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MULTI-DRUG RESISTANT ORGANISMS AND PATIENTS' RISK FACTORS IN THE INTENSIVE CARE UNIT OF KING FAHAD HOFUF HOSPITAL, SAUDI ARABIA

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ABSTRACT: *Healthcare Acquired Infections (HAIs), including Multi-Drug Resistant Organisms (MDROs) are significant global public health problems. This paper analyses a surveillance system dataset in order to describe the epidemiology of HAIs (MDROs and non-MDROs) in the intensive care unit (ICU), King Fahad Hofuf Hospital (KFHH), Saudi Arabia. The three year period (2010 to 2012) of KFHH surveillance system data (both sporadic and outbreak) were analysed. There were 496 notifications of HAI cases, with 68.2% being MDROs and 31.8% non-MDROs. A total of 758 organisms were identified with 90% being Gram Negative Organisms (GNO). Of the GNOs, 51% were MDROs. Device-associated infections were detected in 48.9% of patients. The most common device-associated infections were ventilator-associated pneumonia, central line associated blood stream infections, and catheter-associated urinary tract infections. The most frequently isolated MDROs were Acinetobacter species at 57.4%, extended spectrum beta lactamase producing Klebsiella pneumonia at 13.2%, MRSA at 9.8%, and Pseudomonas aeruginosa at 6.5%. HAIs cause a significant burden of disease at KFHH. The high prevalence of risk factors including pre-existing medical conditions, invasive procedures, and the long duration of hospital stays, are more prominent in ICU. This study highlights the changing trend of MDROs towards MDR gram negative organisms. High rates of multidrug resistant Acinetobacter baumannii were prominent in the ICU.*

KEYWORDS*: Infection control, MDROs, ICU, Surveillance, KFHH, Saudi Arabia*

INTRODUCTION

The growing prevalence of both HAIs and MDROs pose overwhelming challenges to healthcare systems globally (Dettenkofer et al., 2011). HAIs, due primarily to MDROs, are an important patient safety and public health concern owing to their spread within society and in healthcare settings (Woodford & Livermore, 2009). Several studies have demonstrated that MDRO

infections are associated with heightened patient morbidity and mortality, as well as increased healthcare costs (Marschall et al., 2008). The problem is most apparent in Intensive Care Units (ICUs) which care for the most critically-ill patients (Erlandsson, 2007). However, the burden of HAIs due to MDROs varies widely according to geographical region, healthcare setting, type of pathogen, and antimicrobial substance (Siegel et al., 2007).

The emergence of antimicrobial resistance (Muto et al., 2003) or the ability of microorganisms to withstand treatment with drugs to which they were once susceptible is a significant global public health problem (Heddini et al., 2009), and Saudi Arabia is no exception. MDROs and other HAIs represent a significant clinical and economic burden and are responsible for increased direct societal costs, prolonged hospitalization, and high rates of disability and death (Blot, 2008; Vandijck et al., 2008).

The surveillance of Healthcare Associated Infections (HAIs) allows healthcare facilities to detect trends, identify risk factors and assess the impact of their infection prevention and control programs (Siegel et al., 2007).Although the surveillance system in the King Fahad Hofuf Hospital (KFHH) has been in operation for the past three years, the researchers understand that to date there has not been a systematic study which has analysed the surveillance data system. There is a gap in the literature in relation to MDROs in Saudi Arabia, and in particular, when related to MDROs in ICUs in the country. Although a few studies have been conducted, they have tended to focus on prevalence and incidence, and have studied single organisms only (Baby, 2007; El-Feky & Aref, 2011). A few cross-national studies provide only one view of MDROs, and are often limited to an examination of a single organism (Maragakis, 2010; Recinos et al., 2009). Finally, none of the studies about MDROs have been conducted in the King Fahad Hofuf Hospital Institute. The purpose of the current study is analyse the data to provide evidence which can be used to develop strategies for the prevention and control of HAIs including MDROs, and to highlight the risk factors for the same in this healthcare facility. In addition, the epidemiological data will enhance further understanding of the characteristics of MDROs and of the most susceptible patients. This evidence will prepare the hospital to improve patient management should those with similar characteristics be admitted in the future. The aim of this study was fourfold including to:

- Investigate the epidemiological characteristics of multidrug resistant organisms in the Intensive Care Unit at the King Fahad Hofuf Hospital.
- Identify existing gaps in the prevention of MDROs and infection control measures in the ICU at the King Fahad Hofuf Hospital.
- Provide recommendations for effective strategies to address MDROs and infection control in the ICU at the King Fahad Hofuf Hospital.
- Outline the characteristics of HAIs susceptibilities to antimicrobial drugs.

