Original Article

An epidemiological study of health-care-associated infections and their antimicrobial sensitivity pattern in the Al-Qassim region of Kingdom of Saudi Arabia

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ABSTRACT

Background: In the USA, up to 2 million health-care-associated infections (HAIs) per year are reported, of which 80,000 are lethal. **Materials and Methods:** This was a hospital-based observational (retrospective) study. **Results:** Hospital-wide rate of HAI ranges from 0.35 to 1.96 per thousand patients per day. The most common organism observed in the last 5 years is *Acenatobacter* (88 [27%]) followed by *Pseudomonas aeruginosa* (73 [22%]). Significant cases in these 5 years were reported from Intensive Care Unit (157 [48%]) followed by medical wards (males and females) (106 [32%]). The common site reported in the present study is catheter-associated urinary tract infection which was significantly higher (CA-UTI) (152 [46%]) followed by ventilator-associated pneumonia (VAP) (66 [20%]). The common organisms reported to cause UTI are *P. aeruginosa* (22%) followed by *Escherichia coli* (19%), and the most common microbial agent associated with VAP is *Acenatobacter baumannii* (48 [72%]) which was found to be significantly higher. The antibiogram of microorganism responsible for HAI was observed, and 56% isolates of *Acinetobacter baumannii* were sensitive to aztreonam followed by imipenem 54%, ceftazidime 47%, and amikacin 36%. Another common organism reported was *P. aeruginosa*, and the majority of isolates of this were sensitive to imipenem 79% followed by amikacin 68%, ceftazidime 53%, aztreonam, and ciprofloxacin 49% and least sensitive to meropenem 9%. Most of the *Klebsiella pneumoniae* strains during the same period were found to be sensitive to imipenem 94% followed by piperacillin/tazobactam 71%, amikacin 69%, cefepime 59%, and ceftriaxone 56% and least sensitive to nitrofurantoin 11% only. **Conclusion:** HAI is a big threat for patients' safety and prolongs patients' stay and cost of health care, so effective utilization of hospital data is crucial for prevention and control.

Key words: Contributing areas, health-care-associated infection, hospital, Intensive Care Unit, microorganism, sensitivity pattern, site of infection

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INTRODUCTION

Health-care-associated infections (HAIs) are the infections that patients acquire during receiving treatment for medical or surgical problems and are the most frequent adverse event that can occur during care delivery process.[1] HAI is a major concern for patient safety and can lead to prolonged hospital stay, long-term disability, increased resistance of microorganisms, an extra financial burden to the health-care system, more costs for patients and their families, and increased mortality.[2,3] HAI is defined as: "An infection occurred in a patient during the process of care in a hospital or other health-care institution which was not present or incubating at the time of admission." This includes infections acquired in the hospital, but appearing after discharge.[4] Many international agencies such as Centers for Disease Control and Prevention (CDC) and WHO work to monitor and prevent these infections because they are a big threat to patient safety and outcome. In India, it has been estimated that around 10%–30% of patients admitted to the hospitals and various nursing homes acquire a nosocomial infection. Surveys were conducted in 183 hospitals in the USA and 4% of HAIs are reported. The most common types were pneumonia (21.8%), followed by surgical-site infections (21.8%) and gastrointestinal infections (17.1%).[5] The study conducted by Horen *et al*. in 2004 about surveillance of nosocomial infections at a Saudi Arabian military hospital observed 32.3% of respiratory tract infection (RTI), 25.7% of urinary tract infection (UTI), and 18.6% of bloodstream infection (BSI).[6] Device-associated infections (i.e., central catheter-associated BSI, catheter-associated-UTI [CA-UTI], and ventilator-associated pneumonia [VAP]), which have traditionally been the focus of programs to prevent HAIs, accounted for 25.6% of such infections. We estimated that there were 648,000 patients with 721,800 HAIs in the U.S. acute care hospitals in 2011; of the 33,848 pathogens reported, 87% were bacteria and 13% were fungi.[6] Over 15% of infections were polymicrobial.[7] The most commonly isolated pathogens were coagulase-negative staphylococci (CoNS), *Staphylococcus aureus*, *Enterococcus* species, *Candida* species, *Escherichia coli*, and *Pseudomonas aeruginosa*. In Europe, 5 million HAI cases per year are reported, of which 50,000 (1%) are lethal and contribute to death in 135,000 cases (2.7%).[8,9] This study was carried out to find the epidemiology of HAI, and with the study findings, we can develop effective intervention/infection control program in our hospital to prevent and control the HAIs.

