in the survey was sent to hospital directors in July 2016. Participation was voluntary. The survey was conducted from 19th September to 2nd December 2016. The study was approved by the Ethical Review Committee of the Ghana Health Service (GHS-ERC 08/05/2016) and the Institutional Review Board of Korle-Bu Teaching Hospital (KBTH-STC/IRB/00044/2016). Informed consent was waived for the conduct of the study. Patients were de-identified from study data to ensure anonymity. Arbitrary numbers were allotted to all data assigned to the study.

Patient selection

Inpatients of any age admitted and monitored for >24 h at the included hospitals were eligible for inclusion in the study. Patients attending outpatient areas, accident and emergency departments, those who had been admitted for <24 h, and those on rehabilitation units were excluded. The medical records of inpatients at or before 8am on the survey date were reviewed by the study team within 12 h. For hospitals with a high bed capacity (>1000), the total time frame for data collection on all wards of a single hospital did not exceed one week.

Data collection personnel and tools

Study information was collected manually on standardized data forms. Two teams collected data from each hospital: a primary team of research investigators from the HAI Ghana research team and a secondary team of a selected group of health professionals (members of the quality assurance or infection control team) from each hospital. The secondary teams were constituted to build the capacity of participating hospitals to conduct future HAI prevalence surveys. The primary team reviewed medical records at each hospital, and identified and collected information on patients who were receiving antimicrobial agents for the treatment of active infections or for no documented reasons using ECDC surveillance definitions [11]. Data collected from the medical and nursing records and other relevant charts were interpreted with the help of attending physicians to determine whether patients had an HAI. Medical records of patients that did not fulfil the case definition for HAIs were reviewed by the secondary team for data extraction. The secondary team received training in

