University of Dundee

Laboratory-confirmed hospital-acquired infections

Iliyasu, Garba; Dayyab, Farouq Muhammad; Abubakar, Salisu; Inuwa, Salisu; Tambuwal, Sirajo Haliru; Tiamiyu, Abdulwasiu Bolaji

Published in:
Heliyon

DOI:
10.1016/j.heliyon.2018.e00720

Publication date:
2018

Document Version
Publisher's PDF, also known as Version of record

Heliyon

Received:
15 March 2018
Revised:
5 July 2018
Accepted:
31 July 2018

Cite as: Garba Iliyasu, Farouq Muhammad Dayyab, Salisu Abubakar, Salisu Inuwa, Sirajo Haliru Tambuwal, Abdulwasiu Bolaji Tiamiyu, Zaiyad Garba Habib, Muktar Ahmed Gadanya, Abdulrahman Abba Sheshe, Muhammad Sani Mijinyawa, Aliyu Aminu, Muhammad Shuaibu Adamu, Kabir Mohammad Mande, Abdulrazaq Garba Habib. Laboratory-confirmed hospital-acquired infections: An analysis of a hospital's surveillance data in Nigeria. Heliyon 4 (2018) e00720. doi: 10.1016/j.heliyon.2018.e00720

Laboratory-confirmed hospital-acquired infections: An analysis of a hospital's surveillance data in Nigeria

Garba Iliyasu [a], **Farouq Muhammad Dayyab** [b,*], **Salisu Abubakar** [c], **Salisu Inuwa** [d], **Sirajo Haliru Tambuwal** [b], **Abdulwasiu Bolaji Tiamiyu** [b], **Zaiyad Garba Habib** [b], **Muktar Ahmed Gadanya** [e], **Abdulrahman Abba Sheshe** [f], **Muhammad Sani Mijinyawa** [a], **Aliyu Aminu** [g], **Muhammad Shuaibu Adamu** [g], **Kabir Mohammad Mande** [b], **Abdulrazaq Garba Habib** [a]

[a] *Department of Medicine, College of Health Sciences, Bayero University Kano, Kano, Nigeria*

[b] *Department of Medicine, Aminu Kano Teaching Hospital, Kano, Nigeria*

[c] *Department of Nursing Sciences, College of Health Science, Bayero University Kano, Kano, Nigeria*

[d] *Infection Control Unit, Department of Nursing Services, Aminu Kano Teaching Hospital, Kano, Nigeria*

[e] *Department of Community Medicine, College of Health Sciences, Bayero University Kano, Kano, Nigeria*

[f] *Department of Surgery, College of Health Sciences, Bayero University Kano, Kano, Nigeria*

[g] *Department of Medical Microbiology and Parasitology, Aminu Kano Teaching Hospital, Kano, Nigeria*

[*] Corresponding author.

E-mail address: farouqmuhd@yahoo.com (F.M. Dayyab).

Abstract

Objective: Hospital-acquired infections (HAI) are a global problem and a major public health concern in hospitals throughout the world. Quantification of HAI is needed in developing countries; hence we describe the results of a 2-year surveillance data in a tertiary hospital in Nigeria.

Methodology: This study is a 2-year review using secondary data collected at a tertiary referral center in northwestern Nigeria. The data was collected using surveillance forms modeled based on the Centre for Disease Control (CDC) protocol. Descriptive statistics were used to present results as frequencies and percentages.

https://doi.org/10.1016/j.heliyon.2018.e00720

Result: 518 patients developed HAI out of 8216 patients giving an overall prevalence of 6.3%. The mean age of the patients was 35.98 years (±15.92). Males constituted 281 (54.2%). UTI 223 (43.1%) was the most prevalent HAI. Overall, *E. coli* 207 (40.0%) was the most frequent isolates followed by *P. aerugenosa* 80 (15.4%). There was a high prevalence of cloxacillin resistant *S. aureus* (67.9%) and gram-negative rods resistant to third-generation cephalosporins. Trimethoprim-sulfamethoxazole resistance across the board was more than 90%.
Conclusion: There is a high burden of HAI especially UTI in our hospital with resistance to commonly used antibiotics documented.