Objectives

1. To know the epidemiology of HAIs
2. To find the antimicrobial sensitivity pattern of various common microorganisms responsible for HAIs in the hospital.

MATERIALS AND METHODS

The present retrospective study was carried out by Infection Prevention and Control Department of the Al Rass General Hospital, having a capacity of 250 beds with 10 separate beds for Intensive Care Unit (ICU); all types of patients are treated here such as road traffic accident, internal medicine, surgery, orthopedics, neurosurgery, obstetrics, and gynecology, and pediatrics. This hospital-based retrospective observational study was carried out in ICU and various wards of the hospital. All patients admitted in ICU and other wards during the study period for any reasons and develop HAI were taken as a sample and data were collected from laboratory on a daily basis about culture and sensitivity reporting. This study collected data from January 2012 to December 2016, and the data were compiled and analyzed in the period of 3 months from October to December 2016. HAI data were collected by infection control department from ICU and various other departments during surveillance, then according to HAI definition, the collected data were categorized and compiled and monthly submitted to higher authority.

Sample size

All patients admitted during the study period and acquired any types of HAI were taken as a sample. During the study period from 2012 to 2016, a total of 331 cases of HAI were reported. Sampling method: No sampling method was applied and all cases those who develop HAI were taken as sample. Data collection tool: A predesigned and pretested pro forma was used as the data collection tool. Study variables: age, gender, hospital-wide rate, VAP, CLABSI, CA-UTI, SSI, contributing areas, sites of HAI, type of microorganisms, and antibiotic sensitivity patterns.

Data analysis

SPSS version 20 developed by IBM (Armonk, New York, United States) was used for statistical analysis. Statistical tests such as Chi-square test, means, and standard deviation were used. $P \leq 0.05$ was considered statistically significant.

Ethical clearance was obtained from Institutional Review Board, informed written consent was not obtained because there was no direct human subject involvement in the study or intervention, and only secondary data were analyzed from medical records.

Inclusion criteria

HAI cases presented during the study period and fall under CDC definition were included in the study.

Exclusion criteria

Cases that do not fall under CDC definition and not reported during the study periods were excluded from the study.

RESULTS

Figure 1 shows that health care associated infection were in increasing trend from 2012-15, somewhat downtrends reported in 2016 only 54 cases were reported showing a slight decreasing trend for the first time in the last 5 years. Hospital-wide rate of HAI ranged from 0.35 to 1.96 per thousand patients per day in this period. Table 1 shows the common organism observed in the last 5 years: *Acinetobacter baumannii* (88 [27%]) followed by *P. aeruginosa* (73 [22%]), *E. coli* (38 [11%]), *Klebsiella pneumoniae* (34 [10%]), and *Candida* (28 [9%]), and the combined infection rate due to these five organisms was 80%.

Table 2 shows the major contributor of HAI cases in these 5 years in the present study was ICU (159 [48%]) followed by medical wards (males and females) (106 [32%]); if we combined these two areas of our hospital they are the most common contributor of HAI cases in the hospital (265 [80%]), and a highly significant difference was observed ($\chi^2 = 40.6$, $P < 0001$) between ICU and the male medical ward. Table 3 shows that the common site/type reported in the present study was CA-UTI (153 [46%]) followed by VAP and BSI, respectively (66 [20%] and 62 [19%]). Differences between CA-UTI and VAP cases were highly significant ($\chi^2 = 25.7$, $P < 0.0001$). The mean VAP rate in ICU (per 1000 ventilator days) was reported from 2012 to 2016 in range of 2.14-5.1.