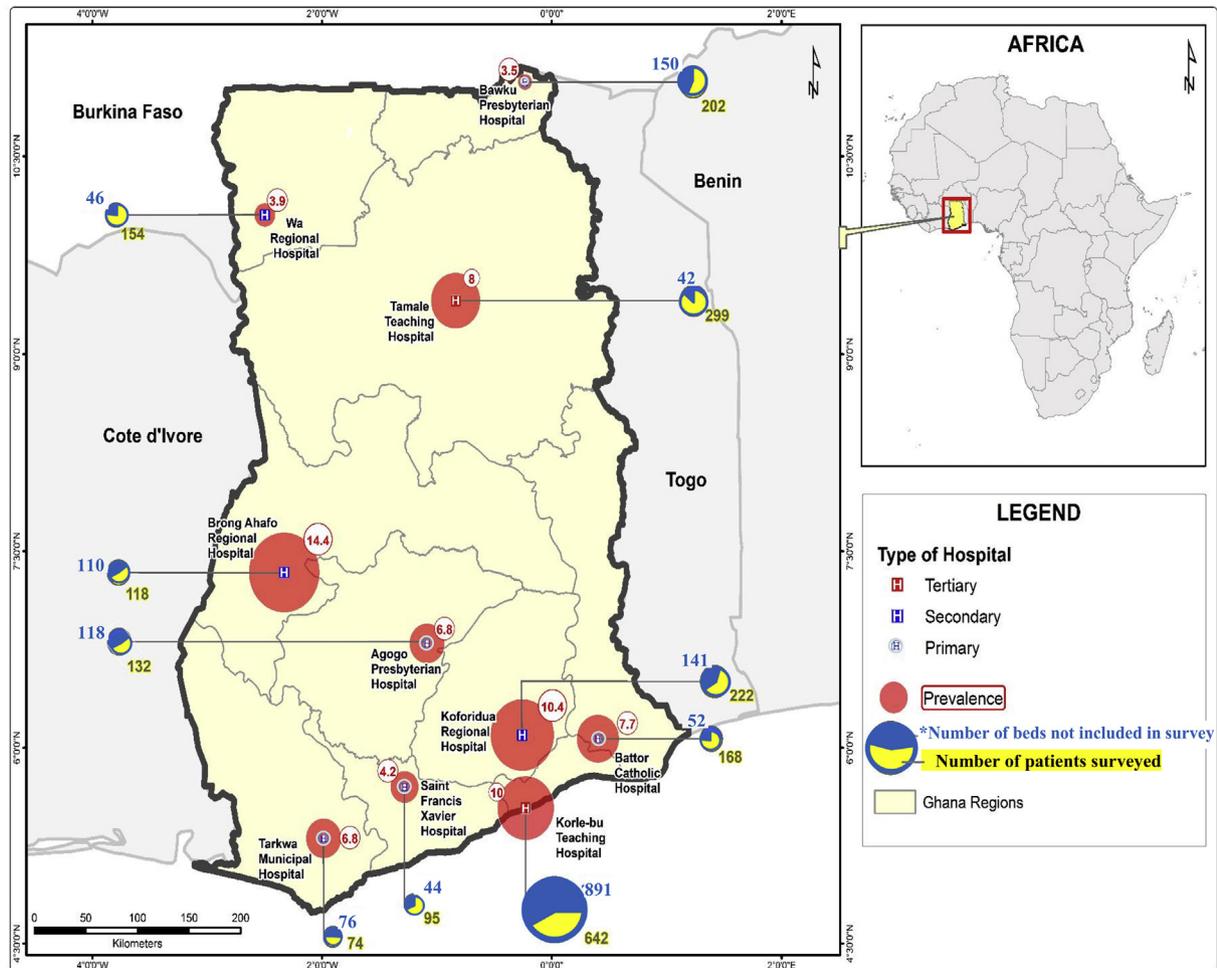


Figure 1. Prevalence of hospital-acquired infection (HAI) across study hospitals categorized as primary, secondary and tertiary. The width of the prevalence circle is proportional to the HAI burden. Number of beds not included in survey = total of all inpatient beds excluded from the survey based on inclusion/exclusion criteria plus all other vacant hospital beds.

conducting an HAI survey. Training sessions were concluded with a pilot point-prevalence survey on selected hospital wards to allow for remedial action. Standardized training packages were developed and made available for use by participating hospitals for future surveys. Data were collected on hospital characteristics, including ward type and size, number of beds, and number of patients admitted in each ward at the time of the survey. Patient-based variables included age, sex, surgery since admission, presence of indwelling devices, patients' antimicrobial usage, presence of active HAI, results of routine microbiological tests performed, and McCabe score. The McCabe score categorizes the severity of underlying medical conditions into non-fatal disease (expected survival of at least five years), ultimately fatal disease (expected survival between one and five years), rapidly fatal disease (expected death within one year) and unknown [11]. The specialty of the main disease of the patient or of the consulting physician in charge of the patient was captured as consultant specialty.

Case definitions

HAI was defined in accordance with ECDC guidelines [11]. An active infection was reported when signs and symptoms

were evident on the survey date (with or without laboratory results) and the patient was receiving corresponding antibiotic treatment. Patients were considered to be infected even when signs and symptoms were no longer present but the patient was still receiving treatment for that infection on the survey date. In this case, the signs and symptoms present from the start of antibiotic treatment until the survey date were checked to verify whether an infection was hospital acquired. An infection was considered to be hospital acquired when the onset of the signs and symptoms occurred >48 h after the current admission, or became apparent within 48 h of admission but the patient had been discharged from an acute care hospital <48 h before the current admission [11]. For surgical site infections, the definition included infections that occurred up to 30 days after surgical intervention and affected either the incision or deep tissue at the operating site, or infections related to an implant that occurred within one year. Device-associated HAI was recorded for urinary tract infections (urinary catheter in place within seven days preceding HAI onset), bloodstream infections (vascular catheter in place within 48 h before HAI onset) and pneumonia (intubation within 48 h before HAI onset).

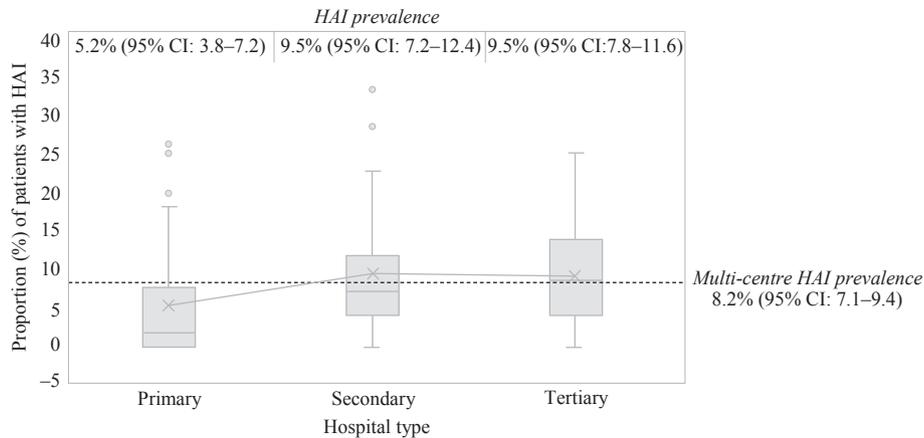


Figure 2. Distribution of hospital-acquired infection (HAI) prevalence by hospital type. The box shows interquartile range, horizontal line in box shows median of the distribution, X denotes mean of distribution, lower whisker shows 25th percentile or lower quartile, upper whisker shows 75th percentile or upper quartile. HAI prevalence: primary hospitals < secondary hospitals = tertiary hospitals (Marascuilo post hoc: overall Chi-squared=11.44, $P=0.003$). CI, confidence interval.

Statistical analysis

Data were analysed using Access (Microsoft Corp., Redmond, WA, USA) and Statistical Package for Social Sciences Version 21.0 (IBM Corp., Armonk, NY, USA). The point prevalence of HAIs was reported as the percentage of patients with at least one HAI over the total number of patients. For descriptive statistics, prevalence rates were calculated with 95% confidence intervals (95% CI), mean \pm standard deviation (SD) or median with interquartile range (IQR), where appropriate. Univariate and multi-variate analyses were performed to identify independent risk factors associated with HAIs. A multi-variable logistic regression with linear or restricted cubic splines was used to model the association between the proportion of HAIs and duration of hospital stay before the day of the survey.