Keywords: Public health, Infectious disease

1. Introduction

Hospital-acquired infections (HAI) are a global problem and a major public health concern in hospitals throughout the world. Mostly caused by multi drug resistance (MDR) organisms, HAI significantly contributes to increased morbidity, mortality, and hospital cost [1, 2, 3]. HAI is also a major global safety concern for both patients and health-care professionals [4, 5].

In developed countries, HAI rates of 5% to 15%, sometimes up to 50%, have been reported among hospitalized patients in the regular wards and intensive care units (ICUs) respectively [6, 7]. In developing countries, the problem is likely much higher, and yet, the magnitude of the problem remains underestimated or even unknown largely because HAI diagnosis is complex and surveillance activities which requires expertise and resources, are lacking in most of these countries [8]. Furthermore, infection control practices remain rudimentary as most hospitals lack effective infection control programs and trained professionals [9].

Quantification of HAI is needed through an effective surveillance system in developing countries to understand the burden and help to justify resources dedicated to infection control. We describe the results of a 2-year surveillance data including bacterial etiologic agent and antimicrobial resistance in a major tertiary hospital in northwestern Nigeria.

2. Materials and methods

This study is a 2-year review using secondary data collected from January 2012 to January 2014 at a tertiary referral center in northwestern Nigeria. The hospital has a total bed capacity of 500 and provides a tertiary level care to a mixed population of patient comprising urban, semi-urban and rural population It has several clinical departments including Medicine, Surgery, Pediatrics, Obstetrics and Gynecology with the full support of well-equipped laboratories. It serves as a referral center

https://doi.org/10.1016/j.heliyon.2018.e00720

to neighboring states in the northwestern Nigeria with an estimated population of over thirty five million people. Since the establishment of the hospital's infection control committee, the HAI surveillance team comprising of trained infection control nurses take a daily round to take a point prevalence of HAI (defined as onset of infection after 48 hours of admission which was not present and without evidence of incubation at the time of admission to the hospital) in all the wards of the hospital. Data was collected using modified surveillance forms modeled after the Centre for Disease Control (CDC) protocol [10] which contained essential identifying data like age, sex, hospital identification number, wards or location within the hospital, service, and date of admission. Others are the date of infection, site of infection and the organism(s) isolated from the specimen and antimicrobial susceptibility pattern of the isolates. These are further analyzed quarterly to generate data for the overall frequency and distribution pattern of HAI in our hospital. A record of this data sheets from January 2012 to January 2014 was collected from the committee, and the data was extracted using a questionnaire which was administered retrospectively. Infections developing after discharge were not captured and acute care units (Emergency units and Labour wards) were also excluded. Patients with clinical record of suspected HAI without microbiologic confirmation were excluded. Patients who were on admission not because of an infection and have stayed on admission for at least 48 hours were considered as the total number of admissions during the study period.

Relevant specimen(s) depending on the HAI clinical syndrome were collected appropriately and delivered to the laboratory. Standard bacteriologic methods using conventional culture media including MacConkey agar, blood agar and chocolate agar incubated overnight under different necessary conditions were employed to isolate causative pathogens. Depending on the gram staining reaction, differential biochemical tests such as catalase test or oxidase test and other phenotypic characteristics such as, colony color, pigment production, odor and motility were used to identify the isolate(s). In line with Clinical and Laboratory Standards Institute (CLSI) guidelines [11], isolates were tested against a full spectrum of antibiotic groups using disk diffusion technique.

The information from the questionnaires was initially entered into excel sheet and subsequently exported and analyzed using STATA SE version 12.1 (Stata Corp., College Station, TX). Descriptive statistics were used to present results as frequencies and percentages. Chi-square tests and relative risks were computed to describe associations. A p-value less than 0.05 was considered statistically significant.

Ethical approval to conduct the study was obtained from the ethics committee of the Hospital with reference number NHREC/21/08/2008/AKTH/EC/1994.

https://doi.org/10.1016/j.heliyon.2018.e00720

3. Results

A total of 518 patients developed HAI out of 8216 patients who were on admissions during the study period, giving an overall prevalence of 6.3%. The mean age of the patients was 35.98 years (±15.92) with males constituting 281 (54.2%, Table 1). Majority of the patients were on admission following surgery 103 (19.9%), followed by diabetic complications 61 (11.8%) and chronic kidney disease (CKD) 54 (10.4%). Table 1, shows the distribution of HAI syndrome, with urinary tract infection (UTI) 223 (43.1%) been the most prevalent followed by soft tissue infection 177 (34.2%) and surgical site infections (SSI) 94 (18.1%). The frequency of the infections in each of the ward is shown in Table 2, ICU recorded the highest prevalence followed by surgical ward, while paediatric ward had the least prevalence. Overall

Table 1. Demographic and clinical characteristics of the patients.