METHODS

The surveillance system at the King Fahad Hofuf Hospital

The HAI surveillance system at the KFHH is operated by the Department of Preventive Medicine of the National Ministry of Health in Saudi Arabia. This dual system (laboratory and

clinical data) conducts both active (from the infection control team) and passive (from routine collection) surveillance. According to Centers for Disease Control and Prevention (CDC)/ National Healthcare Safety Network (NHSN), a Healthcare Associated Infection (HAI) is defined as *"a localized or systemic condition resulting from an adverse reaction to the presence of an infectious agent(s) or its toxin(s). There must be no evidence that the infection was present or incubating at the time of admission to the acute care setting"* (Horan, Andrus, & Dudeck, 2008). The case definition was used for all patients admitted to the KFHH ICU during the study period who became infected with HAIs at one or more anatomical sites after 48 hours of admission.

The ICU data was analysed, including: (i) nosocomial outbreaks, (ii) MDROs and non-MDROs, and (iii) device-associated infections (CAUTI, CLABSI, and VAP). The dataset was comprised of patients' isolate records. The following MDRO infections were included in the current analysis: Methicillin resistant *Staphylococcus aureus* (MRSA), Vancomycin-resistant *Enterococcus* species (VRE), multidrug resistant *Enterobacter species*, multidrug resistant *Escherichia coli*, multidrug resistant *Klebsiella* species, multidrug resistant *Acinetobacter baumannii*, multidrug resistant *Pseudomonas aeruginosa*, Cotrimoxazole resistant *Stenotrophomonas maltophilia*, and intermediate Vancomycin resistant *Staphylococcus aureus* (VISA).

Surveillance data analysis

Through the use of SPSS software, version 21 (2011), the surveillance system data collected over a three year period (2010-2012) was analysed. All patients notified with HAIs were eligible for inclusion in the analysis.

The univariate analysis included: (i) demographic information; (ii) patient treatment specialty; (iii) patient risk factors; and (iv) MDRO characteristics. The bivariate analysis included categorical variables between patient groups (e.g. MDROs v non-MDROs), and where appropriate these were compared using the chi-square test, or Fisher's exact tests. A p-value of 0.05 was considered to be statistically significant. Risk factors which were found to be significant after bivariate analysis were included in the multivariate logistic regression models through which logistic regression was performed.

Ethical considerations

An independent researcher who does not work in the surveillance system analysed the de-identified data. The study was approved by the Social and Behavioural Ethics Committee of Flinders University in South Australia, and by the King Fahad Hofuf Hospital research and ethics committee. In addition, the research was approved by the Saudi Arabia Ministry of Health Research Committee.

RESULTS FROM THE SURVEILLANCE DATA

Demographic characteristics of patients

Of the 496 ICU patients notified with HAIs, 58.3% were males and 41.7% were females. Their ages ranged between 12 and 100 years (mean 53±24SD). A significant group (27.2%) was between 25 and 44 years (Table 1).

There was a high proportion (93.8%) of MDROs cases during January of 2010 and 2011. Although MDROs were detected throughout the period of analysis, there was a low proportion (36.8%) of cases during November of 2012. Data were missing during August 2010 and 2011 respectively (Figure 1).

