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Original article

Incidence of Healthcare-Associated Infections (HAIs) and the adherence to the HAIs' prevention strategies in a military hospital in Alkharj

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ABSTRACT

Background: Healthcare-associated infections (HAI) are considered one of the most common adverse events in health care service provision. In order to prevent the occurrence of HAIs, it is important to implement several prevention strategies.
Objectives: This study aims to determine the incidence of healthcare-associated infections in a military hospital in Alkharj and the adherence to the HAIs' prevention strategies.
Methods: This study included exporting data for all infected cases confirmed by the infection disease specialists in 2019. The data were collected from the reports that were written by infection control unit and infectious disease department.
Results: The rate of healthcare associated infections (HAIs) in 2019 was 0.43% of total patient admissions. The rate of central line associated bloodstream infections in 2019 was 1.15 per 1000 central line days. The rate of catheter associated urinary tract infections in 2019 was 1.00 per 1000 catheter days. The rate of ventilator associated pneumonia in 2019 was 2.11 per 1000 ventilator days and the rate of surgical site infections in 2019 was 0.41 %.
Conclusion: The rate of overall healthcare-associated infections (HAI) was low. The compliance rate of health care workers to preventive measures that control HAIs was generally high but there was a need for more awareness particularly regarding personal protective equipment and hand hygiene. So it is important to attend more awareness activities and workshops particularly regarding personal protective equipment and hand hygiene. Furthermore, infection control unit and infectious disease department in the hospital should support the robust HAI prevention programs.

1. Introduction

Healthcare-associated infections (HAI) are considered one of the most common adverse events in health care service provision. HAIs are infections that first appear 48 h or more after hospitalization or within 30 days after having received health care (Revelas, 2012). The term HAIs initially referred to those infections linked with admission to an acute-care hospital (earlier called nosocomial infections), but the term now includes infections developed in various settings where patients obtain health care such as family medicine clinics, long-term care, ambulatory care, and home care (Haque et al., 2018). Health care-associated infections (also called nosocomial infections) affect patients in health-care facilities including hospital; these infections aren't present or incubating at admission time. They also include the infections that are acquired by patients in the hospital or health-care facility but appearing after patients' discharge, and include also occupational infections among health care staff (WHO, 2020).

Center for Disease Prevention and Control (CDC) reported that healthcare-associated infections include ventilator-associated

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pneumonia (VAP), central line-associated bloodstream infections (CLABSI) and catheter-associated urinary tract infections (CAUTI). Additionally, HAIs include infections that occur at surgery sites, which are known as surgical site infections (SSIs). CDC works to monitor and to avoid these infections because they are a major threat to patient safety (CDC, 2020). Similarly, Al-Tawfiq and Tambyah reported that the main HAIs are surgical site infections, central line-associated bloodstream infections, catheter-associated urinary tract infections and ventilator-associated pneumonia (Al-Tawfiq and Tambyah, 2014). Ventilator-associated pneumonia is a lung infection that develops in a person who is on a ventilator (CDC, 2016). A central line-associated bloodstream infection (CLABSI) is a serious infection that occurs when germs (usually bacteria or viruses) enter the bloodstream through the central line (CDC, 2016). A urinary tract infection (UTI) is an infection involving any part of the urinary system, including urethra, bladder, ureters, and kidney (CDC, 2016). A surgical site infection is an infection that occurs after surgery in the part of the body where the surgery took place (CDC, 2016).

In addition to that HAIs also include other infections such as *Clostridium difficile* infections and antibiotic-resistant infections. There are several multidrug-resistant bacteria such as *Klebsiella pneumoniae* (mainly colistin-resistant *Klebsiella pneumoniae*, metallo-β-lactamase (NDM-1)-producing *Klebsiella pneumoniae* and carbapenemases-producing clinical *Klebsiella pneumoniae*) (Ripabelli ET AL., 2020; Di Tella et al., 2019).

