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Original Research Article

Additional costs of healthcare-associated infections (HAI) in three hospitals in the City of Bobo Dioulasso, Burkina Faso, 2022: A nested cohort case-control study

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The economic and human impact of healthcare-associated infections (HAIs) remains poorly documented in Sub-Saharan African countries. This study aimed to assess the human and economic costs of HAIs in the main hospitals of Bobo Dioulasso. A nested cohort case-control study with matched cases of HAIs and controls (1:1) by age, sex, reason for hospitalization, and ward. The study was conducted in three wards of the Sourô Sanou University Hospital and in the postoperative wards of the Do and Dafra district hospitals. Paired groups with and without HAIs were compared based on mortality, medical expenses, length of hospital stay, and duration of illness. The Wilcoxon test and the McNemar test were used to test hypotheses between groups. The statistical significance level was 5% for all analyses. A total of 118 patients with HAIs and 118 without HAIs (236 patients) were included. HAIs were associated with a 4.4-day increase in hospital stay (8.4 vs 4.0 days; p=0.000), a 7.7-day increase in duration of illness (19.2 vs 11.5 days; p=0.000). In-hospital mortality rate was 18.6% in patients with HAIs and 7.6% in patients without HAIs (p=0.02). HAIs resulted in an additional medical cost estimated at US$ 60.6 (p=0.000), representing a 33.0 % increase in health expenditure. This is mainly due to additional drug costs (US$ 55.6). Treatment of HAIs were more expensive in the intensive care unit (US$ 295.2) than in other wards (US$ 155.6), p=0.017. These findings show that HAIs increased the burden of the disease. The quantified financial burden will be useful to policymakers in allocating resources to reduce HAIs.

Keywords: Additional cost, healthcare-associated infections, hospitals Burkina Faso.

INTRODUCTION

Healthcare-associated infections (HAIs) are one of the most common adverse events in healthcare and a major public health problem. WHO estimates that at any given time, at least 7% of patients in developed countries and 10% in developing countries will develop at least one HAI (World Health Organization, 2017). These infections, which occur in patients treated for other conditions, not only lead to increased morbidity and mortality, but also carry a significant financial burden on the patient, the health system, and the country (Murray et al., 2022; World Health

Organization, 2011).

In the United States, for example, HAIs are estimated to cost the healthcare system between $35 billion and $45 billion a year (Fox et al., 2023). Recent Studies (Upadhyay and Smith, 2023; Beauvais et al., 2024) also show a direct link between infection rates and reduced operating margins for hospitals.

In Africa, where the prevalence of HAIs is higher (World Health Organization, 2011), the negative impact of HAIs on patients' quality of life and healthcare budgets is considerable (Irek et al., 2018; Gidey et al., 2023). Indeed, the total economic cost of HAIs in Mali in 2022 is estimated at US$73 million. This represents 2.5% of total health expenditure and 0.39% of gross domestic product in 2022 (WaterAid, 2024). In a study of 14 countries in Sub-Saharan Africa, HAIs accounted for an average of 5.6 % of health expenditures (Hutton et al., 2024). HAIs result in direct additional costs, which may include the costs of examinations, medications, and hospitalizations, as well as additional indirect costs associated with prolonged periods of unproductive time and death of the patient (Fenny et al., 2020). Estimating the additional costs of healthcare-associated infections is a complex challenge in Africa because of the diversity of health systems and the lack of comprehensive data on these infections. This may explain the wide variation in HAIs costs across countries and studies, depending on available resources, level of care, and infection type.

In Burkina Faso, as in most Sub-Saharan African countries, the economic and human impact of HAIs remains poorly documented. However, the assessment of the latter provides a necessary evidence base for the implementation of interventions to reduce the incidence of these infections. The aim of this study, conducted from the patient's perspective, was to estimate the additional costs borne by the patient or a third-party payer in the event of a HAI in three hospitals in Bobo Dioulasso city, in Burkina Faso.

MATERIALS AND METHODS

Study setting

This study was conducted from May 1 to November 30, 2022 in three health facilities in Bobo-Dioulasso, Burkina Faso's second largest city. These include 2 district hospitals (Do and Dafra) and one university hospital (CHUSS de Sourô Sanou – CHUSS) in Bobo-Dioulasso. In the district, Do and Dafra hospitals, the study took place in the postoperative care ward. At the Sourô Sanou University Hospital, the study was conducted in the intensive care, gynecology and postoperative obstetrics and neonatology wards.