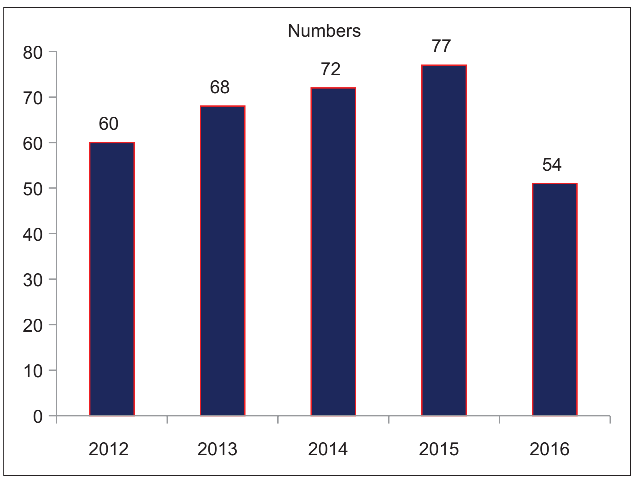

Figure 1: Year-wise number of health-care-associated infection cases reported (2012–2016) in the hospital

Table 4 shows that common organisms reported in UTI were *P. aeruginosa* (22%) followed by *E. coli* (19%), but the difference was not statistically significant, and the most common microbial agent associated with VAP is A. *baumannii* (72%); in other words, Acinetobacter B was significantly associated with VAP cases in comparison to any other organism and the common microbial agents associated with BSI are *Staphylococcus* species (26%) followed by *P. aeruginosa* (22.5%) and A. *baumannii* (21%), but difference was not statistically significant. Figure 2 shows that most common contributing area of HAI in the hospital was ICU followed by medical ward.

The antibiogram of microorganism commonly responsible for HAI was observed, 56% of isolates of A. *baumannii* were sensitive to aztreonam followed by imipenem 54%, ceftazidime 47%, ciprofloxacin 47%, gentamicin 42%, meropenem 40%, and amikacin 36%. The second common organism reported was *P. aeruginosa*, the majority of isolates of this were sensitive to imipenem 79% followed by amikacin 68%, ceftazidime 53%, aztreonam, and ciprofloxacin 49% and least sensitive to meropenem 9%. Most of the *K. pneumoniae* strains during the same period were sensitive to imipenem 94% followed by Pipaeracillin/Tazobactam 71%. The *S. aureus* observed during the study period was most sensitive to Vancomycin 100% followed by gentamicin 75% and least sensitive to penicillin. *E. coli* isolates were most sensitive to nitrofurantoin 100%, followed by imipenem 94%, amikacin 90%, aztreonam 88%, gentamycin, and cefoxitin 78% and least sensitive to cephalothin.

Table 1: Distribution of health-care-associated infection cases according to types of organism isolated from 2012 to 2016

Name of organism	2012 (%)	2013 (%)	2014 (%)	2015 (%)	2016 (%)	Total (%)
P. aeruginosa	15 (25)	13 (19)	13 (18)	20 (26)	12 (24)	73 (22)
A. baumannii	15 (25)	17 (25)	21 (29)	28 (36)	7 (14)	88 (27)
E. coli	9 (15)	8 (12)	8 (11)	3 (4)	10 (18)	38 (11)
S. epidermidis	4 (6.7)	0	1 (1.3)	1 (1.3)	0	6 (2)
Candida spp.	4 (6.7)	10 (15)	5 (7)	5 (6.5)	4 (8)	28 (8.5)
P. mirabilis	3 (5)	5 (7)	4 (5.5)	3 (4)	2 (4)	17 (5)
K. pneumoniae	2 (3.4)	6 (9)	6 (8.3)	8 (10)	12 (24)	34 (10)
S. marcescens	3 (5)	0	0	0	0	3 (1)
S. aureus	1 (1.7)	3 (4)	4 (5.5)	2 (2.6)	6 (8)	16 (4)
S. hominis	1 (1.7)	0	0	0	0	1 (0.3)
S. saprophyticus	1 (1.7)	2 (3)	2 (2.8)	03 (4)	0	8 (2.4)
E. cloacae	1 (1.7)	1 (1.4)	1 (1.3)	0	0	3 (1)
E. faecalis	1 (1.7)	1 (1.4)	6 (8.3)	4 (5)	1 (2)	13 (4)
S. pneumoniae	0	2 (3)	0	0	0	2 (0.6)
S. maltophilia	0	0	1 (1.3)	0	0	1 (0.3)
Total	60 (100)	68 (100)	72 (100)	77 (100)	54 (100)	331 (100)