Garnacho-Montero and Amaya-Villar found that multidrug-resistant *Acinetobacter baumannii* has developed resistance to most of the available antibiotics including carbapenems, which are the drugs of choice in the treatment of severe infections (Garnacho-Montero and Amaya-Villar, 2010). Karlowsky et al and Hackel et al stated that the propensity of *Acinetobacter baumannii* to be multidrug-resistant or extensively drug-resistant presents therapeutic challenges (Karlowsky et al., 2017; Hackel et al., 2015). In Al-Kharj a study about the drug resistance of the most common gram negative bacteria in 2017 and 2018 showed that *Acinetobacter baumannii* was resistant to all antibiotics except 1 antibiotic, therefore its resistance was classified as extensively drug resistance. They also found that *Pseudomonas aeruginosa* and *Klebsiella pneumonia* was resistant to 3 antibiotics in 3 different categories, so its resistance was classified as multidrug resistance (Ahmed et al., 2021).

It has been reported that for every one-hundred patients admitted to hospital, seven patients in high-income economies and ten in emerging and low-income economies acquire at least one type of HAI (Haque et al., 2020; Danasekaran et al., 2014; Khan et al., 2017a, 2017b; Haque et al., 2018; Klevens et al., 2007; WHO, 2016). In the United States at any one time, 4 % of the hospitalized patients are affected by an HAI (Magill et al., 2014). In Africa, the total prevalence of HAI range between 2.5 and 14.8% (Nejad et al., 2011), and this rate was twofold the average rate from European prevalence as stated by the European Center for Disease Prevention and Control (ECDC, 2008). In Europe, about 3.2 million patients acquire a HAI yearly and about 37,000 die as a direct consequence of HAI and also because of the increasing multi-drug resistance of HAI-associated pathogens (Allegranzi et al., 2011; ECDC, 2013). Moreover, several studies conducted in Italia showed a 5–10% incidence rate of HAI with a mortality rate up to 20–30% (Mancini et al., 2016; Capozzi et al., 2004; Messineo and Marsella, 2015).

Health care-associated infections (HAIs) affect millions of patients annually with up to 80,000 affected in Europe on any given day. This represents a significant societal and economic burden (Murphy et al., 2020). Evidence indicates that HAIs lead to long-term disability, extended hospital stay, higher antimicrobial resistance rate, extra financial burden, and even prevenTable deaths (Allegranzi et al., 2011). Moreover, previous studies found that healthcare-associated infections (HAIs) are a major source of morbidity and mortality and are the second most prevalent cause of death (Danasekaran et al., 2014; Khan et al., 2017a, 2017b; Haque et al., 2018; Klevens et al., 2007; WHO, 2016; Ripabelli et al., 2019).

In order to prevent the occurrence of HAIs, it is important to implement several prevention strategies. Collins reported that it is important to adhere to hand hygiene, environmental cleanliness, leadership, proper use of personal protective equipment, consistent evidence-based practices, antimicrobial-resistance campaign, respiratory hygiene and cough etiquette and evaluation Strategies (H.E.L.P. C.A.R.E) to prevent the occurrence of HAIs. Therefore, this study aims to determine the incidence of healthcare-associated infections in Alkharj Military Industrial Corporation Hospital in Alkharj city, Saudi Arabia and to determine the adherence to the HAIs' prevention strategies.

2. Methodology

2.1. Setting

The study was conducted in Alkharj Military Industrial Corporation Hospital. The hospital is initiated at the end of 1979 in Alkharj city that is located in the southeast of Riyadh city. The hospital is a small hospital (with less than 100 beds) includes only 60 beds. The hospital implemented HAI surveillance system by observing all inpatients during their staying in the hospital.

2.2. Inclusion/exclusion criteria

All of the infected HAI cases that were confirmed by the infectious disease department in 2019 were included. Other types of infections or infections before 2019 were excluded.

2.3. Data collection

This study included exporting data for all infected cases confirmed by the infection disease specialist in 2019. The data were collected from the reports that were written by infection control unit and infectious disease department.

Ethical approval

Ethical approval was obtained from the IRB Ethical Committee of the hospital No:

4101728. The study excluded patient identifiers in order to protect the privacy of the patients.

2.4. Data analysis

The data were represented as a frequencies and rates in 7 Tables that include the percentage of HAIs, the rate of CLABSI, the rate of CAUTI, the rate of VAP, the rate of SSIs, the rate of infections caused by multi-drug resistant organism (MDRO) and the adherence to HAIs' prevention strategies.