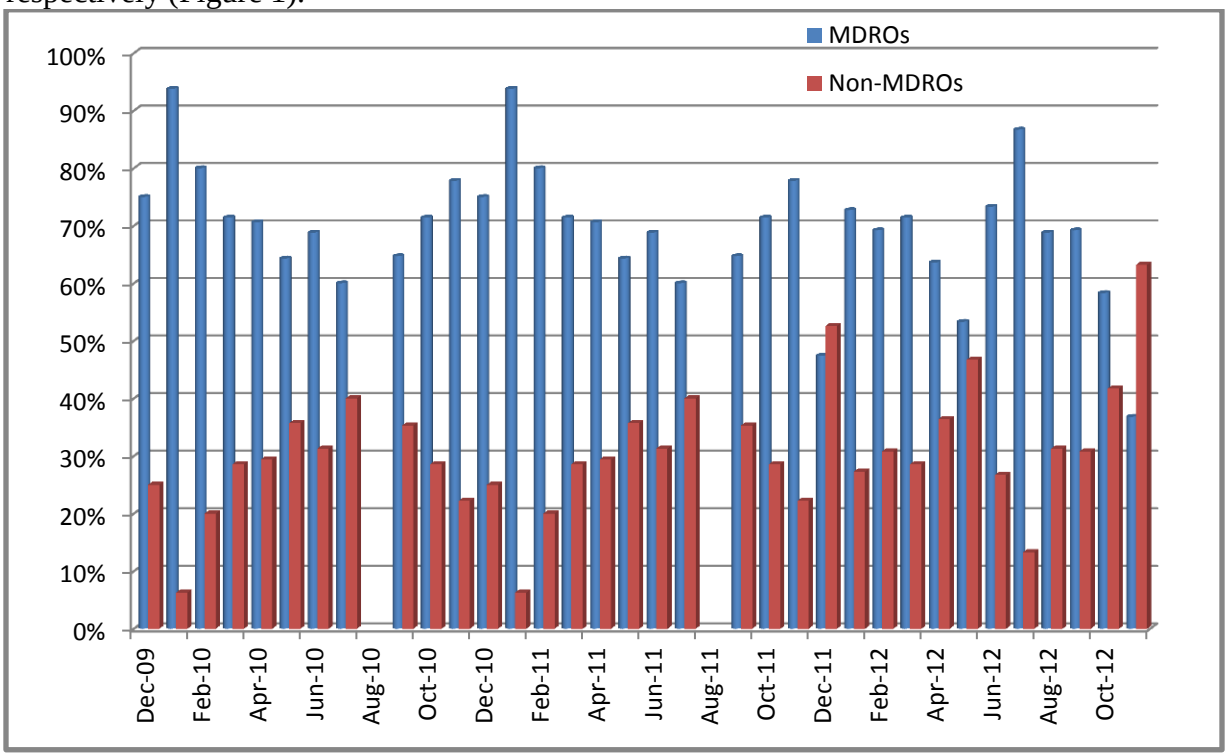

Figure 1: Proportion of MDROs and non-MDROs per month

Note: Data were missing during August 2010 and August 2011

Patient admissions and the hospital setting

The mean length of ICU stay was 44 days (range 2 - 490 days). A significant proportion of patients - 31.9% - stayed in the ICU between 15 and 35 days, while a small percentage - 16.9% - stayed between 36 and 56 days. Treatment specialities were 68.6% medical and 31.4% surgical. 40.7% of patients were treated under general medicine, and a small proportion - 0.2% - under urology (Table 1).

Patients and existing conditions

44.2% of ICU patients had no pre-existing condition. However 36.7% had one pre-existing condition and 13.7% had more than one pre-existing condition. The most frequently reported pre-existing condition (13.7%) was diabetes mellitus in combination with other diseases, such as

renal failure, pulmonary disease, or a neuromuscular disease. 13.3% of patients had chronic lung disease, while 9.5% had a neuromuscular disease or encephalopathy (Table 1).

Patients with MDROs and Risk factors

Most patients had contact with medical devices which may have exposed them to infections. These devices included: central venous lines (61.1%), Foley catheters (58.7%), and ventilators (51.8%). A large proportion of patients (40.7%) had contact with three medical devices, 23.2% had contact with one device, while 13.3% had contact with two devices. However, a small proportion of patients (22.8%) had no medical interventions (Table 1).

Table 1. Demographic characteristics of patients and medical intervention

Variable			Count (n=496)	(%) (proportion of study population)
Age	< 25 years		75	15.1
	25-44 years		135	27.2
	45-64 years		89	17.9
	65-79 years		113	22.8
	80+ years		84	16.9
Gender	Male		289	58.3
	Female		207	41.7
Nationality	Saudi		475	95.8
	Non-Saudi		21	4.2
Treating specialty		General Medicine	202	40.7
	Medical specialty	Chest	82	16.5
		Nephrology	25	5
		Neurology	20	4
		Cardiology	8	1.6
		Gastroenterology	4	0.8
		General Surgery	43	8.7
	Surgical specialty	Orthopaedics	40	8.1
		Urology	1	0.2
		Plastic	2	0.4
		Thoracic surgery	5	1
		Neurosurgery	62	12.5
		Vascular	2	0.4
Length of ICU stay (days)	2 – 14 days		125	25.3
	15 – 35 days		158	31.9
	36 – 56 days		84	17
	>56 days		128	25.9
Comorbidity (pre-existing condition)	No pre-existing condition		219	44.2
	Patients with one pre-existing condition	Chronic lung diseases	66	13.3
		All other diseases	21	4.2
		Neuromuscular diseases	47	9.5
		Diabetes mellitus	23	4.6
		Renal failure	25	5
	Patients with two or more	DM & other diseases	67	13.7
Medical intervention/devices	Patients without devices		113	22.8
	Patients with one device		115	23.2
	Patients with two or more devices		268	54
	Patient with ventilator		257	51.8
	Patient with Foley catheter		291	58.7
	Patient with central line		303	61.1

Characteristics of organisms and number of organisms per patient

758 organisms were isolated, 90% of which were gram negative, and 10% were gram positive. 68.2% of the patients had MDRO isolates, and less than one-third of patients (31.8%) had non-MDRO isolates. 51% and 49% of gram negative organisms had MDROs and non-MDROs respectively.