Variables	**n = 518**
Age (Mean)	35.98 years (±15.92)
Gender	N (%)
Male	281 (54.2)
Female	237 (45.8)
Admission diagnoses	N (%)
Diabetes	61 (11.8)
Chronic kidney disease (CKD)	54 (10.4)
Human immunodeficiency virus (HIV) infection	28 (5.4)
Cerebrovascular disease (CVD)	37 (7.1)
Chronic heart disease	19 (3.7)
Post-surgery	103 (19.9)
Solid tumours	36 (6.9)
Leukaemias	10 (1.9)
Trauma	37 (7.1)
Burns	31 (6.0)
Renal transplants	4 (0.8)
Pre-term	41 (7.9)
Protein energy malnutrition (PEM)	13 (2.5)
Tuberculosis	26 (5.0)
Others	18 (3.5)
Site of hospital-acquired infection	N (%)
Soft tissue	177 (34.2%)
Nosocomial pneumonia	14 (2.7%)
Blood stream infection	10 (1.9%)
Urinary tract infection	223 (43.1%)
Surgical site infection (SSI)	94 (18.1%)

https://doi.org/10.1016/j.heliyon.2018.e00720

Table 2. Prevalence of HAI by hospital ward.

Ward	Number of patients	Number of infections (%)
Surgical ward	2602	236 (9.1)
Medical ward	2714	180 (6.6)
Obstetrics and gynaecology	1360	45 (3.3)
Paediatrics ward	1087	27 (2.5)
Intensive care unit	202	23 (11.4)
Special care baby unit	250	7 (2.8)

Escherichia coli 207 (40.0%) was the most frequent isolates followed by *Pseudomonas aeruginosa* 80 (15.4%) while *Staphylococcus aureus* and *Proteus* spp. were isolated with equal frequency 78 (15.1%), (Table 3). Among patients with nosocomial pneumonia and blood stream infection, *K. pneumoniae* and *E. coli* were the most frequent isolates respectively. *S. aureus* was the commonest isolates in patients with soft tissue infection and surgical site infection (Table 3). The highest number of blood stream infections were recorded in the intensive care unit (ICU) followed by the special care baby unit (SCBU), while most of the cases of nosocomial pneumonia were seen in the medical ward. Furthermore, soft tissue infections and SSI were most frequent in the surgical ward (Table 4). Table 5 shows the distribution of the isolates according to the site of infection, the majority of the *P. aeruginosa* isolates 3 (21.4%) were in patients with hospital-acquired pneumonia, while, 69 (49.4%) of the *S. aureus* isolates was in patients with surgical site infection (SSI) and soft tissue infection combined. The only 2 enterococcal isolates were in patients with UTI and one case of *Streptococcus pneumoniae* SSI was seen.

Tables 6 and 7 shows the resistance pattern of gram negative and gram positive isolates respectively. The highest proportions of resistance among the Enterobacteriaceae isolates were observed against amoxicillin/clavulanic acid and trimethoprim-sulfamethoxazole. Resistance to trimethoprim-sulfamethoxazole across the board

Table 3. Distribution of the identified nosocomial pathogens.

Isolates n = 518	N (%)
Proteus spp.	78 (15.1)
Pseudomonas aeruginosa	80 (15.4)
Staphylococcus aureus	78 (15.1)
Klebsiella pneumonia	65 (12.5)
Escherichia coli	207 (40.0)
Citrobacter freundii	1 (0.2)
Streptococcus pyogenes	5 (1.0)
Streptococcus pneumonia	2 (0.4)
Enterococcus spp.	2 (0.4)

https://doi.org/10.1016/j.heliyon.2018.e00720

Table 4. Infection site by ward.