P. aeruginosa: *Pseudomonas aeruginosa*, *A. baumannii*: *Acinetobacter baumannii*, *E. coli*: *Escherichia coli*, *P. mirabilis*: *Proteus mirabilis*, *S. aureus*: *Staphylococcus aureus*, *K. pneumonia*: *Klebsiella pneumonia*, *E. cloacae*: *Enterobacter cloacae*, *S. marcescens*: *Serratia marcescens*, *S. saprophyticus*: *Staphylococcus saprophyticus*, *E. faecalis*: *Enterococcus faecalis*, *S. epidermidis*: *Staphylococcus epidermidis*, *S. pneumonia*: *Streptococcus pneumonia*, *S. hominis*: *Staphylococcus hominis*, *S. maltophilia*: *Stenotrophomonas maltophilia*

Table: 2 Distribution of health-care-associated infection cases according to department/wards from 2012 to 2016

Hospital wards/area	2012 (%)	2013 (%)	2014 (%)	2015 (%)	2016 (%)	Total (%)
ICU	30 (50)	35 (51.5)	35 (48.6)	34 (44)	25 (46)	159 (47.9)
Neonatal - ICU	5 (8.4)	4 (5.9)	2 (2.8)	9 (11.7)	2 (3.7)	25 (7.6)
Male medical	8 (13.4)	13 (19)	13 (18)	11 (14.3)	7 (13)	52 (15.9)
Female medical	10 (16.7)	8 (11.8)	12 (16.7)	13 (17)	11 (20.5)	54 (16.5)
Male surgical	1 (1.7)	4 (5.9)	5 (6.9)	3 (3.9)	2 (3.7)	15 (4.5)
Female surgical	0	0	0	1 (1.3)	1 (1.85)	1 (0.3)
Artificial kidney unit	1 (1.7)	2 (2.9)	3 (4)	1 (1.3)	1 (1.85)	8 (2.4)
Male ortho	3 (5)	1 (1.5)	0	2 (2.6)	2 (3.7)	8 (2.4)
Gynecology	1 (1.7)	1 (1.5)	2 (2.8)	3 (3.9)	2 (3.7)	8 (2.7)
Pediatrics	1 (1.7)	0	0	0	1 (1.85)	1 (0.3)
Total	60 (100)	68 (100)	72 (100)	77 (100)	54 (100)	331 (100)

ICU: Intensive Care Unit

Table 3: Distribution of health-care-associated infection cases according to site of infection or system involved from 2012 to 2016

Site of infection or system involved	*n* (%)
RTI	12 (3.6)
CAUTI	153 (46.5)
BSI	61 (18.4)
Umbilical venous catheter - BSI	2 (0.6)
SSI	29 (8.76)
VAP	66 (20)
Hospital-acquired pneumonia	8 (2.8)
Total	331 (100)

VAP: Ventilator-associated pneumonia, SSI: Surgical-site infection, BSI: Bloodstream infection, RTI: Respiratory tract infection, CAUTI: Catheter-associated urinary tract infection