While half of the patients had one organism, the other half had multiple organisms. The most frequent type of isolated organisms was *Acinetobacter* species (29.3%), *Pseudomonas aeruginosa* (21.6%), *Klebsiella pneumonia* (7%), ESBL producing *Klebsiella pneumonia* (6.7%), and Methicillin Resistant *Staphylococcal Aureus* (MRSA) 5%. *Flavimonas* and *Enterococcus* multidrug resistant organisms were rarely isolated during the study period. The majority of patients (69.7%) had one anatomical infection site. 23.4% and 6.9% of patients had two site and three infection sites respectively (Table 2).

Table 2. Characteristics of organisms

	Microorganisms (MDROs & Non-MDROs)	Number	Proportion (%)
Number of organisms per	Patients with one organism	252	50.8
Patient *(N=496)*	Patients with two organisms	148	29.8
	Patients with three organisms	54	10.9
	Patients with four organisms	12	2.4
	Missing	30	6
Microorganisms	*Acinetobacter* MDR	222	29.3
(N=758)	*Pseudomonas*	164	21.6
	Klebsiella sensitive	53	7
	Klebsiella ESBL	51	6.7
	MRSA	38	5
	Proteus sensitive	28	3.7
	Pseudomonas MDR	25	3.3
	Stentrophomonas	23	3
	Acinetobacter sensitive	20	2.6
	Enterococcus	18	2.4
	Providencia sensitive	17	2.2
	Providencia ESBL	16	2.1
	Proteus ESBL	14	1.8
	E-Coli ESBL	10	1.3
	Staph aureus	10	1.3
	Streptococcus	9	1.2
	Enterobacter cloacae	8	1.1

	Serratia	7	0.92
	Morganilla ESBL	6	0.79
	Citrobacter	5	0.66
	Stenotrophomonas MDR	4	0.53
	Morganilla sensitive	3	0.39
	Enterobacter	2	0.26
	Xanthomonas Maltophilia	2	0.26
	E- Coli sensitive	1	0.13
	Flavimonas	1	0.13
	Enterococcus MDR	1	0.13
Number of specimens	Patients with one specimen	325	69.7
	Patients with two specimens	109	23.4
	Patients with three or more specimens	32	6.9

MDROs (Multidrug Resistant Organisms), ESBL (Extended Spectrum Beta-Lactamase), MRSA (Methicillin Resistant staphylococcus Aureus)

The most common multidrug resistant organisms were *Acinetobacter* species (57.4%), *Klebsiella* ESBL (13.2%), MRSA (9.8%), and *Pseudomonas aeruginosa* (6.5%). *Enterococcus* was the scarcest organism isolated - 0.26% (Table 3).The most common antibiotic susceptible bacteria were *Pseudomonas aeruginosa* (44.2%), *Klebsiella pneumonia* (14.3%), and *Proteus* (7.5%). Device-associated infections were detected in 48.9% of patients, while 51.1% had non-device-associated infections. The most common device-associated infections were ventilator associated pneumonia (VAP) (14.8%), central line associated blood stream infections (CLABSI) (14%), and catheter associated urinary tract infections (CAUTI) (10.5%) (Table 3).

Table 3. Characteristics of healthcare-associated infections and organisms

	Microorganisms	Count	Proportion (%)
Number of MDROs per Patient	Patients with one MDRO	244	52.3
(N=466)	Patients with two MDROs	71	15.2
	Patients with three MDROs	3	0.64
	Patients with non- MDROs	148	31.8
MDROs	*Acinetobacter* MDR	222	57.4
(N=387)	*Klebsiella* ESBL	51	13.2
	MRSA	38	9.8
	Pseudomonas MDR	25	6.5
	Providencia ESBL	16	4.1
	Proteus ESBL	14	3.6
	E-Coli ESBL	10	2.6
	Morganilla ESBL	6	1.6
	Stenotrophomonas MDR	4	1.03
	Enterococcus MDR	1	0.26
Non-MDROs	*Pseudomonas*	164	44.2
(N=371)	*Klebsiella* sensitive	53	14.3
	Proteus sensitive	28	7.5
	Stentrophomonas	23	6.2
	Acinetobacter sensitive	20	5.4
	Enterococcus	18	4.8
	Providencia sensitive	17	4.6
	Staph aureus	10	2.7
	Streptococcus	9	2.4
	Enterobacter cloacae	8	2.1
	Serratia	7	1.9
	Citrobacter	5	1.3
	Morganilla sensitive	3	0.8
	Enterobacter	2	0.54
	Xanthomonas Maltophilia	2	0.54
	E-Coli sensitive	1	0.27
	Flavimonas	1	0.27
Infections *(N=466)*	Non-Device associated infections	238	51.1
Device-associated infections	VAP	69	14.8
	CLABSI	65	14
	CAUTI	49	10.5
	CAUTI & CLABSI	18	3.9
	CLABSI & VAP	11	2.4
	CAUTI & CLABSI & VAP	10	2.2
	CAUTI & VAP	6	1.3