Ward	n (%) of infection				
	Soft tissue n = 177	Pneumonia n = 14	Blood stream n = 10	UTI n = 223	SSI n = 94
Surgical ward	98 (55.4)	1 (7.1)	1 (10.0)	62 (27.8)	74 (78.7)
Medical ward	47 (26.6)	10 (71.4)	2 (20.0)	121 (54.3)	0 (0.0)
Obstetrics and Gynecology	15 (8.5)	2 (14.3)	0 (0.0)	12 (5.4)	16 (17.0)
Pediatrics ward	9 (5.1)	1 (7.1)	0 (0.0)	17 (7.6)	0 (0.0)
ICU	7 (4.0)	0 (0.0)	4 (40.0)	11 (4.9)	1 (1.1)
SCBU	1 (0.6)	0 (0.0)	3 (30.0)	0 (0.0)	3 (3.2)

UTI- Urinary Tract Infection, SSI- Surgical Site Infection, ICU- Intensive Care Unit, SCBU- Special Care Baby Unit.

was over 90%. However, ciprofloxacin and gentamicin fared better with resistance rate of 21.3% and 28.7% respectively across the Enterobacteriaceae isolates. Although fewer isolates was tested against colistin and meropenem, sensitivity was 100% among gram-negative bacilli. Resistance to cloxacillin among the *S. aureus* isolates was 67.2%, while resistance to ciprofloxacin, chloramphenicol, and clindamycin was 11 (15.1%), 13 (18.1%) and 13 (20.6%) respectively.

4. Discussion

The overall prevalence of HAI in this study was 6.3%, with the ICU having the highest prevalence. Urinary tract infection was the commonest infection seen followed by soft tissue infection, while overall *E. coli* was the most frequent isolates.

Table 5. Frequency of the isolates by infection site.

Isolates	n (%) of infection				
	Soft tissue n = 177	pneumonia n = 14	Blood stream n = 10	UTI n = 223	SSI n = 94
Proteus spp.	32 (18.1)	0 (0.0)	0 (0.0)	33 (14.8)	13 (13.8)
P. aeruginosa	28 (15.8)	3 (21.4)	1 (10.0)	36 (16.1)	12 (12.8)
S. aureus	48 (27.1)	1 (7.1)	2 (20.0)	6 (2.7)	21 (22.3)
K. pneumonia	21 (11.9)	5 (35.7)	1 (10.0)	33 (14.8)	5 (5.3)
E. coli	46 (26.0)	2 (14.3)	3 (30.0)	114 (51.1)	42 (44.7)
C. freundii	0 (0.0)	0 (0.0)	0 (0.0)	1 (0.4)	0 (0.0)
S. pyogenes	0 (0.0)	3 (21.4)	2 (20.0)	0 (0.0)	0 (0.0)
S. pneumonia	0 (0.0)	0 (0.0)	1 (10.0)	0 (0.0)	1 (1.1)
Enterococcus spp.	0 (0.0)	0 (0.0)	0 (0.0)	2 (0.9)	0 (0.0)

SSI- Surgical Site Infection, UTI- Urinary Tract Infection.

https://doi.org/10.1016/j.heliyon.2018.e00720

Table 6. Resistance patterns of gram negative bacterial isolates to main antimicrobial agents.

Isolates	Number of isolates resistant/number of isolates tested (%)								
	Chloramphenicol	**Gentamicin**	**Ceftriaxone**	**Ciprofloxacin**	**TPM/SMX**	**Ceftazidime**	**AMC/CLV**	**Meropenem**	**Colistin**
Proteus spp.	15/67 (22.4)	21/66 (31.8)	37/63 (58.7)	13/67 (19.4)	56/65 (86.2)	34/60 (56.7)	48/70 (68.6)	0/15 (0.0)	0/24 (0.0)
P. aeruginosa	7/16 (43.8)	10/54 (18.5)	N	19/75 (25.3)	N	2/21 (9.5)	N	0/6 (0.0)	0/25 (0.0)
K. pneumonia	11/56 (19.6)	21/63 (33.3)	46/65 (70.8)	10/60 (16.8)	58/63 (92.1)	19/34 (55.9)	48/64 (75.0)	0/9 (0.0)	0/8 (0.0)
E. coli	23/110 (20.9)	58/203 (28.6)	156/207 (75.4)	43/198 (21.7)	81/86 (94.2)	35/61 (57.3)	161/202 (79.7)	0/21 (0.0)	0/50 (0.0)
C. freundii	N	1/1 (100.0)	N	N		0/1 (0.0)	1/1 (100.0)		0/1 (0.0)

N- Not tested, TPM/SMX- Trimethoprim-Sulphamethoxazole, AMC/CLV- Amoxycillin-Clavulanic Acid.

https://doi.org/10.1016/j.heliyon.2018.e00720

Table 7. Resistance patterns of gram positive bacterial isolates to main antimicrobial agents.