Dafra District Hospital Post-Operative Care ward

The post-operative care ward of Dafra District Hospital received 888 post-operative patients in 2022. This unit includes 2 inpatient rooms with a total capacity of 16 beds. During the survey, the department was staffed by 52 nurses, 2 hospital hygiene technicians, and 2 full-time doctors. The care provided in this ward includes (i) managing surgical wounds, bandages and drains, (ii) monitoring hemodynamic status, (iii) preventing and managing complications such as thromboembolism, infections, etc. Dafra District Hospital did not have an infection prevention and control committee.

Do District Hospital Post-Operative Care ward

The post-operative care ward of Do District Hospital received 1706 post-operative patients in 2022. The unit has six inpatient rooms with a total capacity of 34 beds. At the time of the survey, the staff of the ward consisted of 59 nurses and one hospital hygiene technician, 5 permanent doctors and about 5 medical trainees. The care provided in this ward includes (i) managing surgical wounds, bandages and drains, (ii) monitoring hemodynamic status, (iii) preventing and managing complications such as thromboembolism, infections, etc. Do District Hospital did not have an infection prevention and control committee.

Post-operative gyneco-obstetric care ward of the Sourô Sanou University Hospital

In 2022, the gynecology and obstetrics post-operative care ward of the Sourô Sanou University Hospital received 1,946 women who had been operated upon, including 1,433 caesarean sections. This unit has 30 hospital beds. The staff consists of 16 doctors, 4 nurses and 21 midwives. The care provided in this ward includes (i) managing surgical wounds, bandages and drains, (ii) monitoring hemodynamic status, (iii) preventing and managing complications such as thromboembolism, infections, etc. CHUSS did not have an infection prevention and control committee.

Intensive Care Unit of the Sourô Sanou University Hospital

In 2022, 525 patients were admitted to the intensive care unit (ICU) of the Sourô Sanou University Hospital. The unit has 14 hospital beds. The staff of this unit consists of 5 anesthesiologists, about 10 resident doctors, 23 nurses and 3 hospital hygiene technicians. This Unit is designed to care for life-threatening patients who require advanced monitoring and treatment. Care provided in this unit includes (i) monitoring and maintenance of vital functions, (ii) management of drains and surgical wounds, and (iii) infection prevention and management, etc.

Neonatal ward of the Sourô Sanou University Hospital

In 2022, the neonatal ward of the Sourô Sanou University Hospital received 2,765 newborns. It has a hospital room that includes 6 incubators and 34 cribs. The staff consists of 2 pediatric specialists, 2 general practitioners, about 10 resident doctors, 28 nurses and 3 hospital hygiene technicians., This ward provides specialized neonatal medical care, especially for babies born prematurely or with birth complications. This care may include intensive monitoring, respiratory support, parenteral nutrition, infection prevention and management, etc.

Study design and population

A multicenter case-control study integrated into a cohort to analyze the financial and clinical consequences of HAIs. The cohort consisted of all consenting patients admitted to the postoperative care wards of the Do and Dafra District Hospital or to one of the target wards of the CHUSS during the period of active surveillance of HAIs. This period of active surveillance of HAIs extended from 1 May to 30 June 2022 in the post-operative wards of the Do and Dafra District Hospital from 1 August to 30 November 2022 in the wards of the CHUSS. The patients included in the study were followed until they were completely cured. The case population consisted of patients in the cohort who had any of the following HAIs during follow-up: surgical site infection, newborn infection, bacteremia, urinary tract infection. These cases were matched (1:1) by the following variables: age at diagnosis ±5 years, sex, hospital ward and reason for hospitalization, to patients from the no-HAI cohort (control population). When there was more than one control for a case, the matching control was selected randomly in Excel. The additional cost of HAIs was considered to be the difference between the average cost of treating patients with HAIs (cases) and patients without HAIs (controls).

Data collection

A team consisting of a medical epidemiologist, two clinicians and three nurse managers was responsible for active data collection in collaboration with the department head. Three times a week, the data collection team reviewed hospital registers, inpatient records, dressings records and bacteriology laboratory records for cases of HAIs. Information from these sources was complemented with information from patients and caregivers and recorded on individual data collection forms, which included: sociodemographic data (age, sex, origin, intellectual level), risk factors related to patients and care, type of HAI (location, time of onset), outcome and costs of health care. Health care costs for each patient were estimated using payment receipts for procedures, examinations, and drugs purchased. For patients covered by the free care program in Burkina Faso (children under 5 and pregnant women), we collected data from the bills generated by the hospitals' financial services for the free care program.

Variables

Outcome variables

Our primary outcome variables were economic and clinical.