Results

Data were collected from two teaching hospitals, three regional hospitals and five district hospitals. Overall, 4208 acute care beds were included in this study, representing 32.9% of the total bed capacity for government hospitals in Ghana. Patient-based data were collected for a total of 2107 inpatients, representing 50.1% of the total bed capacity of participating hospitals.

Hospital and patient characteristics

Of the hospitals surveyed, five were primary, three were secondary, two were tertiary, and none were specialized facilities. The median bed size of the included hospitals was 304 beds (range 139–1533 beds). The overall bed occupancy rate was 59.1%. Only one of the participating hospitals had an infection control nurse, and none of the participating hospitals had an infection control doctor. There were no active surveillance programmes on HAIs in any of the participating hospitals. The median age of the patients surveyed was 26 years. This varied from one day to 90 years (IQR 2–46 years). Males comprised 43.5% of all patients surveyed. The mean length of stay from

admission until the survey date was 17.3 (SD 7.3) days (range 2.1–33.1 days; median 11 days; IQR 3.4–20.6 days). The median length of stay of patients with HAI was six days (IQR 4–16 days) until onset of infection, and 12.5 days (IQR 7–23 days) until the survey date. The median length of stay until the survey date in patients without HAI was three days (IQR 2–9 days).

Prevalence of HAIs

In total, 184 infections in 172 patients fulfilled the criteria of HAI, corresponding to a point prevalence of 8.2% ($N=172/2107$; 95% CI 7.1–9.4). Overall, 161 (93.6%) patients had one HAI. The remaining 11 patients had multiple HAIs: 10 patients had two HAIs and one patient had three HAIs on the survey date. The prevalence of HAIs differed across hospitals (Figure 1) and within each hospital category (Figure 2). Across tertiary hospitals, the burden of HAIs was 9.2%, with a median ward prevalence of 8.9% and IQR of 5.2–14.3%. A similar distribution was observed in secondary hospitals: prevalence of HAIs, 9.5%; median ward prevalence, 7.0%; and IQR, 4.7–14.8%. Primary hospitals had a significantly lower prevalence of HAIs of 5.2%, with a median ward prevalence of 2.1% and IQR of 1.1–5.4%. The most frequently reported types of HAI were surgical site infections ($N=60$, 32.6%), bloodstream infections ($N=36$, 19.5%), urinary tract infections ($N=34$, 18.5%) and respiratory tract infections ($N=30$, 16.3%) (Table 1). The prevalence of HAIs was highest among patients admitted to surgical departments (Figure 3), where 11.2% ($N=58/517$) of patients had at least one HAI compared with an average of 7.2% ($N=114/1590$) for all other specialties combined.

Device-associated HAIs and origin of infection

Hospital-acquired urinary tract infections were device associated in 17.6% ($N=6/36$) of all cases. Overall, 86.1% ($N=31/36$) and 13.8% ($N=5/36$) of patients with bloodstream infections had peripheral and central vascular catheters, respectively, present in the 48 h preceding infection. The bloodstream infections were secondary to another infection site in 16.7% ($N=6/36$) of cases [respiratory tract infection

Table I
Prevalence of hospital-acquired infection (HAI) by type among 2107 patients surveyed

HAI Type	Number	Prevalence among total HAIs		Prevalence among total surveyed patients	
		%	95% CI	%	95% CI
Surgical site infections	60	32.6	26.2–39.7	2.8	2.2–3.7
Bloodstream infections	36	19.5	14.5–25.9	1.7	1.2–2.7
Urinary tract infections	34	18.5	13.5–24.7	1.6	1.1–2.3
Respiratory tract infections	30	16.3	11.6–22.3	1.4	1.0–2.0
Others					
Skin and soft tissue	10	5.4	3.0–9.7	0.5	0.3–0.9
Gastrointestinal infections	10	5.4	3.0–9.7	0.5	0.3–0.9
Ear, nose and throat	2	1.1	0.3–3.9	0.1	0.02–0.3
Central nervous system	1	0.5	0.09–3.0	0.1	0.01–0.3
Not specified	1	0.5	0.09–3.0	0.1	0.01–0.3
Total	184				

CI, confidence interval.

($N=4/6$); skin and soft tissue infection ($N=2/6$]). For 83.3% ($N=30/36$) of bloodstream infections, the source of infection was unknown. Of the HAIs identified, 159 (86.4%) were related to the current hospital stay and occurred in 147 patients. The HAIs originated from another hospital facility in 25 (13.6%) cases, and were all present at the time of admission. These included 10 (40%) surgical site infections, six (24%) urinary tract infections, three (12%) respiratory tract infections, three (12%) bloodstream infections, two (8%) skin and soft tissue infections, and one (4%) gastrointestinal tract infection.