The HAI surveillance system was conducted by trained personnel to determine the presence of HAI according to the criteria for defining HAI. The relevant data were extracted from electronic health records to detect incident HAIs by reviewing admission/discharge/transfer records, patient charts, microbiology laboratory records in addition to visits to patient wards for observation and for discussion with caregivers. The surveillance was conducted prospectively and included the monitoring of the patients during their hospitalization and for SSIs, the monitoring should be conducted not only during hospitalization but also during the post-discharge period.

The percentage of HAIs was calculated by dividing the total number of HAIs by total number of patient admissions * 100%. The prevalence of SSI was described as a percentage and calculated by dividing the number of SSIs by the total number of surgery cases * 100%. The rate of CLABSI was calculated by dividing number of infections by central line days * 1000. Moreover, the rate of CAUTI was calculated by dividing number of catheter associated urinary tract infections by catheter days * 1000 and the rate of VAP was calculated by dividing number of ventilator associated pneumonia by ventilator days * 1000. *Clostridium difficile* infections rate was calculated by dividing the number of confirmed case by the total number of patients * 100. The rate of infections caused by multidrug resistant organism was calculated by dividing number of multidrug resistant organism cases by number of patients' days * 1000.

The compliance rates of health care workers to preventive measures that control HAIs were shown as percentages and included compliance to overall central line insertion bundle, compliance to overall central line maintenance bundle, compliance to overall surgical site infection bundle, compliance to overall ventilator bundle, compliance to overall urinary catheter bundle, compliance to overall safe injection practice, compliance to overall personal protective equipment and compliance to overall hand hygiene.

3. Results and discussion

3.1. The rate of healthcare associated infections

The rate of healthcare associated infections (HAIs) in 2019 was 0.43% of total patient admissions (total number of patient admissions in 2019 was 7,703 admissions and total number of HAIs was 33). The highest rate of HAIs infections was between January and March (0.80%) and the lowest rate was between July and September (0.23%). Table 1 shows the rate of HAIs in 2019.

The prevalence of healthcare associated infections had a seasonal variation, so some types of infections increased in summer and other increased in winter or other seasons. The changing in weather and in temperature affects the occurrence of these infections. Previous studies showed that a regional difference also impacted the seasonal variations (Richet, 2012; Chen et al., 2013; Zhang et al., 2019a, 2019b). Richet stated that for the surgical wound infections, winter peaks were detected in the USA and summer peaks were reported in Finland (Richet, 2012). He also stated that a significant correlation between lower urinary tract infections and higher temperature and decreased relative humidity could explain the seasonality of some bloodstream infections (Richet, 2012). Chen et al reported that in south of China there are no obvious seasonal peaks in nosocomial infection (Chen et al., 2013). However, there exist remarkable variations of the outdoor temperature between south and north in China (Zhang et al., 2019a, 2019b).

Fortunately, the findings of the present study reported a rate of HAIs less than 1 %. Several studies in different countries showed a higher HAIs rate. In the United States, the rate is 4 % of the hospitalized patients (Magill et al., 2014) and in Africa, the total prevalence range between 2.5 and 14.8% (Nejad et al., 2011). In Italy, previous studies showed a 5–10% incidence rate of HAIs (Mancini et al., 2016; Capozzi et al., 2004; Messineo and Marsella, 2015). Additionally, in a study conducted in 189 hospitals in china, Zhang et al stated that the pooled HAI prevalence was 1.24% and the overall frequency of HAIs was 1.41% (Zhang et al., 2019a, 2019b). In Saudi Arabia, several studies showed also a HAIs rate more than the rate in the present study. Al Kuwaiti and Subbarayalu reported that the overall HAI rate was observed as 4.18 in a public hospital in Al-Khobar, Saudi Arabia (Al Kuwaiti and Subbarayalu, 2017). Balkhy et al reported that the overall rate of HAIs in their hospital was 8% in a tertiary care center in Riyadh, Saudi Arabia (Balkhy et al., 2006). Halwani et al reported that in Jeddah, the prevalence rate of healthcare-associated infections (HAI) during three-year study period was 2.4 % (Halwani et al., 2016).

3.2. The rate of central line associated bloodstream infections

The rate of central line associated bloodstream infections in 2019 was 1.15 per 1000 central line days. The rate between January to March was 4.27 per 1000 central line days and for 9 months the rate was zero. The rate of central line associated bloodstream infections is shown in Table 2.

