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Antibiotic Resistance Patterns of Pathogens Isolated from Surgical Site Infections at Public Health Facilities in Belize

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Abstract

Surgical site infections are amongst the leading cause of morbidity, mortality and cost due to increased hospital stay by patients. A study was conducted to understand antimicrobial susceptibility patterns of major pathogens isolated from surgical site infections in Belize.

A study was conducted utilizing existing data for a nine-year period collected through the Belize Health Information System, Ministry of Health. Raw data from 2009 to 2017 was compiled and arranged in an orderly manner and a detailed statistical analysis was carrying out using SPSS and Microsoft-Excel. Descriptive analysis was conducted to extrapolate sensitivity patterns of isolates. From the 630 samples that were cultured only 50% (315) had pathogen growth. A single pathogen was isolated from 93.3% of the samples while multiple pathogens were isolated from 6.7% of samples. The most common pathogen was *Staphylococcus aureus* (31.1%), followed by *Escherichia coli* (17.6%), *Klebsiella spp* (13.5%), *Pseudomonas aeruginosa* (9.7%) and *Enterobacter spp.* (6.45%). Aerobic Gram negative bacteria accounted for 58.1%, while aerobic Gram positive bacteria accounted for 38.4%. Cesarean procedures accounted for the highest number of infections with 28.3% while the age group most affected was between 20 - 29 years of age. Sixty-two percent of *Staphylococcus aureus* isolates were resistant to Erythromycin whereas all of *Escherichia coli* isolates (100%) were resistant to Erythromycin. The antimicrobial resistant patterns of the pathogens showed that more than 20% of all isolates were resistant to most antibiotics in all the years of the study with some isolates were seen multidrug resistant. More than 50% of all isolates during the study period showed resistance to erythromycin. Continuous surveillance of SSIs and compliance to regulations is essential and a reduction in antibiotic usage must be targeted as this will help to reduce the development of antibiotic resistance in pathogens.

Keywords: Antibiotic Resistance; Surgical Site Infections; Multi Drug Resistance

Introduction

Infections after a surgical procedure are one of the leading causes of morbidity and mortality globally. Health care-associated infections (HAIs) are infections acquired by patients when receiving medical treatment at a healthcare institution. HAIs is a major safety concern for both health care providers and the patient, as they can present a major risk to human health when considering morbidity, mortality, increased length of hospital stays and added cost to both patient and health care system. Common HAIs include urine, blood, chest, and wound infections (Plowman *et al*. 2001) [1]. One of the most studied types of HAIs is those related to surgical procedures. These types of infections are referred to as surgical site infections (SSIs). SSIs are potential complications that can occur after surgery is done in any part of the body. As defined by the Center of Disease Control (CDC), surgical site infections can sometimes be superficial infections that happen only in the superficial layers of the skin, or in some instances involve more invasive procedures that can involve tissues under the skin, organs, or implanted material. Even though surgical site infections fall under one of the most preventable HAIs, they still represent a significant burden in terms of morbidity and mortality as well as additional costs to health systems due to increase length of hospitalization [2-4]. Surgical site infections are the major component of HAIs and microbes isolated from SSIs are also frequently associated with antibiotic resistance [5-8]. Many recent studies from various parts of the world suggest that the SSIs threaten millions of patients each year and are also a major contributor to the spread of antibiotic resistance [9-11].

Resistance to antibiotics occur when a bacterium changes its response to the use of these medicines making their use ineffective [12]. In the case of resistance, the bacteria become resistant to the antibiotic and not the other way around, were individuals were thought to become resistant to antibiotics. In the event antibiotic resistant bacteria infect humans the infections they cause are harder to treat, when compared to those caused by non-resistant bacteria [12]. The use of antibiotics has long been transformed the field of medicine and saved millions of people around the globe from many infectious diseases. The emergence of antibiotic resistant bacteria is escalating at alarming rates worldwide endangering the life of many. Several factors are said to contribute to the antibiotic crisis, primarily with the overuse of antibiotics, it is believed that the overuse of antibiotics is what has driven bacterial evolution towards resistance. Studies have established the existence of a direct relationship between antibiotic use and the occurrence and spread of bacterial strains that are resistant (Ventola 2015) [13]. Furthermore, it has been shown that incorrectly prescribed antibiotics can also contribute to the growing number of resistant bacteria; in majority of cases prescribed antibiotic treatment, specific agent, or duration of antibiotic treatment is incorrect in 30% to 50% of events contributing immensely to bacterial resistance (Luyt *et al*. 2014) [14]. In many developing countries, the problem is complicated with the lack of regulations regarding retail sale of antibiotics, the easy access to antibiotics, and sale of antibiotics without a prescription. While in other countries where prescriptions are necessary the accessibility of purchasing antibiotics online makes it easier to access in places were regulations are in place [15]. There are many microbial strategies that enable microbes to develop resistance including mutation, adaptive genes, mobile genes and horizontal gene transfer [16].