- The economic results variables, expressed in United states dollar (US$), included all expenditures directly related to the care of patients (hospital costs, medical procedures, paramedical examinations, medications, etc.). They were measured in terms of hospitalization costs, drug costs, and total cost of care (total out – of - pocket expenditures) and presented by their average, standard deviation (sd), and extremes.
- Clinical outcome variables were evaluated in terms of all-cause in-hospital mortality, length of hospital stay and duration of illness. In-hospital mortality was expressed as the ratio of the number of people who died to the number of patients admitted to a ward. Length of stay and duration of illness are expressed in days and reported as average, sd, and extreme values.

Explanatory variable

- Age in years for adults and in days for newborns, presented by its average and sd. It was conveniently classified into 5-day ±5 newborn classes and 5-year-old ± 5-year classes for matching.
- Sex: Male and female
- Residence: Urban and rural
- Comorbidity: High blood pressure and diabetes were the two comorbidities considered in this study.
- Exposures: Surgery, urinary catheter, peripheral venous catheter

Statistical analysis

The data collected on the survey forms were entered into the Epidata3.1® software and analyzed with the Stata13® version 13 software. Patients' socio-demographic and clinical characteristics, direct costs of care, and disease outcomes were described. Qualitative variables were described by their percentages and quantitative variables by their average and standard deviation (sd). Groups matched with and without HAIs were compared based on mortality, medical expenses, length of hospital stay and duration of illness. The Wilcoxon test was used for continuous quantitative variables and the McNemar test for categorical variables to compare the groups. The statistical significance level (p-value) was 5% for all analyses.

Ethical aspects

This study was carried out as part of the study "Surveillance and prevention strategies for healthcare associated infections in Bobo-Dioulasso, Burkina Faso". approved by the National Ethics Committee of Burkina Faso; approval reference letter number 2022-02-020. Signed informed consent was obtained from the participants and an information sheet was given to each participant.

Written and signed informed consent was obtained from parents or guardians for neonates and minors. In addition to parental consent, we obtained assent from children over the age of 12. The data collected were anonymized to ensure confidentiality.

RESULTS

Patient Selection

From the cohort of 664 patients followed, we obtained 118

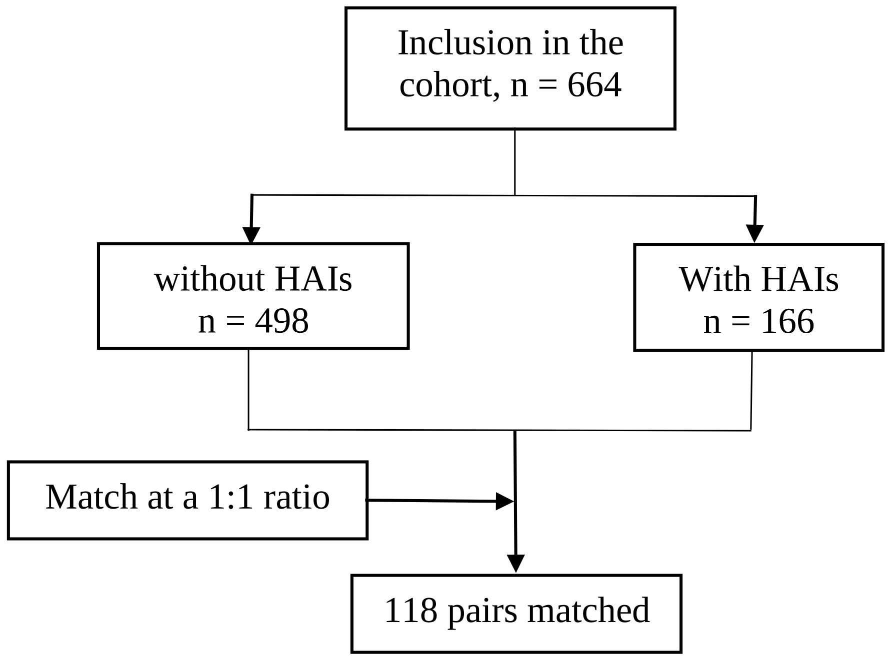

Figure 1: Diagram of selection of patient with healthcare-associated infections and of control in the multicenter cohort study population in three hospitals in the city of Bobo-Dioulasso.

peers for the present study; the remaining 48 cases of HAIs were not a perfect match in the control group (Figure 1).