The rate of central line associated bloodstream infections was low 10 % of all device-associated HAIs. Similarly, Gaid et al stated that CLABSI rate was about 14.2% of all device-associated HAI (Gaid et al., 2018). Additionally, Zhang et al stated that the prevalence rate of central line-associated bloodstream infection was 0.63 per 1000 catheter-days (Zhang et al., 2019a, 2019b). Jahani-

Table 1
Rate of healthcare associated infections in 2019.

Months	Total number of patient admissions	Number of healthcare associated infections	Rate of healthcare associated infections
January – March	2000	16	0.80%
April –June	1706	6	0.35%
July – September	1762	4	0.23%
October - December	2235	7	0.31%
Total	7703	33	0.43%

Table 2
The rate of central line associated bloodstream infections in 2019.

Months	Central line days	Number of central line associated bloodstream infections	Rate of central line associated bloodstream infections
January – March	703	3	4.27 per 1000 central line days
April –June	775	0	0.00 per 1000 central line days
July – September	604	0	0.00 per 1000 central line days
October – December	518	0	0.00 per 1000 central line days
Total	2600	3	1.15 per 1000 central line days

Sherafat reported that among the device associated HAIs in six academic teaching hospitals of Iran, there were 5.84 central line-associated bloodstream infections (CLABSIs) per 1000 central line-days (Jahani-Sherafat et al., 2015). Furthermore, Khan et al stated that among 2157 ICU patients of a 760-bedded teaching hospital in Eastern India, the mean monthly rates of CLABSI was 1.4/1000 device days (Khan et al., 2017a, 2017b). In addition to that, Iordanou et al reported that at a general hospital's intensive care unit (ICU) in the Republic of Cyprus, CLABSI was the most frequent device associated HAIs with 15.9 incidence rate per 1000 central venus catheter (CVC) days (Iordanou et al., 2017).

3.3. The rate of catheter associated urinary tract infections

The rate of catheter associated urinary tract infections in 2019 was 1.00 per 1000 catheter days. The highest infections rate was between January to March 1.90 per 1000 catheter days and the lowest rate was between July and September 0.36 per 1000 catheter days. The rate of catheter associated urinary tract infections in 2019 is shown in Table 3.

The rate of catheter associated urinary tract infections rate was 36.67% of all device-associated HAIs. Similarly, Gaid et al stated that CAUTI rate was 28.4% of all device-associated HAI (Gaid et al., 2018). Additionally, Zhang et al stated that the prevalence rate of catheter-associated urinary tract infection was 2.06 per 1000 catheter-days (Zhang et al., 2019a, 2019b). Jahani-Sherafat reported that among the device associated HAIs in six academic teaching hospitals of Iran, there were 8.99 catheter-associated urinary tract infections (CAUTIs) per 1000 urinary catheter-days (Jahani-Sherafat et al., 2015). Furthermore, Khan et al stated that among 2157 ICU patients of a 760-bedded teaching hospital in Eastern India, the mean monthly rate of CAUTI was 1.25/1000 device days (Khan et al., 2017a, 2017b).

In addition to that, Iordanou et al reported that at a general hospital's intensive care unit (ICU) in the Republic of Cyprus, CAUTI rate was 2.7 per 1000 urinary catheter days (Iordanou et al., 2017).

3.4. The rate of ventilator associated pneumonia

The rate of ventilator associated pneumonia in 2019 was 2.11 per 1000 ventilator days. The highest rate was between January and March 5.35 per 1000 ventilator days and the lowest rate was between July and September 0.00%. The rate of ventilator associated pneumonia in 2019 is shown in Table 4.