MDROs (Multidrug Resistant Organisms), CAUTI (Catheter-Associated Urinary Tract Infection), CLABSI (Central-Line Associated Blood Stream Infection), VAP (Ventilator-Associated Pneumonia), ESBL (Extended Spectrum Beta-Lactamase), MRSA (Methicillin Resistant *staphylococcus Aureus*)

MDROs were isolated from different anatomical sites and positive specimens included sputum (53.6%), blood (21.2%) and urine (15.3%) (Figure 2).

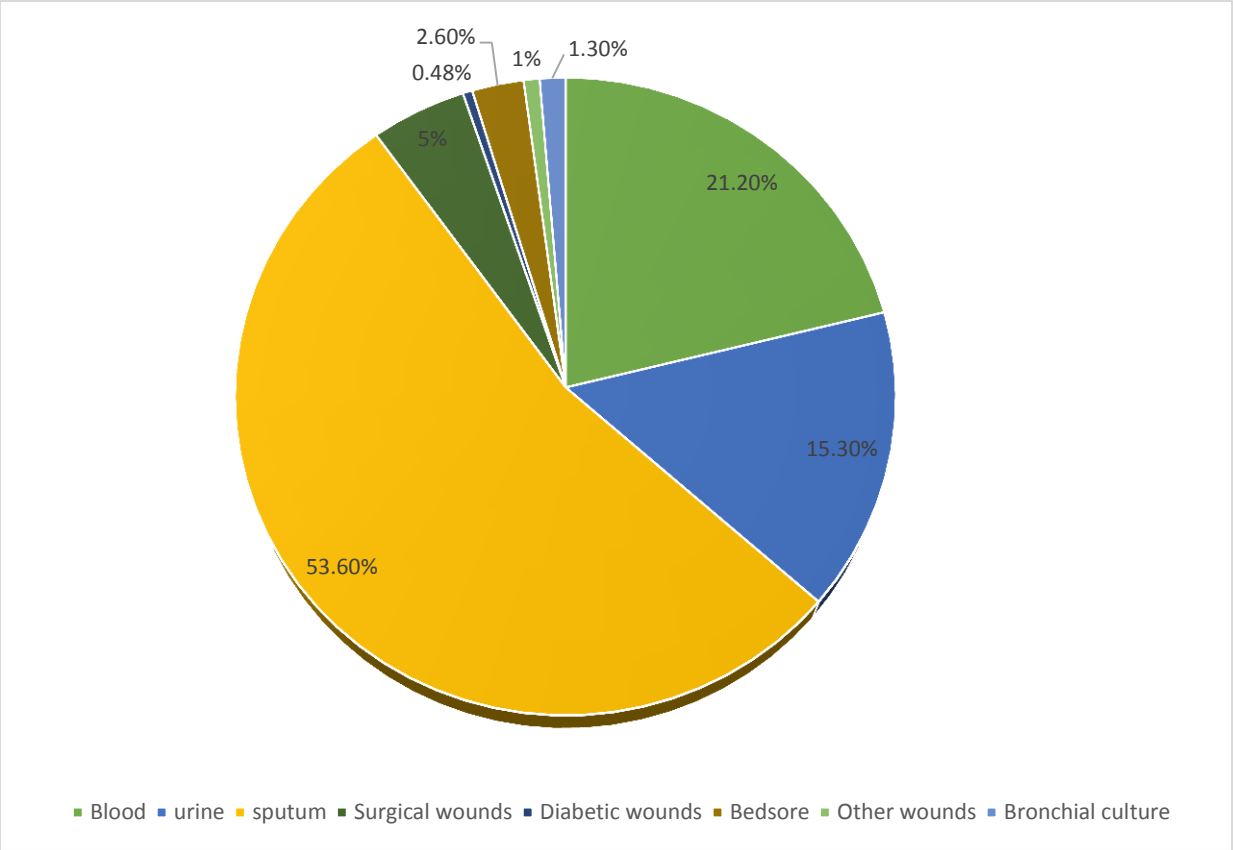

Figure 2: Site of organisms' isolation

Characteristics of patients, MDROs and non-MDROs status

53.5% of patients with MDRO-positive isolates were males compared to 66.9% of patients who were non-MDRO-positive and this gender difference was statistically significant($x^2 = 7.46, p = 0.006$). Patients aged between 25 and 44 years had the highest proportion of HAIs including 24.5% of patients with MDRO and 27.7% of patients with non-MDRO isolates. Patients aged less than 25 years had the lowest proportion of MDROs (13.5%) compared to patients aged between 45 and 64 years and patients more than 80 years of non-MDROs (14.9%). However, there was no statistically significant association between age and HAI status ($x^2 = 5.73, p = 0.22$) (Table 4).

Treatment specialty and HAI status

Of the 318 patients with MDROs, 45.3% were treated under general medicine compared to 29.7% of non-MDRO patients. There was significant association between speciality of treatment and MDROs ($x^2 = 11.77, p = 0.008$). The mean length of stay in the ICU for MDRO and non-MDRO patients was 44 days (range 2 - 490 days). 24.8% of patients with MDROs compared to

26.5% of patients with non-MDRO had an ICU stay of ≥56 days but this difference was not statistically significant ($x^2 = 2.66, p = 0.45$) (Table 4).

Pre-existing conditions and HAI status

45% of patients with MDROs had no pre-existing conditions compared to 42.1% of patients with non-MDROs. However there was no statistically significant between pre-existing conditions and HAIs status ($x^2 = 0.31, p = 0.86$) (Table 4).

Medical interventions, devices and HAI status