Isolates	Number of isolates resistant/number of isolates tested (%)								
	Chloramphenicol	**Gentamicin**	**Ceftriaxone**	**Ciprofloxacin**	**TPM/SMX**	**AMC/CLV**	**Amoxycillin**	**Cloxacillin**	**Clindamycin**
S. aureus	13/72 (18.1)	26/71 (36.6)	61/78 (78.2)	11/73 (15.1)	75/78 (96.2)	45/66 (68.1)	52/73 (71.2)	53/78 (67.9)	13/63 (20.6)
S. pyogenes	0/2 (0.0)	N	0/5 (0.0)	0/2 (0.0)	N	0/5 (0.0)	0/5 (0.0)	0/5 (0.0)	0/1 (0.0)
S. pneumonia	0/2 (0.0)	0/2 (0.0)	0/2 (0.0)	1/2 (0.0)	2/2 (100.0)	0/2 (0.0)	0/2 (0.0)	1/1 (100.0)	0/1 (0.0)
Enterococcus spp.	N	0/2 (0.0)	N	1/2 (50.0)	2/2 (100.0)	N	0/2 (0.0)	N	N

N- Not tested, TPM/SMX- Trimethoprim-Sulphamethoxazole, AMC/CLV- Amoxycillin-Clavulanic Acid.

https://doi.org/10.1016/j.heliyon.2018.e00720

However, in soft tissue infection, SSI and bacteremia, *S. aureus* was the commonest isolate. The high rate of resistance to commonly used antibiotics was documented.

The HAI prevalence of of 6.3% reported in this study is higher than 2.5%−3.5% reported by retrospective studies of HAI in southwestern Nigeria over the period of 1995−2009 [12, 13, 14] but much lower than the 34-14% and 17.9% reported in Uganda and Tunisia respectively [14, 15]. This high discrepancy may be due to differences in the methodologies adopted, hospitals infection control prevention (ICP) and the time gap between these studies. We found the highest prevalence of HAI in the ICU at 23%. Other previous studies in Nigeria reported a prevalence of 15% [12, 13] and 11.8% [16, 17] his can be attributed to a more susceptible patient population, use of broad-spectrum antimicrobial agents and frequent use of invasive devices in an ICU setting.

The findings of UTI as the most common type of HAI is in keeping with the reported figure of 43.9% in a previous study in Nigeria [17] and 48.2% in the Benin Republic [18]. However, a point prevalence study in Ethiopia, as well as a systematic review in sub-Saharan African countries comprising mostly studies from surgical wards, reported SSI as the most prevalent HAI [19, 20]. Similarly, in this study, most of the SSI and skin and soft tissue infections occurred in the surgical ward. Contrary to reports from other studies [21, 22], pneumonia and blood stream infections did not feature prominently in this study, likely because of infrequent use of central intravenous catheters and mechanical ventilators, making urinary catheters the most commonly used invasive device and hence the high prevalence of UTI [22,23,24]. Therefore, infection control programs in our health care facilities must implement and monitor strategies to limit catheter-acquired urinary infection, including surveillance of catheter use, appropriateness of catheter indications, and complications.

As in several other studies in Nigeria, gram-negative rods were the most frequent isolates in this study. Although *E. coli* was the most frequent isolate in our hospital Afolabi *et al.,* [12] and Ige *et al.*, [17] reported *K. pneumonia*, while Onipede *et al.*, [13] reported *P. aeruginosa* as the most frequent isolates. This finding is not surprising as gram-negative rods have been commonly associated with HAIs [25, 26]. *S. aureus* was also the most frequent isolates in the skin and soft tissue infection and SSI, similar to other studies in Nigeria [12, 13, 17]. This is also similar to the findings in Brazil [27], India [28], Taiwan [29], Ethiopia [30], and the United States [31]. We found only 2 (0.04%) cases of *S. pneumoniae* associated HAI, with one been SSI. In agreement with this finding *S. pneumoniae* has been reported to be a rare cause of HAI, and rarely cause SSI. In fact, the first case of SSI caused by *S. pneumoniae* was only reported in 1994 [32, 33].