The rate of ventilator associated pneumonia rate was 53.33% of all device-associated HAIs. Similarly, Gaid et al stated that VAP was the most common device-associated HAI (57.4%) (Gaid et al., 2018). Additionally, Zhang et al stated that the prevalence rate of ventilator-associated pneumonia was 7.92 per 1000 catheter-days, respectively (Zhang et al., 2019a, 2019b). Jahani-Sherafat reported that among the device associated HAIs in six academic teaching hospitals of Iran, there were 7.88 ventilator-associated pneumonias (VAPs) per 1000 mechanical ventilator-days (Jahani-Sherafat et al., 2015). Furthermore, Khan et al stated that among 2157 ICU patients of a 760-bedded teaching hospital in Eastern India, the mean monthly rate of VAP was 2/1000 device days (Khan et al., 2017a, 2017b). In addition to that, Iordanou et al reported that at a general hospital's intensive care unit (ICU) in the Republic of Cyprus, VAP rate was 10.1 per 1000 ventilator days (Iordanou et al., 2017).

3.5. The rate of surgical site infections

In 2019, there were 11 SSIs occurred among the 2,695 total surgeries performed; most of the surgeries were not complex procedures and included mainly gynecological and obstetric Surgery. For example, the number of caesarian section surgeries in 2019 was 756 (28.05% of the total surgeries). The rate of surgical site infections in 2019 was 0.41 %. The highest rate of infections was between July and September (0.49%) and the lowest rate was between April and June (0.31%). The rate of surgical site infections in 2019 is shown in Table 5.

Rate of surgical site infections was 0.41% in the present study in 2019. Similarly, Haseeb et al stated that in a hospital in Makkah the rate of SSIs was 1.9% (Haseeb et al., 2020). John et al reported that in sheikh khalifa medical city, SSI rates in general surgery and the whole department were 4.68% and 3.57% respectively (John et al., 2015). Furthermore, Wong and Holloway stated that in a general surgery department at a general hospital in Malaysia, the SSI incidence was 11.7% Wong and Holloway, 2019). In contrast to the result of the present study, Alsareii reported that in a Saudi tertiary care hospital the overall SSI rate was 10.2% (Alsareii, 2017). Khairy et al informed that in a university Hospital in Riyadh, the rate of surgical site infection was 6.8%) Khairy et al., 2011).

Table 3
The rate of catheter associated urinary tract infections in 2019.

Months	Catheter days	Number of catheter associated urinary tract infections	Rate of catheter associated urinary tract infections
January – March	2629	5	1.90 per 1000 catheter days
April –June	2727	2	0.73 per 1000 catheter days
July – September	2815	1	0.36 per 1000 catheter days
October – December	2733	3	1.10 per 1000 catheter days
Total	10,904	11	1.01 per 1000 catheter days

Table 4
The rate of ventilator associated pneumonia in 2019.

Months	Ventilator days	Number of ventilator associated pneumonia	Rate of ventilator associated pneumonia
January – March	935	5	5.35 per 1000 ventilator days
April –June	1139	2	1.76 per 1000 ventilator days
July – September	854	0	0.00 per 1000 ventilator days
October – December	867	1	0.88 per 1000 ventilator days
Total	3795	8	2.11 per 1000 ventilator days

Table 5
The rate of surgical site infections in 2019.

Months	Number of surgical site infections	Total number of surgery cases	Rate of surgical site infections
January – March	3	635	0.47%
April –June	2	639	0.31%
July – September	3	610	0.49%
October - December	3	811	0.37%
Total	11	2695	0.41%

Table 6
The rate of multi-drug resistant organism (MDRO) infections in 2019.

Months	Number of multidrug resistant organism cases	Number of patients days	MDRO rate per 1000 patient days
January - March	44	9686	4.54 per 1000 patient days
April –June	49	9143	5.36 per 1000 patient days
July - September	33	9945	3.32 per 1000 patient days
October - December	27	9973	2.71 per 1000 patient days
Total	153	38,747	3.95 per 1000 patient days

3.6. The rate of clostridium difficile infections

HAIs also include *clostridium difficile* infections. Fortunately, there was no any confirmed case of *clostridium difficile* infections in the military hospital in 2019. Alzouby et al found that in a tertiary care facility in Riyadh, the incidence of *clostridium difficile* infections was 3.5 per 10,000 patient days (Alzouby et al., 2020). Al-Tawfiq and Abed stated that among 913 patients' specimens in Dhahran, Saudi Arabia, only 42 (4.6%) were positive for *clostridium difficile* toxins (Al-Tawfiq and Abed, 2010). Shajan et al found that the prevalence of *clostridium difficile* toxin in diarrheal stool samples of patients from a general hospital in eastern province in Saudi Arabia was 13.7% (Shajan et al., 2014).