Causative pathogens and antibiotic use

For 12.5% ($N=23/184$) of HAIs, a micro-organism was reported, ranging from 35.3% ($N=12/34$) in urinary tract infections, 10.0% ($N=6/60$) in surgical site infections, and 11.1% ($N=4/36$) in bloodstream infections, to 1.9% ($N=1/54$) in all the other HAI types (Table II). The most frequently isolated micro-organism from HAIs was *Escherichia coli* ($N=4/23$). Meticillin resistance was not reported in any of the *Staphylococcus aureus* isolates with known susceptibility data. The majority, 84.6% ($N=11/13$), of Enterobacteriaceae were resistant to

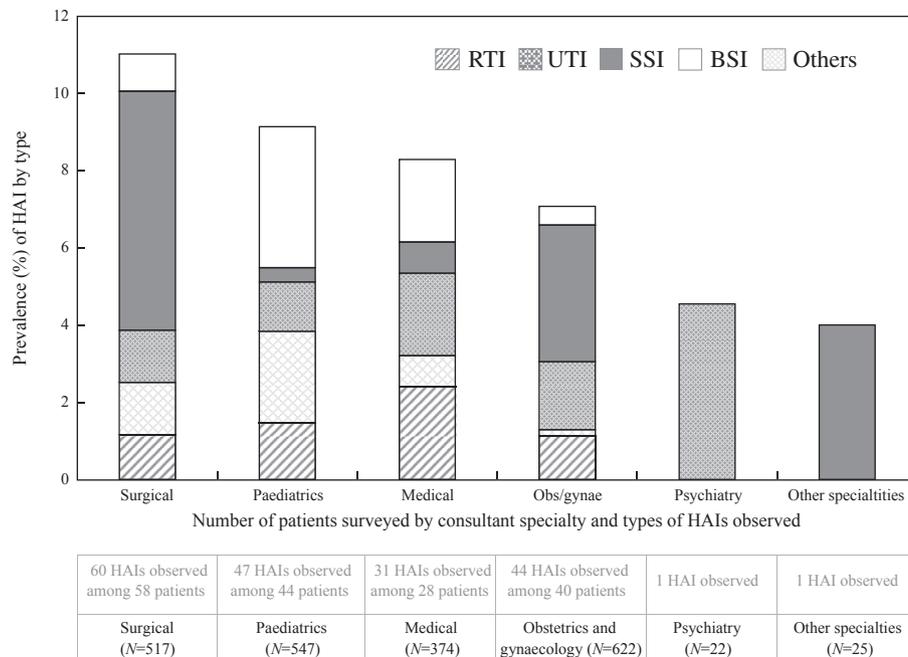


Figure 3. Prevalence of hospital-acquired infection (HAI) by type and speciality among 2107 surveyed patients. RTI, respiratory tract infections (red bars); UTI, urinary tract infections (blue bars); SSI, surgical site infections (yellow bars); BSI, bloodstream infections (green bars); other infection types (orange bars): SST, skin and soft tissue (apart from surgical site infections); GIT, gastrointestinal tract; ENT, ear, nose and throat; CNS, central nervous system. Other specialties: ophthalmology, urology, nephrology and patients with specialty not indicated. Eleven patients had more than one type of HAI: surgical, two patients (both with SSI/RTI); paediatrics, three patients (one with UTI/SST, one with RTI/SST and one with BSI/unspecified infection); medicine, three patients (one with RTI/UTI, one with RTI/SSI and one with SSI/BSI); and obstetrics and gynaecology, three patients (one with SSI/UTI, one with SSI/BSI and one with RTI/SSI/BSI).