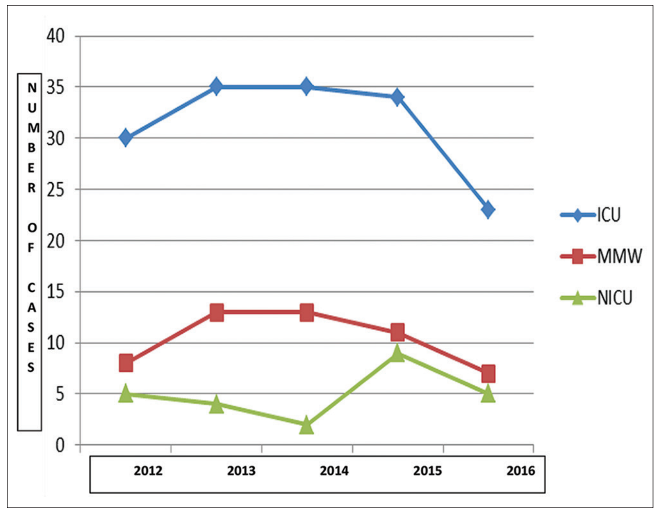

Figure 2: Comparative Distribution of health-care-associated infection cases from the hospital (2012–2016) in the Intensive Care Unit, Neonatal Intensive Care Unit, and medical ward

DISCUSSION

The present study was carried out in the Al Rass General Hospital of Al Qassim region of Saudi Arabia to know the pattern of various HAIs and their sensitivity pattern (antibiogram) was studied. The study conducted by Moataz *et al*. in 2004 about the surveillance of nosocomial infections at a Saudi Arabian military hospital observed 32.3% RTI, 25.7% UTI, and 18.6% BSI. In the present study, CA-UTI observed more than above study 46.3%, the difference may be due to different setting.[10] According to the type of organism reported in the study, *E. coli* 22.3% was the most common organism followed by *P. aeruginosa* 17.6% and K. *pneumoniae* 9.9%. In the present study, the most common Gram-negative organism was A. *baumannii* (27%) followed by *P. aeruginosa* (22%).[10] In a study done by Mahmoud Abu Saud regarding the prevalence of nosocomial infection in Saudi Arabian teaching hospitals, the most common site observed was UTI followed by wound and umbilical cord (133, 48, and 18, respectively). In the present study also, the common site reported was UTI.[11] A study done by Al Tawfiq et al. in Saudi Arabia regarding HAI perspectives and fatality rate and fatality reported in the range of 2.3 to 14.4%, in the present study we not calculated fatality rate due to HAIs.[12] The another study conducted by Abdraboh SN about role of hand hygiene in control of HAIs and concluded hand hygiene improvement is affordable measure to control HAIs.[13] Klevens *et al*. in 2002 who conducted a study in America about estimating HAI and deaths found an estimated number of HAI 1.7 million and 98,987 deaths; in the present study, we estimated the total number of HAI in our hospital was 331 and deaths were not calculated, and the difference in number may be due to the sample size.[14] The systemic review done by Buhl *et al* regarding *P. aeruginosa* and its microbial resistance pattern, in the present study we also found second most common organism in our hospital environment with drug resistance.[15]

The study conducted by Bonelli RR about antimicrobial resistance among Enterobacteriaceae and another study done by Yasmin *et al* about epidemiology of BSIs caused by methicillin-resistant *Staphylococcus aureus* at a tertiary care hospital in New York found that the resistance rate of *S. aureus* to most drugs, including oxacillin, tetracycline, erythromycin, clindamycin, gentamicin, and ciprofloxacin, showed a tendency to decrease and there were no S. aureus strains resistant to linezolid and vancomycin; in the present we also observed same.[16,17] The study conducted by Moreira *et al*. regarding antimicrobial use, incidence, etiology, and resistance patterns in bacteria causing VAP, we also observed same.[18] Another research done by Joseph *et al*. regarding

Table 4: Distribution of health-care-associated infection cases according to site of infection or system involved and types of microorganism from 2012 to 2016