3.7. The rate of multi-drug resistant organism infections

The rate of multi-drug resistant organism (MDRO) infections in 2019 was 3.95 per 1000 patient days. The highest rate was found between April and June (5.36 per 1000 patient days) and the lowest rate was found between October and December (2.71 per 1000 patient days). The rate of multi-drug resistant organism (MDRO) infections in 2019 is shown in Table 6.

The rate of multi-drug resistant organism infections in the present study was low (3.95 per 1000 patient days). Balkhair et al reported that in a teaching hospital in Oman, MDRO patients giving an overall prevalence rate of 10.8 MDRO cases per 1000 admissions (Balkhair et al., 2014). Moreover, similar to the result of the present study, Baig et al stated that the mean incidence rate of hospital acquired MDROs in a military hospital in Riyadh was 4.8 cases/1,000 patient-days (Baig et al., 2015). This low rate of HAIs in the present study is related to the progressive monitoring of inpatients and due to the appropriate implementation of the preventive measures.

3.8. The compliance rate of health care workers to preventive measures

The compliance rate of health care workers to preventive measures that control HAIs was generally high. Higher compliance rate was found to urinary catheter bundle (95%), central line insertion bundle (94%), ventilator bundle (90%) and central line maintenance bundle (87%). The central line insertion bundle included hand hygiene, skin preparations by using chlorhexidine gluconate, maximal sterile barriers upon insertion in addition to the avoidance of the femoral vein as the access site. The maintenance bundle included hand hygiene, aseptic technique for accessing and changing needleless connectors, proper dressing changes in addition to the daily review of catheter necessity. urinary catheter insertion bundle included cleaning of the perineum, hand hygiene, correct disinfection method, aseptic insertion, appropriate fixation of the Foley catheter, aseptic connection between the Foley catheter and urinary bag and maintenance of a sterile closed drainage system. urinary catheter maintenance bundle included hand hygiene, appropriate fixation of the Foley catheter, avoiding filling of the urinary bag to > 80%, position of the urinary bag kept below the urinary bladder, and maintenance of a sterile, closed, and patent drainage system, and daily review of the indications for the urinary catheter. Ventilator bundle includes elevation of patient's head of bed to 30–450, peptic ulcer prophylaxis, prophylaxis for (DVT) Deep vein thrombosis and daily sedation vacation and daily assessment of readiness to extubation in addition to hand hygiene.

Lower compliance rate was found to safe injection practice (79%), personal protective equipment (79%), hand hygiene (77%) and surgical site infection bundle (68%). Regarding surgical site infection a bundle of care includes hair removal before surgery, perioperative antibiotic prophylaxis, operating room discipline, perioperative normothermia and perioperative euglycemia. Personal protective equipment may include hard hats, respirators, gloves, safety glasses and shoes, vests, earplugs or muffs, or coveralls and full body suits. Overall safe injection practice includes prepare injections using aseptic technique in a clean area, use needles, syringes, bags, fluid infusion or bottles of intravenous solution for one patient only, disinfect the rubber septum on a medication vial with alcohol before piercing, use single-dose vials for parenteral medications when possible, avoidance of combining the leftover

Table 7
Compliance rate of health care workers to preventive measures that control HAIs.

Variable	Compliance Rate (%)
Compliance to overall central line insertion bundle	94 %
Compliance to overall central line maintenance bundle	87%
Compliance to overall surgical site infection bundle	68%
Compliance to overall ventilator bundle	90%
Compliance to overall urinary catheter bundle	95%
Compliance to overall safe injection practice	79%
Compliance to overall personal protective equipment	79%
Compliance to overall hand hygiene	77%

contents of single-use vials for later use in addition to that the medication containers should be entered with a new needle and new syringe, even when withdrawing additional doses for the same patient. Compliance rate of health care workers to preventive measures that control HAIs is shown in Table 7.