Patient Characteristics

Patient characteristics adjusted for age, sex, reason for hospitalization and ward are presented in Table 1 and Figure 1. A total of 236 patients were included in the study, 118 cases and 118 controls. The average age of patients was 15.2 years (sd = 13.4), with extremes ranging from 2 days to 40 years, and 40.7% of patients were neonates (<30 days). The majority of patients (70.3%) were female, 83.9% lived in urban areas, 56.4% had surgery, and 83.0% had a peripheral venous catheter. The most common reason for hospitalization was caesarean section, followed by extreme prematurity and perinatal asphyxia (Figure 2). There was no difference in the distribution of patients between cases and controls by age, sex, place of residence, comorbidities, exposure, reason for hospitalization or ward. In the case population, 53% were surgical site infections (SSI), 43% neonatal infections and 6% systemic infections.

Clinical effects of HAIs

The average length of stay was 6.2 days (sd: 5.7), with extremes of 2 and 42 days for all patients. It was 8.5 days (standard deviation: 6.6) for HAIs cases and 4.0 days (sd: 3.1) for controls. The average duration of illness was 15.3 days (sd: 10.2) with extremes of 3 and 47 days for all patients. It was 19.2 days (sd: 11.5) for cases with HAIs and 11.5 days (sd: 6.5) for controls. Thus, HAI was associated with a 4.4-day increase in hospital stay (p=0.000) and a 7.7-day increase in duration of illness (p=0.000). Deaths were observed only in neonatal ward (28.1%) and in ICU (25.0%); No fatalities were observed among the operated patients. The mortality rate was 18.6% in patients with HAIs versus 7.6% in those without HAIs, there was a statistically significant difference in mortality between the case and control groups (p = 0.020), (Table 2). The fraction of risk of death attributable to HAIs in the study population was 42%.

Direct medical costs of hospital-acquired infections

The direct cost of care for all patients was US$ 50,309.1, including US$ 21,594.5 for patients without HAIs and US$ 28,714.6 for patients with HAIs, resulting in an additional cost of US$ 7,120.1 for HAIs. The free healthcare program covered 72.9% (US$ 5,192) of these additional costs. The average cost of a hospital bed was US$ 6.60 (sd: 8.03) with extremes of US$ 1.6 and US$ 33.4. It was US$ 8.2 (sd: 8.1) for cases and US$ 5.0 (sd: 7.6) for controls (p=0.002), a difference from US$ 3.2. The average cost of drugs was US$ 127.9 (sd: 72.2) with extremes of US$ 16.4 and US$ 449 for all patients. It was US$ 155.6 (sd: 85.9) for cases and US$ 100.0 (sd: 40.2) for controls (P = 0.000); The proportion of additional drug costs associated with nosocomial infections was 55.1%. The average direct medical costs of care were US$ 213.1 (sd: 119.9), with extremes of US$ 18.0 and US$ 602.4 for all patients. It was US$ 243.3 (sd: 134.4) for cases and US$ 182.7 (sd: 95.3) for controls (p = 0.000). Comparing the cost of treating patients with HAIs with that of patients without HAIs shows an average additional cost of US$ 60.6 per patient, representing a 33.0% increase in health expenditures per patient with nosocomial infection (Table 3).

Table 1. Patient Demographic and Clinical Characteristics

Characteristics	All patients n(%)	Patients with HAIs n(%)	Patients without HAIs n(%)	P-value
Age (years), average (sd)	15.2 (13.4)	15.2 (13.5)	15.2 (13.5)	0.987
Sex				1.000
• Male	70 (29.7)	35 (29.7)	35 (29.7)	
• Female	166 (70.3)	83 (70.3)	83 (70.3)	
Residence				0.836
• Urban	198 (83.9)	98 (83.1)	100 (84.8)	
• Rural	38 (16.1)	20 (16.9)	18 (15.2)	
Ward / Unit				1.000
• PCW*/Dafra	30 (12.7)	15 (12.7)	15 (12.7)	
• PCW/Do	24 (10.2)	12 (10.2)	12 (10.2)	
• Gyn & Obs PCW/ CHUSS	70 (29.6)	35 (29.6)	35 (29.6)	
• Neonatal/CHUSS	96 (40.7)	48 (40.7)	48 (40.7)	
• Intensive Care Unit/CHUSS	16 (6.8)	8 (6.8)	8 (6.8)	
Comorbidity				
• High blood pressure				0.595
○ Yes	15(6.7)	6(5.1)	9(7.6)	
○ No	221(93.3)	112(94.9)	109 (92.4)	
• Diabetes				1.000
○ Yes	5(2.1)	2(1.7)	3(2.5)	
○ No	231(97.9)	116(98.3)	115(97.5)	
Exhibitions				
• Surgery				0,793
○ Yes	133(56.4)	65(55.1)	68(57.6)	
○ No	103(43.6)	53(44.9)	50(42.4)	
• Urinary catheter				0.894
○ Yes	94(39.8)	48 (40.7)	46 (40.0)	
○ No	142(60.2)	70(59.3)	72(60.0)	
• Peripheral venous catheter				1.000
○ Yes	196 (83.0)	98(83.0)	98(83.0)	
○ No	40(17.0)	20(17.0)	20(17.0)	