Site of infection	Microorganism	*n* (%)
RTI	*P. aeruginosa*	7 (59)
	A. baumannii	5 (41)
CAUTI	*P. aeruginosa*	34 (22)
	E. coli	30 (19.5)
	Candida	21 (14)
	P. mirabilis	14 (9)
	E. faecalis	14 (9)
	A. baumannii	9 (5.8)
	S. saprophyticus	9 (5.8)
BSI	*Staphylococcus*	17 (26.5)
	P. aeruginosa	14 (22.5)
	A. baumannii	13 (21)
	K. pneumoniae	8 (13)
	P. mirabilis	2 (3.2)
	Candida	2 (3.2)
	S. marcescens	2 (3.2)
	E. coli	2 (3.2)
SSI	*P. aeruginosa*	8 (28.5)
	A. baumannii	4 (14.3)
	E. coli	4 (14.3)
	S. aureus	3 (11)
	P. mirabilis	2 (7)
	E. cloacae	2 (7)
	Serratia	1 (3.5)
	Candida	1 (3.5)
	Klebsiella	1 (3.5)
VAP	*A. baumannii*	47 (72)
	P. aeruginosa	12 (20)
	K. pneumoniae	2 (3)
	S. pyogenes	1 (1.5)
	S. aureus	1 (1.5)
Hospital-acquired pneumonia	*A. baumannii*	4 (50)
	P. aeruginosa	4 (50)
Total		331 (100)

VAP: Ventilator-associated pneumonia, SSI: Surgical-site infection, BSI: Bloodstream infection, RTI: Respiratory tract infection, CAUTI: Catheter-associated urinary tract infection, *P. aeruginosa*: *Pseudomonas aeruginosa*, *A. baumannii*: *Acinetobacter baumannii*, *E. coli*: *Escherichia coli*, *P. mirabilis*: *Proteus mirabilis*, *S. aureus*: *Staphylococcus aureus*, *S. pyogenes*: *Streptococcus pyogenes*, *K. pneumonia*: *Klebsiella pneumonia*, *E. cloacae*: *Enterobacter cloacae*, *S. marcescens*: *Serratia marcescens*, *S. saprophyticus*: *Staphylococcus saprophyticus*, *E. faecalis*: *Enterococcus faecalis*

the relationship between antimicrobial consumption and the incidence of antimicrobial resistance in *E. coli* and *K. pneumoniae* isolates observed that *E. coli* isolates showed high resistance for increased use of gentamicin and ciprofloxacin.[19] The study conducted by Tao et al., about device-associated infection rates, overall rate of HAI to be 5.3% and 6.4 infections per 1000 ICU days and the same type of finding was also reported in the present study.[20] Study done by Xie and Xiong regarding point prevalence survey the most common type (64.7%) of HAIs, was RTI followed by UTIs (12.6%) and BSIs (5.4%), in the present study CAUTI was most common.[21,22] HAI occurrences were significantly associated with male sex and age over 85 years. Gram-negative bacteria were found to be the most common (67.1%), with Gram-positive bacteria and fungi reported for 20.3% and 10.5%, respectively. In the present study, we observed little lower prevalence than the above study and the most common type of HAI was CA-UTI in our setting, and the difference may be due to the change of area.[21,22] The study conducted by Ghabrah and Madani et al during Haze, they observed for the prevention of RTIs it is important to encourage personal hygiene, cough etiquette, and hand hygiene among pilgrims, in the present study we were not observed such findings.[23] The study done in Egypt by Maha Talaat and Mona Al shokry observed that 30% were BSIs, 29% SSIs, 26% pneumonia, and 15% UTIs. VAP had the highest incidence of device-associated infections (4.3/1000 ventilator days). The most common pathogens reported were *Klebsiella* spp. (28.7%) followed by *Acinetobacter* spp. (13.7%). In the present study, all HAIs reported lower prevalence rate than the above study such as BSI 19%, SSI only 9%, and VAP 20%, which may be due to better implementation of infection control practices, policies, and procedure than that of the study conducted in Egypt.[24]

CONCLUSION

HAI is a big threat for patients' safety and increases patients' morbidity, mortality, stay, and cost of health care. So effective utilization of hospital data about the pattern of occurrence of HAI, their sensitivity pattern (antibiogram), common site of occurrence, and contributing factors or areas is very important indicators, on the basis of which we can plane effective intervention for prevention and control of HAI in own setting.

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Conflicts of interest

There are no conflicts of interest.

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