The study showed a high compliance rate of health care workers to preventive measures that led to the low rates of HAIs in the hospital. The results showed that ventilator associated pneumonia was higher than catheter associated urinary tract infections and central line associated bloodstream infections and this is rational if we compare between the compliance rates; compliance to overall ventilator bundle was less than compliance to overall central line bundle and compliance to overall urinary catheter bundle. On the other hand, the prevalence of surgical site infections was low and the compliance to overall surgical site infection bundle was not good; this may be due to the use of antibiotics for the majority of the patients who had surgeries in the study period. But the majority of the antibiotics that used for the majority of these surgeries were broad spectrum antibiotics that were used incorrectly and this will increase the rate of bacterial resistance in the future.

The compliance rate of health care workers to preventive measures that control HAIs was generally high but still there was a gap in the knowledge of personal protective equipment and hand hygiene. Engdaw et al reported that the overall level of hand hygiene compliance among health care providers at public primary hospitals in Northwest Ethiopia was poor (Engdaw et al., 2019). Moreover, Musu et al showed that among healthcare workers in six intensive care units, there was a low level of adherence to best hygiene practices (Musu et al., 2017). Al Ra'awji et al reported that there are gaps in the knowledge of health-care workers regarding hand hygiene guidelines in Al-Qassim, Saudi Arabia (Al Ra'awji et al., 2018). Previous studies stated that hand hygiene is the cornerstone of any infection control measures to reduce HAI (Rosenthal et al., 2013; Al-Tawfiq et al., 2013). Therefore, more awareness is needed to encourage the practice of correct hand hygiene among health care professionals. Several previous studies revealed a poor compliance rate of health care workers to preventive measures that control HAIs. Leaper et al reported a poor compliance of health care providers with surgical site infection guidelines and care bundles (leaper et al., 2015). Duszynska et al stated that the range of VAP bundles compliance was between 96.2 and 76.8, the range of CLA-BSI bundles compliance was 29–100 and the rate of hand hygiene standards compliance was 64.7% (Duszynska et al., 2020).

Increasing preventive measures compliance rate lead to decrease HAIs rate as shown in several studies. Al-Thaqafy et al reported that ventilator bundle compliance was 90% in 2010 and significantly increased to 97% in 2013 after the implementation of IHI ventilator bundle and VAP rate decreased from 3.6 (per 1000 ventilator days) in 2010 to 1.0 in 2013 (Al-Thaqafy et al., 2014). Bagga et al revealed significant reduction of surgical site infections secondary to strict preventive care bundle adherence (Bagga et al., 2020). Moreover, Yaseen et al found that the implementation of IHI prevention bundle decreased CLABSI rates from 2.0 to 0 cases/1000CL days (Yaseen et al., 2016). Prakash et al reported a statistically significant reduction in the CAUTI rate by about 51.4% after the implementation of a care bundle approach (Prakash et al., 2017). Ormsby et al stated that the maintenance bundle reliability increased after implementation of Central venous catheter bundle, accompanied by a nonsignificant decrease in the CLABSI rate (Ormsby et al., 2020). In addition to that there was a need to encourage the appropriate use of personal protective equipment such as wearing facemasks. Previous studies reported that the use of facemasks is valuable in infectious disease control, particularly in avoiding droplet transmission (Furuya, 2007; Eastwood et al., 2009). Several studies showed that even if the facemasks are ill-fitting, they are still able to prevent the spreading of particles and airborne viruses to the breathing zones of people nearby appropriately (Van der Sande et al., 2008; Tang et al., 2009). Nowadays, there is need for strict adherence to environmental, hand hygiene and to other personal protective equipment such as wearing facemasks due to the high prevalence of reported nosocomial transmissions of severe acute respiratory syndrome coronavirus 2 that cause COVID-19 (Ong et al., 2020).

4. Limitations and strengths

The main limitation in the study is the small sample size and limited size of the hospitals compared to other hospitals in other cities. The main strengths of the study is that it is conducted in a short space of time due to small sample size and also obtaining ethical and institutional approval in the study is easier than obtaining the approval in studies that are conducted in large multicenter institution.

5. Conclusion

The rate of HAIs including central line associated bloodstream infections, surgical site infections, multi-drug resistant organism infections, ventilator-associated pneumonias and catheter-associated urinary tract infections were generally low. The compliance rate of health care workers to preventive measures that control HAIs was generally high but there was a need for more awareness particularly regarding the implementation of safe injection practice, personal protective equipment and hand hygiene. Infection control unit and infectious disease department in the hospital should support the robust HAI prevention programs.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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