Although extended-spectrum beta-lactamase (ESBL) testing was not routine in our hospital during the study period, high rate of resistance among the

https://doi.org/10.1016/j.heliyon.2018.e00720

Enterobacteriaceae isolates to the tested third-generation cephalosporins was observed. Therefore this suggests the probable high burden of ESBL pathogens in our hospital. The rate of *S. aureus* isolates resistant to cloxacillin was alarming and suggests a high burden of MRSA. Previously in the same hospital, we reported a high prevalence of cloxacillin resistant *S. aureus* and gram-negative rods resistant to third-generation cephalosporin [16, 34]. This pattern of resistance is also similar to what has been reported by Ohoye *et al.* in the Benin Republic [18]. The availability of all classes of antibiotic as over the counter drugs in Nigeria has fueled misuse of these drugs among the public. This coupled with the inappropriate use of antibiotics in our hospitals due to lack of antibiotic stewardships program in most of these hospitals, may be directly connected to the pattern of resistance seen in this study as well as other studies in Nigeria. High cost and unavailability of the carbapenems and colistin in Nigeria means these drugs are out of reach of most patients, hence, less likely to be abused. Therefore, this explains the excellent sensitivity of meropenem and colistin seen in this study. Of note chloramphenicol which is an old and cheap drug showed relatively good sensitivity profile among all the isolates. This is likely because of a decline in the rate of misuse of chloramphenicol following the emergence of MDR salmonella and availability of cheaper generic quinolones.

Giving the retrospective nature of the study and limited infection control resources in our hospital, it is likely that the actual burden of HAI may have been substantially underestimated. Also, HAI that developed after hospital discharge would have been missed. Lack of routine screening for MRSA, Vancomycin Resistant *S. aureus* (VRSA), Vancomycin Resistant *Enterococci* (VRE) and extended-Spectrum beta-Lactamases is another limitation. However, high prevalence of cloxacillin resistant *S. aureus* and gram-negative rods resistant to third generation cephalosporin indirectly reflect the high burden of MRSA and ESBL producing Enterobacteriaceae respectively. Length of hospital stay and some co-morbidities that are important risk factors for HAI were not captured. It is also unclear whether the findings of this single center study are generalizable nation wide. Despite these limitations, our study presents detailed assessment of the burden of HAI in north-west Nigeria that will serve as a useful reference for surveillance and monitoring trends.

Previously, we have reported on the poor infection control practices in our hospital [35]. This is further confounded by overcrowding in hospitals with relatives having to take up temporary residence in the hospital to provide food, care, and comfort, therefore, impeding interruption of HAI transmission [36, 37]. Hence we strongly recommend policy change in the hospital to impose implementation of ICP protocol. Both at the local and national level, there is a need for antibiotic policy. Eventually, this may lead to having an effective antibiotic stewardship program in our hospitals.

https://doi.org/10.1016/j.heliyon.2018.e00720

Conclusion

The findings of this study highlight the high burden of HAI especially UTI in our hospital with resistance to commonly used antibiotics also documented. This is a cause for concern considering the unavailability and high cost of the alternative antibiotics in this resource-limited country. There is a need for effective antibiotic stewardship program in our hospitals and prospective nationwide HAI surveillance to monitor the burden and trends of HAI in Nigeria.

Declarations

Author contribution statement

Garba Iliyasu, Farouq M Dayyab, Abdulrazaq Garba Habib: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Salisu Abubakar, Salisu Inuw, Sirajo Haliru Tambuwal, Abdulwasiu Bolaji Tiamiyu, Zaiyad Garba Habib, Abdulrahman Abba Sheshe: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Muktar Ahmed Gadanya, Muhammad Sani Mijinyawa, Aliyu Aminu, Muhammad Shuaibu Adamu, Kabir Mohammad Mande: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Funding statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Competing interest statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

Acknowledgements

We acknowledge all members of the infection control committee of the hospital.

 https://doi.org/10.1016/j.heliyon.2018.e00720

References

[1] C. Geffers, P. Gastmeier, Nosocomial infections and multidrug-resistant organisms in Germany: epidemiological data from HISS (the Hospital Infection Surveillance System), Dtsch. Ärztebl. Int. 108 (6) (2011) 87–93.

[2] B. Allegranzi, D. Pittet, Preventing infections acquired during health-care delivery, Lancet 372 (2008) 1719–1720.