A significant proportion of patients with MDROs and patients with non-MDROs had three medical interventions (41.5% and 47.3% respectively). A small proportion (22.6%) of patients with MDROs and 18.2% of patients with non-MDRO had no medical interventions. However, there was no statistically significant association between medical interventions and HAIs ($x^2 = 1.77, p = 0.62$). Similarly, there were no statistically significant differences in the number of infection sites between MDRO and non-MDRO patients ($x^2 = 5.55, p = 0.062$) (Table 4).

Table 4. Association between risk factors and MDROs

Potential risk factor		Total (N=466)%	Non-MDRO (N=148)%	MDRO (N=318)%	$x^2, p - value$
Sex	Male	57.7	66.9	53.5	7.46, 0.006
	Female	42.3	33.1	46.5	
Age	< 25 years	15.7	20.3	13.5	5.73, 0.22
	25-44 years	25.5	27.7	24.5	
	45-64 years	18.7	14.9	20.4	
	65-79 years	23	22.3	23.3	
	80+ years	17.2	14.9	18.2	
Speciality	General medicine	40.3	29.7	45.3	11.77, 0.008
	Medical subspecialty	29	33.1	27	
	General surgery	8.4	8.1	8.5	
	Surgical subspecialty	22.3	29.1	19.2	
Comorbidity	Patients with no pre-existing condition	44.1	42.1	45	0.31, 0.86
	Patients with one existing condition	40.6	42.1	39.9	
	Patients with two or more existing conditions	15.3	15.7	15.1	
Duration of	2 – 14 days	25.6	28.6	24.2	2.66, 0.45

ICU stay					
	15 - 35 days	31.6	31.3	31.8	
	36 - 56 days	17.4	13.6	19.2	
	> 56 days	25.4	26.5	24.8	
Devices	Patients without devices	21.2	18.2	22.6	$1.77, 0.62$
	Patients with one device	2.2	20.9	21.4	
	Patients with two devices	14.2	13.5	14.5	
	Patients with three devices	43.3	47.3	41.5	
	Patient with ventilator	53	56.8	51.3	$1.23, 0.27$
	Patients with Foley catheter	62	65.5	60.4	$1.14, 0.29$
	Patients with central line	64.2	67.6	62.6	$1.09, 0.296$
Number of specimens	One specimen	69.7	77	66.4	$5.55, 0.062$
	Two specimens	23.4	18.2	25.8	
	Three specimens	6.9	4.7	7.9	

MDROs (Multidrug Resistant Organisms), CAUTI (Catheter-Associated Urinary Tract Infection), CLABSI (Central-Line Associated Blood Stream Infection), VAP (Ventilator-Associated Pneumonia)