Table II
Reported causative pathogens, according to type of infection

HAIs pathogens	UTI (N=34)	SSI (N=60)	BSI (N=36)	Others (N=54)	Reported antibiotic susceptibility ^a
Gram-negatives					
<i>Acinetobacter</i> spp. (N=1)	0	0	1	0	Mer-S; Cip-S; Cot-R; Cef-R
<i>Citrobacter</i> spp. (N=1)	1	0	0	0	Amk-S; Cip-R; Cef-R; Amo-clav-R
<i>Klebsiella oxytoca</i> (N=1)	1	0	0	0	Mer-S; Amk-S; Cip-R; Cef-R, Amo-clav-R; Nit-S
<i>Proteus mirabilis</i> (N=1)	1	0	0	0	Amk-S; Gen-S; Cip-R; Cxr-R; Cef-R; Tet-R
Other coliforms (N=2)	0	2	0	0	Cip-S (N=2/2); Lev-S (N=2/2); Gen-R (N=2/2); Amk-S (N=1/1); Chl-R (N=1/1); Pip/Taz-R (N=2/2); Cef-R (N=2/2)
<i>Enterobacter</i> spp. (N=2)	1	1	0	0	Mer-R (N=1/2); Amk-R (N=1/1); Cip-R (N=1/2); Cxr-R (N=1/1); Cef-R (N=1/1)
<i>Klebsiella</i> spp. (N=2)	2	0	0	0	Mer-R (N=1/1); Amk-R (N=1/1); Gen-R (N=1/1); Cip-R (N=2/2); Cxr-R (N=1/1); Lev-R (N=1/1); Pip/Taz-R (N=1/1); Cot-R (N=1/1); Cef-R (N=2/2)
<i>Pseudomonas aeruginosa</i> (N=2)	0	2	0	0	Amk-s (N=2/2); Gen-R (N=2/2); Cip-R (N=2/2); Lev-R (2/2); Cef-R (N=1/2)
<i>Escherichia coli</i> (N=4)	3	1	0	0	Amk-R (N=3/4); Gen-S (N=1/4); Cip-R (N=2/2); Lev-R (2/2); Cef-R (N=2/3); Nit-S (N=1/1); Chl-R (N=1/1); Cot-R (N=1/1); Pip/Taz-R (N=1/1)
Subtotal (N=16)	9 (26.5)	6 (10.0)	1 (2.8)	0	
Gram-positives					
<i>Enterococcus faecalis</i> (N=1)	1	0	0	0	Van-S; Amp-S; Lev-R
<i>Enterococcus</i> spp. (N=1)	1	0	0	0	Van-S; Cip-R; Lev-R
<i>Staphylococcus aureus</i> (N=1)	1	0	0	0	Ery-S; Gen-S; Chl-S; Tet-S; Cot-S.
<i>Staphylococcus epidermidis</i> (N=2)	0	0	1	1	Cip-S (N=2/2); Gen-R (N=1/1); Chl-S; Tet-S
<i>Streptococcus viridans</i> (N=2)	0	0	2	0	Pen-S (N=1/2); Cef-S (N=1/1); Ery-R (N=1/2); Lev-R (N=1/2); Van-S (N=1/1)
Subtotal (N=7)	3 (8.8)	0	3 (8.3)	1 (1.9)	
Total (N=23)	12 (35.3)	6 (10.0)	4 (11.1)	1 (1.9)	

UTI, urinary tract infections; SSI, surgical site infections; BSI, bloodstream infections; others, respiratory tract infections, skin and soft tissue infections apart from surgical site infections, central nervous system infections, gastrointestinal tract infections and unspecified infections; R, resistant; S, susceptible; N, proportion of tested isolates that are susceptible or resistant to the indicated antibiotic; Mer, meropenem; Amk, amikacin; Gen, gentamicin; Cip, ciprofloxacin; Pip/Taz, piperacillin/tazobactam; Pen, penicillin; Amp, ampicillin; Cef, cefotaxime; Cxr, cefuroxime; Lev, levofloxacin; Van, vancomycin; Ery, erythromycin; Chl, chloramphenicol; Nit, nitrofurantoin; Cot, cotrimoxazole; Tet, tetracycline.

^a The antibiotic susceptibilities may not be generally representative with the very few isolates reported.

third-generation cephalosporins. Two out of five Gram-negative isolates tested were resistant to meropenem. Overall, 61.3% (N=1291/2107) of the patients surveyed were treated with antibiotics, whilst 89.5% (N=154/172) of patients with HAIs received at least one antimicrobial agent on the survey date. Antibiotic use in patients without documented HAIs was 58.8% (N=1137/1934). In primary hospitals, 59.9% (N=402/671) of the surveyed patients were treated with antibiotics, compared with 76.5% (N=317/494) and 60.8% (N=572/941) for secondary and tertiary hospitals, respectively. Data on antibiotic prescription patterns and indications for use will be published elsewhere.

Patient risk factors

The presence of a relevant invasive device prior to HAI onset, and length of hospital stay ≥ 15 days were strongly associated with HAI in the univariate analysis (Table A, see online supplementary material). In the final multi-variate model, patients admitted to a primary care hospital were significantly less likely to develop HAIs (Table III). The strongest independent

predictors for HAIs were the presence of a relevant invasive device before onset of infection, and duration of hospital stay before the survey date. The relationship between HAI and duration of hospital stay was best described by linear spline functions (Figure 4) incorporating three breakpoints at 6, 10 and 20 days of hospital admission. The adjusted odds ratios can be interpreted as the odds of protection against HAI acquisition decreasing at a rate of 4% from date of admission (day 0) to day 6, followed by increasing HAI levels at varying rates thereafter (here, the odds of HAI acquisition increased by 9% from day 6–10, with a further 17% increase from days 10–20. The rate of acquiring an HAI nearly doubles after day 20.

Discussion

This paper represents the first multi-centre point-prevalence study of HAIs from Ghana, and includes data from patients at various levels of health service delivery in different parts of the country. The overall prevalence of HAIs was 8.2%, with the highest prevalence seen among surgical inpatients.