*PCW = Postoperative Care Ward; Gyn & obs = gynecology and obstetric

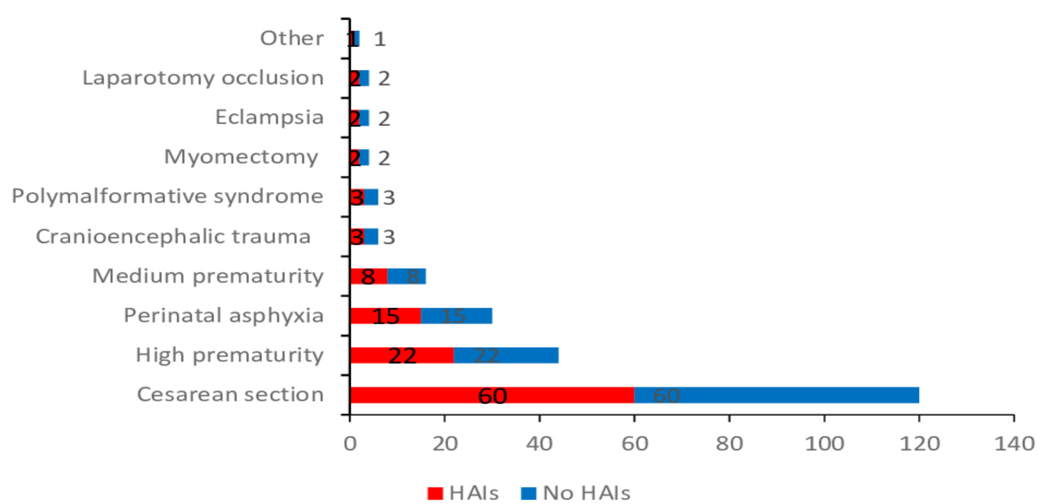

Figure 2: Distribution of 236 patients by reason for admission

Direct medical Costs by HAI Type

The costs of HAIs varied according to infection type, with systemic infections associated with the highest additional costs. For patients of the same age, sex, and reason for hospitalization in the same ward, those with HAIs incurred significant additional health care costs. This was true regardless of the type of HAI (Table 4).

Table 2. Clinical burden of patients with and without HAIs

	Patients with HAIs	Patients without HAIs	Average difference	P-value
In-hospital mortality n(%)	22 (18.6)	9 (7.6)		0.020
Length of stay (days), average (sd)	8.4(6.6)	4.0(3.1)	4.4	0.000
Duration of illness (days), average (sd)	19.2 (11.5)	11.5 (7.0)	7.7	0.000

Table 3. Direct medical costs of patients with and without HAIs in US$

	Patients with HAIs	Patients without HAIs	Average difference	P-value
Average drug cost (standard deviation)	155.6 (85.9)	100.0 (40.2)	55.6	0.000
Average cost of hospital bed (sd)	8.2(8.1)	5.0(7.6)	3.2	0.002
Other cost, average (sd)	79.5 (75.2)	77.7(75.4)	1.8	0.851
Total cost, average (sd)	243.3(134.4)	182.7(95.3)	60.6	0.000

Table 4. Direct medical costs of patients with and without HAIs in US$ by type of HAI and by ward/unit.

	Patients with HAIs		Patients without HAIs		Average difference	P
Type HAIs	N	Average cost (sd)	N	Average cost (sd)		
SSI	63	341.7(92.3)	63	263.0(41.1)	78.7	0.000
Systemic infection	7	259.9(76.4)	7	121.5(70.9)	138.4	0.028
Neonatal infections	48	111.8(47.7)	4	86.9(30.7)	24.9	0.009
Ward / Unit						
PCW/Dafra	15	256.4(34.9)	15	220.6(20.3)	35.8	0.005
PCW/Do	12	289.2(105.1)	12	222.6(34.9)	66.6	0.005
Gyn &obst PCW/ CHUSS	35	390.6 (60.2)	35	293.5(9.8)	97.1	0.000
Neonatal/CHUSS	48	111.8(47.7)	48	86.9(30.7)	24.9	0.009
Intensive Care Unit/CHUSS	8	295.2(122.5)	8	155.6 (95.6)	139.6	0.017

PCW = Postoperative Care ward ; Gyn & obst = gynecology and obstetrics

Direct medical costs per ward/unit

Medical expenses vary according to ward/unit. The highest average cost per respiratory infection was observed in intensive care (US$ 139.6) and lowest in neonatology (US$ 24.9). In all wards/unit, the HAIs were associated with additional health care costs (Table 4).