[3] D. Pittet, L. Donaldson, Clean care is safer care: a worldwide priority, Lancet 366 (2005) 1246–1247.

[4] J.P. Burke, Infection control – a problem for patient safety, N. Engl. J. Med. 348 (2003) 651–656.

[5] D.W. Bates, I. Larizgoitia, N. Prasopa-Plaizier, A.K. Jha, Global priorities for patient safety research, BMJ 338 (2009) b1775.

[6] WHO Guidelines on Hand Hygiene in Health Care, World Health Organization, Geneva, 2009.

[7] J.L. Vincent, J. Rello, J. Marshall, et al., EPIC II Group of Investigators, An international study of the prevalence and outcomes of infection in intensive care units, JAMA 302 (2009) 2323–2329.

[8] B. Allegranzi, S. Bagheri Nejad, C. Combescure, et al., Burden of endemic health-care-associated infection in developing countries: systematic review and meta-analysis, Lancet 377 (2011) 228–241.

[9] S.O. Samuel, O.O. Kayode, O.I. Musa, et al., Nosocomial infections and the challenges of control in developing countries, Afr. J. Clin. Exp. Microbiol. 11 (2) (2010) 102–110.

[10] C.E. Starling, B.R. Couto, S.M. Pinheiro, Applying the centre for disease control and prevention and national surveillance system methods in Brazilian hospital, Am. J. Infect. Contr. 25 (1997) 303–311.

[11] Clinical and Laboratory Standard Institute (CLSI), Performance Standards for Antimicrobial Susceptibility Testing: Sixteenth Informational Supplement, CLSI document M100-S16, CLSI, Wayne, PA, 2006.

[12] O.T. Afolabi, A.O. Onipede, S.K. Omotayo, et al., Hospital acquired infection in Obafemi Awolowo University Teaching Hospital, Ile-Ife, Southwest, Nigeria: a ten year review (2000–2009), Sierra Leone J. Biomed. Res. 3 (2) (2011) 110–115.

 https://doi.org/10.1016/j.heliyon.2018.e00720

[13] A.O. Onipede, C.O. Oluyede, A.O. Aboderin, et al., A survey of hospital acquired infections in Obafemi Awolowo University Teaching Hospital Complex, Ile-Ife, Afr. J. Clin. Expert Microbiol. 5 (1) (2004) 108−116.

[14] M. Ogwang, D. Paramatti, T. Molteni, et al., Prevalence of hospital-associated infections can be decreased effectively in developing countries, J. Hosp. Infect. 84 (2) (2013) 138−142.

[15] H. Kallel, M. Bahoul, H. Ksibi, et al., Prevalence of hospital-acquired infection in a Tunisian hospital, J. Hosp. Infect. 59 (4) (2005) 343−347.

[16] G. Iliyasu, F.M. Daiyab, A.B. Tiamiyu, S. Abubakar, Z.G. Habib, A.M. Sarki, A.G. Habib, Nosocomial infections and resistance pattern of common bacterial isolates in an intensive care unit of a tertiary hospital in Nigeria: a 4-year review, J. Crit. Care 34 (2016) 116−120.

[17] O.K. Ige, A.A. Adesanmi, M.C. Asuzu, Hospital-acquired infections in a Nigerian tertiary health facility: an audit of surveillance reports, Niger. Med. J. 52 (2011) 239−243.

[18] T.A. Ahoyo, H.S. Bankole, F.M. Adeoti, et al., Prevalence of nosocomial infections and anti-infective therapy in Benin: results of the first nationwide survey in 2012, Antimicrob. Resist. Infect. Contr. 3 (2014) 17.

[19] W.W. Yallew, A.K. Takele, F.M. Yehuala, Point prevalence of hospital-acquired infections in two teaching hospitals of Amhara region in Ethiopia, Drug Healthc. Patient Saf. 8 (2016) 71−76.

[20] S. Bagheri Nejad, B. Allegranzi, S.B. Syed, B. Ellis, D. Pittet, Health-care-associated infection in Africa: a systematic review, Bull. World Health Organ. 89 (2011) 757−765.

[21] R. Azzam, M. Dramaix, A one-day prevalence survey of hospital-acquired infections in Lebanon, J. Hosp. Infect. 49 (2001) 74−78.