Table IIIMulti-variable logistic regression analysis^a of risk factors associated with hospital-acquired infection (HAI) in patients

Patient characteristics	Level	Adjusted odds ratio	95% confidence interval	P-value
Duration of hospital stay before HAI onset	1 day	2.78	2.08–10.18	<0.001
Surgery since admission	Yes/no	1.79	1.35–2.98	0.001
Presence of any invasive device	Yes/no	5.03	4.77–13.35	0.001
Urinary catheter in place during hospitalization	Yes/no	1.76	1.13–3.30	<0.001
Peripheral vascular catheter in place during hospitalization	Yes/no	1.73	1.22–2.57	<0.001
Patient/consultant specialty (surgery)	Yes/no	1.81	1.26–2.59	0.001
Admission to a primary care hospital	Yes/no	0.37	0.33–0.71	0.010

^a The predictive accuracy of the models evaluated by Hosmer and Lemeshow goodness-of-fit test was non-significant with $P > 0.05$, suggesting that the model predicted accurately, on average. The discriminatory power of the multiple logistic regression analysis as measured by the area under the receiver operating characteristic curve was 0.791. Stepwise modelling was adjusted for univariate variables with $P < 0.1$.

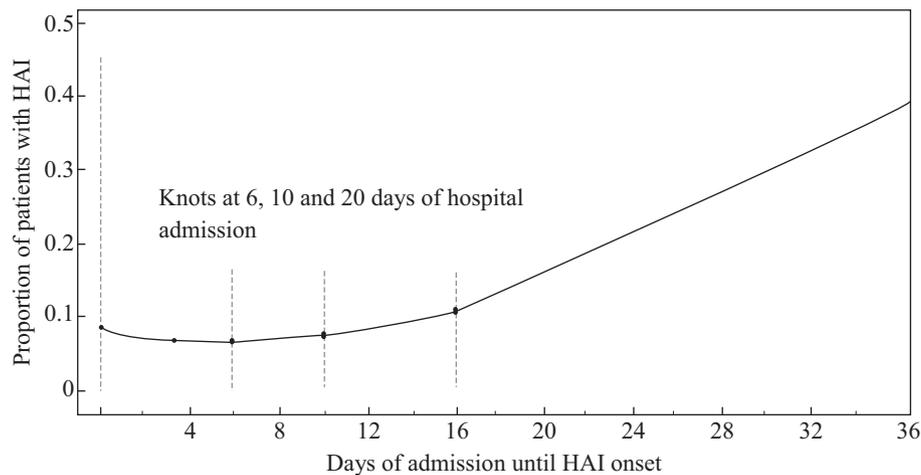


Figure 4. Changes in the odds of hospital-acquired infection (HAI) with length of hospital stay. Model is a linear spline function estimate shown on the logit scale based on the least Akaike's Information Criterion (Tables B and C, see online supplementary material).

The prevalence across the various hospitals ranged from 3.5% to 14.4%, with a higher proportion of infections found in secondary and tertiary care facilities. These findings are comparable to findings from other studies conducted in Africa, where the overall prevalence of HAIs has been found to be between 2.5% and 14.8% [1,2], and studies from Europe, Brazil and Vietnam with prevalence rates of 7.2%, 10.2% and 7.8%, respectively [11–13]. A recent survey in Benin, however, reported a prevalence of HAI of 19.1% [14]. The present study was conducted using ECDC-approved methodology, and direct comparison of the present results to other studies is hampered by the differences in methodologies applied.

Surgical site, urinary tract and bloodstream infections were the most common HAIs in this study. In the only previously reported point-prevalence survey of HAIs in Ghana, surgical site infections accounted for 39.3% of all HAIs [8]. In a recent survey of abdominal surgery from the Tamale Teaching Hospital, 11.25% of all cases developed surgical site infections [15]. Surgical site infections represent a commonly reported HAI worldwide, particularly in low-income countries, compared with urinary tract and respiratory tract infections which predominate in high-income countries [16]. The higher prevalence of surgical site infections may be due to inadequate pre-, peri- and postoperative hygienic practices in low-resource settings. In a recent study of air quality in operating theatres at a tertiary care facility in Ghana, high levels of air contamination

were detected, and this correlated with high rates of door openings and number of people present during surgery [17]. High rates of surgical site infections may also be ascribed to these infections being easier to recognize and diagnose in low-resource settings compared with other HAIs [2]. However, in the present study, the reported values for surgical site infections may be understated as a proportion of surgical site infections may occur after hospital discharge and may not have been reported [2,18]. Recognition of surgical site infections arising after hospital discharge would require setting up a surveillance system that includes active follow-up. The relatively high rates of surgical site infections reported in this study highlights the need to improve safety in surgical practice across hospitals in Ghana by implementing the new World Health Organization (WHO) guidelines for the prevention of surgical site infections [19].