Relationship between patients' HAIs status and medical sub-specialities

Interestingly, patients who were treated under medical subspecialties were 0.46 times less likely to develop MDROs compared to patients who were treated under general medicine ($OR = 0.46, 95\%\ CI\ 0.27 - 0.80, p = 0.006$). Similarly, patients who were treated under the surgical subspecialty were 0.39 times less likely to develop MDROs compared to those treated under general medicine ($OR = 0.39, 95\%\ CI\ 0.20 - 0.79, p = 0.008$). Patients who were treated under general surgery were 0.47 times less likely to develop MDROs compared to general medicine, however this result was not statistically significant ($OR = 0.47, 95\%\ CI\ 0.19 - 1.13, p = 0.09$). Surprisingly, patients with two or more co-morbid diseases were 0.47 times less likely to develop MDROs compared to patients without co-morbidities ($OR = 0.47, 95\%\ CI\ 0.22 - 0.99, p = 0.048$). Patients with two specimens were 1.78 times more likely to get MDROs compared to patients with one specimen ($OR = 1.78, 95\%\ CI\ 1.02 - 3.12, p = 0.043$), while patients with three specimens showed higher odds of developing MDROs, but not statistically significant ($OR = 2.57, 95\%\ CI\ 0.86 - 7.65, p = 0.09$)(Table 5).

Table 5. Binary logistic regressions for predictor factors

Predictor factor	OR	95% C.I	P-value
Age			0.41
25-44 years	1.37	.70 - 2.68	0.35
45-64 years	1.95	.92 - 4.14	0.08
65-79 years	1.14	.54 - 2.39	0.73
80+ years	1.11	.49 - 2.53	0.80
Gender	1.45	.90 - 2.33	0.12
Subspecialty			0.013
Medical subspecialty	.46	.27 - .80	0.006
General surgery	.47	.19 - 1.13	0.46
Surgical subspecialty	.39	.20 - .79	0.008
Duration of hospital stay			0.36
3 - 5 weeks	1.01	.58 - 1.77	0.97
6 - 8 weeks	1.66	.85 - 3.27	0.14
> 8 weeks	.94	.52 - 1.71	0.84
Comorbidity			0.13
Patients with one comorbidity disease	.65	.38 - 1.14	0.14
Patients with two or more comorbidity	.47	.22 - 0.99	0.048
Devices			0.85
Patients with one device	$2.67*10^{4}$	.00 - ∞	1
Patients with two devices	$9.66*10^{8}$	.00 - ∞	1
Patients with three devices	$4.0*10^{13}$	.00 - ∞	1
Specimens			0.050
Patient with two specimens	1.78	1.02 - 3.12	0.43
Patient with three specimens	2.57	.86 - 7.65	0.09
Ventilator	.000	.00 - ∞	1
Foley catheter	.000	.00 - ∞	1
Central line	.000	.00 - ∞	1
Constant	3.19		0.012

C.I. (confidence interval)

DISCUSSION

Elsewhere, HAIs rates among ICU patients have been reported to be higher than the rates in the general hospital, even though ICUs represent much less hospital beds when compared to general wards in any hospital (Weinstein, 1991). In the current study, the ICU represents one-twentieth

of the hospital beds. Consistent with similar studies (Al Johani et al., 2010; S Caini et al., 2013), the current study demonstrated that a significant proportion of HAIs were found in ICU patients. The current study showed overall high level of MDROs in the ICU, compared to others (Hidron et al., 2008; S Caini et al., 2013). Moreover, the present study reported higher proportion (90%) of gram negative MDROs in ICU than other studies (Kallen et al., 2010; Maragakis, 2010).
The annual summary report of the National Healthcare Safety Network (NHSN) between 2006 and 2007 showed that most patients with HAIs were adults, and the rate of patients more than 20 years was 85% (Hidron et al., 2008). Old age i.e. more 60 years has been recognised as one of important factors for HAIs (Craven et al., 1988; Legras et al., 1998). The findings of the current study were consistent with the above descriptions with a significant number of patients being adults.

Reporting of the association between hospital length of stay and the rate of HAIs including MDROS has been contradictory. Several studies have reported that the length of ICU stay was associated with increased rate of HAIs (Appelgren et al., 2001; McCusker, Périssé, & Roghmann, 2002). Similar to findings of the study by Erbay and colleagues (Erbay et al., 2003), the present study showed that the length of stay in the ICU was not a significant risk factor for MDROs. However, the type of infection has been reported to have a large influence on the length of hospital stay (McCusker et al., 2002).