[22] A. Gikas, J. Pediaditis, J.A. Papadakis, et al., Prevalence study of hospital-acquired infections in 14 Greek hospitals: planning from the local to the national surveillance level, J. Hosp. Infect. 50 (2002) 269−275.

[23] S. Singh, Y. Pandya, R. Patel, M. Paliwal, A. Wilson, S. Trivedi, Surveillance of device-associated infections at a teaching hospital in rural Gujarat-India, Indian J. Med. Microbiol. 28 (2010) 342−347.

[24] L.E. Nicolle, Catheter-associated urinary tract infections, Antimicrob. Resist. Infect. Contr. 3 (2014) 23.

 https://doi.org/10.1016/j.heliyon.2018.e00720

[25] G. Robert, J.R. Edwards, Overview of nosocomial infections caused by gram-negative bacilli, Clin. Infect. Dis. 41 (2005) 848−854.

[26] A.K. Zaidi, W.C. Huskins, D. Thaver, Z.A. Bhutta, Z. Abbas, D.A. Goldmann, Hospital-acquired neonatal infections in developing countries, Lancet 365 (2005) 1175−1188.

[27] M.V. Arnoni, E.N. Berezin, M.D. Martino, Risk factors for nosocomial bloodstream infection caused by multidrug-resistant gram-negative bacilli in pediatrics, Braz. J. Infect. Dis. 11 (2007) 267−271.

[28] A. Jain, A.K. Awasthi, M. Kumar, Etiological and antimicrobial susceptibility profile of nosocomial blood stream infection in neonatal intensive care unit, Indian J. Med. Res. 25 (2007) 299−306.

[29] C.J. Wu, H.C. Lee, N.Y. Lee, H.I. Shih, N.Y. Ko, L.R. Wang, W.C. Ko, Predominance of Gram-negative bacilli and increasing antimicrobial resistance in nosocomial bloodstream infections at a university hospital in southern Taiwan, 1996−2003, J. Microbiol. Immunol. Infect. 39 (2006) 135−143.

[30] R.E. Mengesha, B.G.-S. Kasa, M. Saravanan, D.F. Berhe, A.G. Wasihun, Aerobic bacteria in post-surgical wound infections and pattern of their antimicrobial susceptibility in Ayder Teaching and Referral Hospital, Mekelle, Ethiopia, BMC Res. Notes 7 (2014) 575.

[31] H. Wisplinghoff, T. Bischoff, S.M. Tallent, H. Seifert, R.P. Wenzel, M.B. Edmond, Nosocomial bloodstream infections in US hospitals: analysis of 24,179 cases from a prospective nationwide surveillance study, Clin. Infect. Dis. 39 (2004) 309−317.

[32] M. Guillet, J.R. Zahar, M.O. Timsit, et al., Horizontal transmission of *Streptococcus pneumoniae* in the surgical ward: a rare source of nosocomial wound infection, Am. J. Infect. Contr. 40 (1) (2012) 71−72.

[33] J.C.C. Torea, M.J. Rolón, M. Grandjean, J.M. Casellas, Surgical-site infection due to *Streptococcus pneumoniae* following laparoscopic cholecystectomy, Clin. Infect. Dis. 19 (4) (1994) 803−804.

[34] G. Iliyasu, F.M. Dayyab, T.A. Bolaji, Z.G. Habib, I.M. Takwashe, A.G. Habib, Pattern of antibiotic prescription and resistance profile of common bacterial isolates in the internal medicine wards of a tertiary referral centre in Nigeria, J. Glob. Antimicrob. Resist. 3 (2) (2015) 91−94.

[35] G. Iliyasu, F.M. Dayyab, Z.G. Habib, A.B. Tiamiyu, S. Abubakar, M.S. Mijinyawa, A.G. Habib, Knowledge and practices of infection control

 https://doi.org/10.1016/j.heliyon.2018.e00720

among healthcare workers in a Tertiary Referral Center in North-Western Nigeria, Ann. Afr. Med. 15 (2016) 34–40.

[36] F. Simon, P. Kraemer, J.J. De Pina, E. Demortiere, C. Rapp, Le risqué nosocomial en Afrique intertropical – Partie 2: Les infections des patients, Med. Trop. 67 (2007) 197–203.

[37] K.A. Western, R.K. St John, L.A. Shearer, Hospital infections control an international perspective, Infect. Contr. 3 (1982) 453–455.

 https://doi.org/10.1016/j.heliyon.2018.e00720