Among the patients surveyed, 61.3% were actively on antibiotics on the survey date, with higher rates of antibiotic use observed in secondary and tertiary hospital facilities than primary hospitals. Antibiotic use among patients who had HAIs (89.5%) was significantly higher compared with patients without documented HAIs (58.8%). The authors did not collect adequate clinical data to enable evaluation of whether antibiotic use was justified based on clinical indication. However, the high rates of antibiotic use are comparable with findings from countries with similar developmental profiles [13,14], and could be

contributing to the high levels of antibiotic resistance recorded in Ghana [20–22]. Low records of associated pathogens were found among patients with HAIs. Notably, five of the hospitals that participated in the study did not have infrastructure for microbiological culture and antibiotic susceptibility testing. The data may further represent low utilization of microbiological diagnostics which may be linked with high out-of-pocket costs associated with performance of these tests. Lack of information regarding antibiotic susceptibility affects the selection of appropriate agents for therapy, as well as implementation of IPC precautions. Among 16 Gram-negative isolates reported, widespread resistance was observed against commonly used beta-lactam, aminoglycoside and quinolone antibiotics, and two of the five isolates tested were resistant to meropenem (Table II). Resistance appeared to be less common in Gram-positive bacteria, but the low number of clinically relevant isolates does not allow any firm interpretation of these data. The findings should be interpreted with great caution as results were drawn from local laboratories, and isolates were not stored for confirmation by the study team. Nevertheless, the findings are alarming and suggest widespread antimicrobial resistance in Ghana, as reported elsewhere [21,23,24].

The risk of acquiring HAIs in this study was associated with prolonged hospital stay. However, the risk of HAI was low for patients admitted to primary hospital facilities compared with secondary and tertiary hospital facilities. This could be because secondary and tertiary facilities are more likely to provide complex care to critically ill patients, with more frequent use of devices such as central venous catheters and artificial ventilators usually associated with the development of HAIs. None of the hospitals enrolled in this study had an IPC doctor, only one hospital had a full-time infection control nurse, and none of the hospitals had an active infection control team. Several of the hospitals made use of quality assurance teams to perform the role of infection control teams. This state of affairs persists despite the availability of a national IPC policy document, which stipulates the implementation of all the core components of infection prevention and control [7,25]. Implementation of IPC activities is important to reduce the burden of HAIs, and should be adapted to the local context [26]. The standard at the surveyed hospitals is far from the goals of the infection prevention guidelines, which recommend one full-time infection control nurse per 100 beds in acute care centres and per 150–205 beds in long-term care facilities [27] or 250 beds as stipulated by WHO core component guidelines [28]. It is instructive to note that improving the human resource personnel for infection prevention has been outlined as a global priority area [29].

This study has potential limitations. Although the hospitals in this study represent different levels of hospital facilities, they may not be representative of all healthcare facilities in Ghana. The prevalence figures may be underestimated, as infections that occur after discharge but may have originated from hospitals were not taken into account. Also, the low rates may have been affected by the relatively low bed occupancy rate of 59% and the variable availability of microbiological culture results. The findings are also based on folder review, which is prone to poorly recorded or incomplete data as well as absent information. A key strength of this study is that data were actively collected using international standardized tools, and validated by a set of trained individuals, leading to a reduction in the variability in case definition and detection.

In conclusion, this study found a prevalence of HAIs of 8.2%, which is low compared with findings from other low- and middle-income countries. Addressing the problem of HAIs in low-resource countries may require significant investment and commitment to IPC, including training and deployment of infection control healthcare professionals as an additional strategy to help implement the numerous guidelines and recommendations.

Acknowledgements

The manuscript was revised for intellectual content by Jorgen Kurtzhals. The authors wish to thank Edmund Tetteh Nartey for his technical support in auditing the HAI database.

Conflict of interest statement

None declared.

Funding source

Financial support for this study was provided by the Danish Ministry of Foreign Affairs as part of the HAI-Ghana project (DANIDA Grant No. 16-PO1-GHA).

Appendix A. Supplementary data

Supplementary data related to this article can be found at <https://doi.org/10.1016/j.jhin.2018.04.019>.

References

- [1] Rothe C, Schlaich C, Thompson S. Healthcare-associated infections in sub-Saharan Africa. *J Hosp Infect* 2013;85:257–67.
- [2] Nejad SB, Allegranzi B, Syed SB, Pittet D. Health-care-associated infection in Africa: a systematic review. *Bull World Health Organ* 2011;89:757–65.
- [3] World Health Organization. Report on the burden of endemic health care-associated infection worldwide. Geneva: WHO; 2011. p. 1–88.
- [4] Cardoso T, Ribeiro O, Aragão I, Costa-Pereira A, Sarmiento A. The impact of healthcare-associated infection on mortality: failure in clinical recognition is related with inadequate antibiotic therapy. *PLoS One* 2013;8:e58418.
- [5] De Angelis G, Murthy A, Beyersmann J, Harbarth S. Estimating the impact of healthcare-associated infections on length of stay and costs. *Clin Microbiol Infect* 2010;16:1729–35.
- [6] Allegranzi B, Nejad SB, Combescurie C, Graafmans W, Attar H, Donaldson L, et al. Burden of endemic health-care-associated infection in developing countries: systematic review and meta-analysis. *Lancet* 2011;377:228–41.
- [7] Ghana Ministry of Health. National policy and guidelines for infection prevention and control in health care settings. Accra: MOH; 2015.
- [8] Newman MJ. Nosocomial and community acquired infections in Korle Bu Teaching Hospital, Accra. *West Afr J Med* n.d.;28:300–303.
- [9] Nsiah-Asare A. The health sector in Ghana: facts and figures 2017. Accra: Ghana Health Service; 2017.
- [10] Saleh K. The health sector in Ghana: a comprehensive assessment. Washington, DC: World Bank; 2013.
- [11] European Centre for Disease Prevention and Control. Point prevalence survey of healthcare-associated infections and antimicrobial use in European acute care hospitals. Stockholm: ECDC; 2013.
- [12] Fortaleza CMCB, Padoveze MC, Kiffer CRV, Barth AL, Carneiro ICDRS, Giamberardino HIG, et al. Multi-state survey of healthcare-associated infections in acute care hospitals in Brazil. *J Hosp Infect* 2017;96:139–44.