DISCUSSION

The objective of this study was to assess the additional human and economic costs of HAIs in the three main hospitals in the city of Bobo Dioulasso. The results show that HAIs were associated with a 4.4-day increase in hospital stay, a 7.7-day increase in length of illness. In-hospital mortality rate was 18.6% for patients with HAIs and 7.6% for patients without HAIs (p=0.020). The fraction of risk of death attributable to HAIs in the study population was 42%. The clinical consequences of HAIs resulted in an additional medical cost estimated at US$ 60.6, representing a 33.0% increase in health expenditure or 84.7% of the guaranteed interprofessional minimum wage in Burkina Faso (US$ 71.5). This increase in expenditure is mainly due to the additional cost of drugs for the treatment of HAIs (US$ 55.6). Treatment of HAIs was more expensive in the intensive care unit than in other wards (US$ 139.6).

In this study, the increase in length of hospital stay associated with HAIs was on average 4.4 days, which is comparable to the 5 days reported by a study conducted in Ethiopia (Sahiledengle et al., 2020), the 3 days reported in Ghana (Otieku et al., 2023a) and the 3.6 days reported in Rwanda (Sutherland et al., 2019). In contrast, the increase in length of hospital stay in our study was less than the 8.3 days reported in Ethiopia (Gidey et al., 2023), the 7.6 days reported in Tanzania (Eriksen, 2003), and the 10 days reported in a review and meta-analysis of several African studies (Epeh and Fenny, 2022). The length of hospital stay may vary from one study to another, depending on the type and severity of the HAI, but also on the organization of the health care system (Otieku al., 2023a). In this study, the majority of HAIs were SSIs, which are usually treated on an outpatient basis.

As with length of stay, the cost of HAIs is very heterogeneous. This variation depends on the type of HAI the resistance profile of the pathogen, and the ward/unit. In this study, systemic infections were found to be costlier than other infections; the same observation was made by other studies (Kwizera et al., 2018; Puhto, 2018). These systemic infections require investigations, antibiotics and sometimes resuscitation, hence the high cost of their management (Aerts et al., 2022; Moura et al., 2017; Otieku et al., 2023b). The cost of HAIs is even higher when they are caused by resistant bacteria witch limits treatment options and forces the use of increasingly expensive antimicrobials (Otieku et al., 2023b; Su et al., 2020).

Similarly, the variation in the incremental costs associated with HAIs across studies depends on the country's financial architecture and standard of living (Aerts et al., 2022; Epeh and Fenny, 2022). The average additional costs associated with HAIs in this study were higher than those reported by in Ethiopia (Ethiopian birrs3033) (Gidey et al., 2023), but comparable to those reported (US$59) in Ghana (Otieku et al., 2023a). Systems that favor out-of-pocket financing of care limit poor patients' access to appropriate, often costly, care. The majority of patients in this study benefited from free care. This meant that they were able to access care within the technical capacity of the health services without paying any money. Similar to this study, other researchers showed the predominance of drug costs in direct HAI care expenditures (Gidey et al., 2023; Otieku et al., 2023a). Overall, health care costs for HAIs in sub-Saharan Africa ranged from 2.5% to 5.6% of total health care expenditures (WaterAid, 2024; Hutton et al., 2024). Moreover, Epeh et al. indicated that the additional costs were higher in Maghreb countries and South Africa than in Sub-Saharan African countries (Epeh and Fenny, 2022). This could be explained by higher levels of access to care, financing, infrastructure, and skills in the Maghreb and South Africa.

Mortality from HAIs in this study (18.6%) was lower than that reported in China (34.0% - 39.4%) (Su et al., 2020). However, the fraction of risk of death attributable to the HAIs in the study population (42%) was above the 22% (95% CI: 14.2–31.4) mortality attributable to HAIs reported in a systematic review and meta-analysis in sub-Saharan Africa (Melariri et al., 2024). The length of illness and therefore of unproductivity in this study was similar to that reported in Ghana (Otieku, Fenny, et al., 2023a), who reported an average period of unproductivity of 19.7 to 15.9 days, depending on the resistance profile of the pathogen. Variations in HAI case fatality rates and the length of illness between studies may be explained by differences in the clinical and demographic characteristics of the study populations, in the health care system. Studies conducted in wards such as neonatal and intensive care units with fragile patients and/or those with serious illnesses report higher case fatality rates.