Patients treated under general medicine in the present study were more likely to develop HAIs, including MDROs. This is a particularly interesting finding considering that infection control procedures within a single hospital are likely to have been similarly applied by Health Care workers across the specialities. This result was consistent with a study conducted in South Australia (Jarratt & Miller, 2013), and was contrary to previously published findings that surgical departments were associated with the highest rates of HAIs and MDROs (S Caini et al., 2013). The reasons for variation in the risk of developing HAIs within the same hospital could be a result of: undergoing several medical procedures, treatment exposure such as broad spectrum antibiotic use, differences in the demographic characteristics of patients and the services offered by different ward.

Various factors have been shown to predispose patients to MDROs infection including: patients' severity of illness, comorbidities such as renal failure, liver failure or other organ failure and surgical procedures (Safdar & Maki, 2002). The current study did not show a significant association between pre-existing conditions and MDROs, despite the fact that more than half of the patients with MDROs (51.7%) had pre-existing conditions. This lack of association between pre-existing chronic disease and HAIs could be due to various factors, including the use antibiotic. Diabetes mellitus was the predominant pre-existing condition in our study, and this is in agreement with other studies which have reported diabetes mellitus as the most common disease in patients colonised or infected with resistant organisms (Moraes et al., 2013).

In contrast to previously published findings (Mangram et al., 1999; Platt et al., 1986; Pujol et al., 1996), no significant association was found between MDROs and several medical procedures. These included intravascular catheters, urinary catheters, and mechanical ventilator support.

These findings are consistent with evidence published elsewhere (Beltrami et al., 2000; Goetz et al., 1998; Pujol et al., 1996).

Consistent with previous studies, the present study found that about half of all ICU HAIs due to MDROs, were caused by device-associated infections, and the most common types were VAP, CLABSI, and CAUTI (Calfee, 2012; Klevens et al., 2007). The most isolates were obtained from the respiratory system. This is supported by previous literature (Günseren et al., 1999).

The most common isolated organisms in the current study were *Acinetobacter* baumannii, *Pseudomonas aeruginosa, Klebsiella pneumonia, Klebsiella pneumonia* ESBL and Methicillin Resistant *Staphylococcal Aureus* (MRSA). The MDROs identified in this study are similar to those in Oliveira et al (Oliveira et al., 2007). However, there were variations in the predominant organisms in ICUs, including Vancomycin resistant *Enterococcus* (VRE) and MRSA, which seemed to be dominant in other studies (Munoz-Price & Stemer, 2010; S Caini et al., 2013). *Acinetobacter baumannii* was the most common organism isolated in the current study (Al Johani et al., 2010). This finding is significant to other studies in Saudi Arabia and it could demonstrate the endemicity of this MDRO in Saudi Arabia.
Higher levels of multidrug resistant *Acinetobacter baumannii* in this study could also be due to improved awareness, which happened after the *Acinetobacter* outbreak in 2008. Poor compliance with infection control strategies and inappropriate use of antibiotics may be part of the leading causes of the emergence of MDROs in healthcare institutions in the KFHH.

LIMITATIONS

The limitations of this study were the short duration, and the lack of available clinical information, particularly on exposure to antibiotics, prior hospitalization, transfers from other hospitals, and attributable mortality or outcome. The other limitation was the retrospective data collection which created a selection bias, and the lack of planned or required data. Our future plan is to extend the period of study to at least five years, in addition to an extensive review of the patients' clinical information to identify the risk factors that predispose these patients to infections due to MDROs.

IMPLICATIONS

- A well-designed infection control program must be constantly maintained in order to improve the quality of health care.
- A comprehensive evaluation of the surveillance system is required to assess its impact on the prevention and control of MDROs at the KFHH.
- Standard precaution measures have to be taken while caring for patients with high risk factors that predispose them to infections due to MDROs.
- Further precautions have to be in place in dealing with patients with previous infection with MDR *Acinetobacter baumannii*.

CONCLUSION

Infections due to MDROs are a growing problem in healthcare settings, especially in ICUs where they cause significant morbidity and mortality, and higher hospital costs. The greater prevalence of risk factors, for example, pre-existing medical conditions, and invasive procedures, such as central venous lines and the long duration of ICU stays, are more prominent in the KFHH ICU. Data from this setting has highlighted the changing trend of MDROs towards MDR gram negative organisms in the ICU. This result has yielded increased rates of resistance to gram negative isolates. High rates of multidrug resistant *Acinetobacter baumannii* were more prominent, in addition to *Klebsiella Pneumonia*, MRSA and *Pseudomonas aeruginosa*. In light of these results, and in order to decrease the rate of MDROs, improve patient safety and the quality of patient care, infection control strategies have to be maintained through efficient infection control programs within the hospital. Furthermore, a comprehensive evaluation of the surveillance system is required to assess its impact on the prevention and control of MDROs at the KFHH.

Conflicts of interest
There are no conflicts of interest.
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