- [13] Thu TA, Hung NV, Quang NN, Archibald LK, Harun-Or-Rashid M, Sakamoto J. A point-prevalence study on healthcare-associated infections in Vietnam: public health implications. *Infect Control Hosp Epidemiol* 2011;32:1039–41.
- [14] Ahofo T, Bankolé H, Adéoti F, Gbohoun AA, Assavèdo S, Amoussou-Guénou M, et al. Prevalence of nosocomial infections and anti-infective therapy in Benin: results of the first nationwide survey in 2012. *Antimicrob Resist Infect Control* 2014;3:17.
- [15] Tabiri S, Yenli E, Kyere M, Anyomih TTK. Surgical site infections in emergency abdominal surgery at Tamale Teaching Hospital, Ghana. *World J Surg* 2018;42:916–22.
- [16] Magill SS, Edwards JR, Bamberg W, Beldavs ZG, Dumyati G, Kainer MA, et al. Multistate point-prevalence survey of health care-associated infections. *N Engl J Med* 2014;370:1198–208.
- [17] Stauning MT, Bediako-Bowan A, Andersen LP, Opintan JA, Labi AK, Kurtzhals JAL, et al. Traffic flow and microbial air contamination in operating rooms at a major teaching hospital in Ghana. *J Hosp Infect* 2018;99:263–70.
- [18] Pittalis S, Ferraro F, Piselli P, Puro V. Regional Center for Healthcare Associated Infections Latium Region. Superficial surgical site infection postdischarge surveillance. *Am J Infect Control* 2014;42:86–7.
- [19] Allegranzi B, Bischoff P, de Jonge S, Kubilay NZ, Zayed B, Gomes SM, et al. New WHO recommendations on preoperative measures for surgical site infection prevention: an evidence-based global perspective. *Lancet Infect Dis* 2016;16:e276–87.
- [20] Newman MJ, Frimpong E, Donkor ES, Opintan JA, Asamoah-Adu A. Resistance to antimicrobial drugs in Ghana. *Infect Drug Resist* 2011;4:215–20.
- [21] Labi A-K, Obeng-Nkrumah N, Bjerrum S, Enweronu-Laryea C, Newman MJ. Neonatal bloodstream infections in a Ghanaian tertiary hospital: are the current antibiotic recommendations adequate? *BMC Infect Dis* 2016;16:598.
- [22] Eibach D, Campos CB, Krumkamp R, Al-Emran HM, Dekker D, Boahen KG, et al. Extended spectrum beta-lactamase producing Enterobacteriaceae causing bloodstream infections in rural Ghana, 2007–2012. *Int J Med Microbiol* 2016;306:249–54.
- [23] Egyir B, Guardabassi L, Monecke S, Addo KK, Newman MJ, Larsen AR. Methicillin-resistant *Staphylococcus aureus* strains from Ghana include USA300. *J Glob Antimicrob Resist* 2015;3:26–30.
- [24] Groß U, Amuzu SK, de Ciman R, Kassimova I, Gross L, Rabsch W, et al. Bacteremia and antimicrobial drug resistance over time, Ghana. *Emerg Infect Dis* 2011;17:1879–82.
- [25] World Health Organization. Core components for infection prevention and control programmes. Report of the Second Meeting Informal Network on Infection Prevention and Control in Health Care. Geneva: WHO; 2009.
- [26] Zimmerman P-A. Help or hindrance? Is current infection control advice applicable in low- and middle-income countries? A review of the literature. *Am J Infect Control* 2007;35:494–500.
- [27] Rodríguez-Baño J, del Toro MD, López-Méndez J, Mutters NT, Pascual A. Minimum requirements in infection control. *Clin Microbiol Infect* 2015;21:1072–6.
- [28] Storr J, Twyman A, Zingg W, Damani N, Kilpatrick C, Reilly J, et al. Core components for effective infection prevention and control programmes: new WHO evidence-based recommendations. *Antimicrob Resist Infect Control* 2017;6:6.
- [29] Allegranzi B, Kilpatrick C, Storr J, Kelley E, Park BJ, Donaldson L. Global infection prevention and control priorities 2018–22: a call for action. *Lancet Glob Heal* 2017;5:e1178–80.