In this study, we did not assess the indirect economic impact of HAI, as premature deaths and disease-related lost productivity. However, evidence from studies conducted in the sub-region shows that the indirect consequences of HAIs are very important in economic terms. Otieku et al. in Ghana estimated that about one-third of the additional spending was due to productivity losses (Otieku et al., 2023a). While Huton et al. based on a review of the HAI literature, estimated the economic impact of these infections in 14 countries in Sub-Saharan Africa (Hutton et al., 2024). They showed that the economic loss per HAI was five times greater than the cost of health care. Similarly, the authors found that the cost of premature death accounted for 77% of the total cost of HAIs due to their high case fatality rate. Although the indirect costs of HAIs in Africa are significant, they remain underestimated. Estimates of these costs do not take into account the cost of quality of life (Scott et al., 2019) or the unproductive time of healthcare workers and carers. The latter play an important role in patient management in our context.

This study used a standard cost-of-illness methodology and did not include an assessment of indirect costs of HAIs, such as loss of productive time for the patient and family members, for the healthcare workers, or the cost of premature death. However, this case-control study, matched for key patient characteristics, provides a fairly robust estimate of the direct costs of HAIs in the Burkina Faso context. It could therefore guide the development of interventions to reduce the incidence of HAIs.

CONCLUSIONS

In this study, we estimated the human and economic consequences of HAIs in three hospitals in the city of Bobo-Dioulasso. In human terms, HAIs were associated with a 4-day prolongation of hospital stay, a 7.7-day duration of illness, and a 42% increased risk of death. In economic terms, the average additional cost of a respiratory infection was US$ 60.6, to which must be added various indirect costs such as loss of productivity for patients, healthcare workers, as well as the cost of the patient's quality of life. As Burkina Faso is preparing to implement a universal health coverage program, economic evaluations of HAIs are critical. They will help policy makers allocate the resources needed to reduce these infections.

Ethics approval and consent to participate

The study was approved by the National Health Ethics Committee of Burkina Faso. An information sheet was given to each participant. After reading this information sheet, those who desired to participate in the study signed a free and informed consent form. The data collected were anonymized to ensure their confidentiality.

Competing interests

AH, SAS, ST OK, SS, AP, ZCM, ASO and LS have no competing interests to declare.

Authors' contributions

AH, SAS, OK and ST designed the study; AH, SAS and ST drafted the manuscript. AH, SAS and OK conducted the analyses. AH, SAS, ST, SS, OK, AP, ZCM, ASO and LS contributed to the interpretation of the findings and edited and reviewed the manuscript. All the authors have read and approved the final manuscript.

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REFERENCES

Aerts C, Leahy S, Mucasse H, Lala S, Bramugy J, Tann CJ, Madhi SA, Bardají A, Bassat Q, Dangor Z, Lawn JE, Jit M, Procter SR. (2022). Quantifying the Acute Care Costs of

Neonatal Bacterial Sepsis and Meningitis in Mozambique and South Africa. *Clinical Infectious Diseases*, *74*(Supplement_1), S64–S69. Crossref

Beauvais B, Dolezel D, Shanmugam R, Wood D, Pradhan R. (2024). An Exploratory Analysis of the Association between Healthcare Associated Infections & Hospital Financial Performance. *Healthcare*, *12*(13), 1314. Crossref

Epeh D and Fenny A. (2022). *Costing Health Care Associated Infections: Meta-analysis and modelling of selected African Countries*. https://jscholaronline.org/full-text/IJNSP/1_103/Costing-Health-Care-Associated-Infections.php

Eriksen HM, Chugulu S, Kondo S, Lingaas E. (2003). Surgical-site infections at Kilimanjaro Christian Medical Center. *Journal of Hospital Infection*, *55*(1), 14–20. Crossref

Fenny AP, Asante FA, Otieku E, Bediako-Bowan A, Enemark U. (2020). Attributable cost and extra length of stay of surgical site infection at a Ghanaian teaching hospital. *Infection Prevention in Practice*, *2*(2), 100045. Crossref

Fox JM, Saunders NJ, Jerwood SH. (2023). Economic and health impact modelling of a whole genome sequencing-led intervention strategy for bacterial healthcare-associated infections for England and for the USA. *Microbial Genomics*, *9*(8). Crossref

Gidey K, Gidey MT, Hailu BY, Gebreamlak ZB, Niriayo YL. (2023). Clinical and economic burden of healthcare-associated infections: A prospective cohort study. *PLOS ONE*, *18*(2). Crossref

Hutton G, Chase C, Kennedy-Walker R, Hamilton H. (2024). Financial and economic costs of healthcare-associated infections in Africa. Journal of Hospital Infection, 150:1–8. Crossref

Irek EO, Amupitan AA, Obadare TO, Aboderin AO. (2018). A systematic review of healthcare-associated infections in Africa: An antimicrobial resistance perspective. African J. Laboratory Medicine, *7*(2). Crossref

Kwizera A, Baelani I, Mer M, Kissoon N, Schultz MJ, Patterson AJ, Musa N, Farmer JC, Dünser MW. (2018). The long sepsis journey in low- and middle-income countries begins with a first step...but on which road? *Critical Care*, *22*(1). Crossref

Melariri H, Freercks R, van der Merwe E, Ham-Baloyi WT, Oyedele O, Murphy RA, Claasen C, Etusim PE, Achebe MO, Offiah S, Melariri PE. (2024). The burden of hospital-acquired infections (HAI) in sub-Saharan Africa: a systematic review and meta-analysis. *eClinicalMedicine*, *71*.Crossref

Moura J, Baylina P, Moreira P. (2017). Exploring the real costs of healthcare-associated infections: an international review. Int. J. Healthcare Management, 11(4): 333–340. Crossref

Murray CJL, Ikuta KS, Sharara F, Swetschinski L, Robles Aguilar G, Gray A, Han C, Bisignano C, Rao P, Wool E, Johnson SC, Browne AJ, Chipeta MG, Fell F, Hackett S, Haines-Woodhouse G, Kashef Hamadani BH, Kumaran EAP, McManigal B, … Albertson S. (2022). Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. *The Lancet*, *399*(10325):629–655. Crossref

Otieku E, Fenny AP, Labi A-K, Ofori AO, Kurtzhals JAL, Enemark U. (2023a). Attributable Patient Cost of Antimicrobial Resistance: A Prospective Parallel Cohort Study in Two Public Teaching Hospitals in Ghana. *PharmacoEconomics Open*, *7*(2):257–271. Crossref

Otieku E, Kurtzhals JAL, Fenny AP, Ofori AO, Labi A-K, Enemark U. (2023b). Healthcare provider cost of antimicrobial resistance in two teaching hospitals in Ghana. Health Policy and Planning, *39*(2):178–187. Crossref

Puhto T. (2018). The burden of healthcare-associated infections in primary and tertiary healthcare wards and the cost of procedure-related prosthetic joint infections. https://oulurepo.oulu.fi/bitstream/handle/10024/34280/isbn978-952-62-1985-1.pdf

Sahiledengle B, Seyoum F, Abebe D, Geleta EN, Negash G, Kalu A, Woldeyohannes D, Tekalegn Y, Zenbaba D, Edward Quisido BJ. (2020). Incidence and risk factors for hospital-acquired infection among paediatric patients in a teaching hospital: a prospective study in southeast Ethiopia. *BMJ Open*, *10*(12). Crossref

Scott R, Culler SD, Rask KJ. (2019). Understanding the Economic Impact of Health Care-Associated Infections: A Cost Perspective Analysis. J. Infusion Nursing, *42*(2):61–69. Crossref

Su L-H, Chen I-L, Tang Y-F, Lee J-S, Liu J-W. (2020). Increased financial burdens and lengths of stay in patients with healthcare-associated infections due to multidrug-resistant bacteria in intensive care units: A propensity-matched case-control study. *PLOS ONE*, *15*(5), e0233265. Crossref

Sutherland T, Mpirimbanyi C, Nziyomaze E, Niyomugabo J-P, Niyonsenga Z, Muvunyi CM, Mueller A, Bebell LM, Nkubana T, Musoni E, Talmor D, Rickard J, Riviello ED. (2019). Widespread antimicrobial resistance among bacterial infections in a Rwandan referral hospital. *PLOS ONE*, *14*(8), e0221121. Crossref

Upadhyay S, Smith D (2023). Healthcare Associated Infections and Financial Performance in U.S. Hospitals. *Academy of* Management Proceedings, 2023(1). Crossref

WaterAid. (2024). Costs of healthcare acquired infections due to inadequate water, sanitation and hygiene (WASH) in healthcare facilities in Mali. https://washmatters.wateraid.org/sites/g/files/jkxoof256/files/2024-04/Costs-healthcare-acquired-infections-Mali.pdf

World Health Organization. (2011). Report on the Burden of Endemic Health Care-Associated Infection Worldwide. https://www.who.int/publications/i/item/report-on-the-burden-of-endemic-health-care-associated-infection-worldwide

World Health Organization. (2017). Guidelines on Core Components of Infection Prevention and Control Programmes at the National and Acute Health Care Facility Level. https://www.who.int/fr/publications-detail/9789241549929