Antibiotic resistance was initially believed to be a health facility related problem, however today the antibiotic resistance phenomena has spread to the point where everyone is at risk, as more and more pathogens are becoming resistant. One contributing factor to the change in antimicrobial susceptibility is attributed to the use of antibiotics in agriculture and life stock production. Although the implications of the use of antibiotic in life stock production are not yet clear as to how it relates to the emergence and spread of antibiotic resistance, it is believed that the routine use of antibiotics in life stock production is a major contributor to the clinical problem of resistant pathogens in human medicine [17]. Antimicrobial resistance is considered to be one of the most pressing public health issues the world faces today. It is occurring worldwide, threatening the effective prevention and treatment of an increasing number of infections caused by multiple pathogens. Governments around the world are focusing attention and efforts to the problem as it undermining many other advances in the field of medicine and health. Estimates of the economic impacts of antimicrobial resistance have been carried out, and the findings are worrisome. For instance, the yearly cost to the US health system alone has been estimated at US $21 to $34 billion dollars, followed by more than 8 million additional days in hospital. Moreover considering that antimicrobial resistance affects far beyond the health sector, it is anticipated that it will cause a fall in real gross domestic product of 0.4% to 1.6%, which means several billions of dollars globally. Pathogens are adapting new resistance mechanisms and spreading globally, causing a major threat to the ability of treating common infections. The list of infections that are becoming harder to treat keep getting longer. If actions are not taken, the outcomes of infections might be disastrous and reach the point were common infections and minor injuries can cause death amongst the population [3].

An antibiogram provides an overall sensitivity profile results of specific bacterial isolates to a battery of antimicrobial drugs. Antibiograms are often used by clinicians to be able to select the correct antibiotic for causative bacteria. They serve as a guide for clinicians and pharmacist in selecting the best empiric antimicrobial therapy, in the event of pending culture and susceptibility results. This susceptibility results can be used to monitor resistance of microbes over time within an institution, or country so as to be able to track resistance trends for a time period [18]. Once antibiogram data is collected appropriately and in a continuous manner it can be used to develop yearly trends that can be used to detect changes in susceptibility of bacterial isolates. This can serve many purposes in medical institutions such as, serve as a basis for empirical treatment, guide drug formulary decisions, and changes in prescribing and infection control practices. This information can then be used to develop intervention strategies by multi-sectoral entities [19]. Despite the fact that regional and global data can provide insight on the magnitude of drug resistance, it is best if local or even institutional data is available as this is more valuable to medical providers when managing infections [20].

With this background, the current study attempts to analyze antimicrobial resistance patterns of pathogens isolated from surgical infections at public medical facilities in Belize for a 9-year period from 2009 – 2017. The objective of the study was to find any patterns in the antibiotic resistance of pathogens isolated from SSIs and the possible impact of this on the population. This analysis is important because no study of this kind has been carried out in the country, considering the morbidity and mortality rates of SSIs along with the increase in antimicrobial resistance in other parts of the world it is important to take a closer look at the situation in country. An analysis of this type is a starting point to create awareness of the antimicrobial crisis to relevant stakeholders within the Ministry of Health. This study can serve as a stepping stone to create a standard as it pertains to steps that need to be implemented by the health facilities and the Ministry of Health to tackle the problem.

Methodology

The study used existing data from the Ministry of Health and hence is primarily secondary data analysis. There is a systematic collection of information related to SSIs in Belize and there is need for analysis and interpretation of the data in order to infer certain trends in antibiotic resistance patterns of pathogens isolated. The Central Medical Laboratory (CML) receives clinical samples from various hospitals and the trained technicians at the CML run antibiogram by using a zone diameter interpretive standards chart for determination of antibiotic sensitivity and resistant status by disc diffusion method (Hombach *et al*. 2013) [21].

Data Source

Healthcare in Belize is provided through both public and private healthcare systems. The Ministry of Health (MOH) is the government agency that oversees the entire health sector and is also the largest provider of public health services in Belize. Apart from proving primary health care, the MOH also focuses in preventative health, hence the reason why surveillance systems are in place at all medical institutions. The aim of a surveillance system for HAIs is that data collected can be analyzed to identify and investigate trends of the magnitude of antimicrobial resistance and prevalence of SSIs in the country.

Data used was collected through the Belize Health Information System (BHIS), which is a network used at all public medical facilities under the Ministry of Health mandate. Data includes basic demography as well as the type of pathogens and antibiotic susceptibility results for various antibiotics. These are results for sputum samples collected from selected SSIs at public medical facilities throughout the country. Belize's health system comprises a network of health facilities providing healthcare to the country's population of 368,310; and includes 4 regional hospitals, 3 community hospital, and poly clinics. The four regional hospitals include Northern Regional Hospital (NRH), Western Regional Hospital (WRH) Southern Regional Hospital (SRH) and the Karl Heusner Memorial Hospital (KHMH) which serves a dual role both as the Central Regional Hospital and the National Referral Hospital for the country. The data provided by MOH utilizes a database on pathogens cultured at the Central Medical Laboratory (CML) and made available through BHIS. Data collection through the BHIS allows population-based, health services, and records-based data to be available to users countrywide. It connects the Ministry of Health with every registered citizen who accesses public services, hospital, lab, and pharmacy. It is comprised of a set of interdependent modules surrounding the central electronic record. Modules of BHIS includes: Admission and Discharge and Transfer, Clinician Order Entry, Laboratory, Supply Chain Management, Pharmacy, and Human Resources, Demographic data. To date, BHIS has been installed and functioning in more that thirty-three facilities country-wide. Data is supervised, reconciled and managed by the Epidemiology Unit (Figure 1).

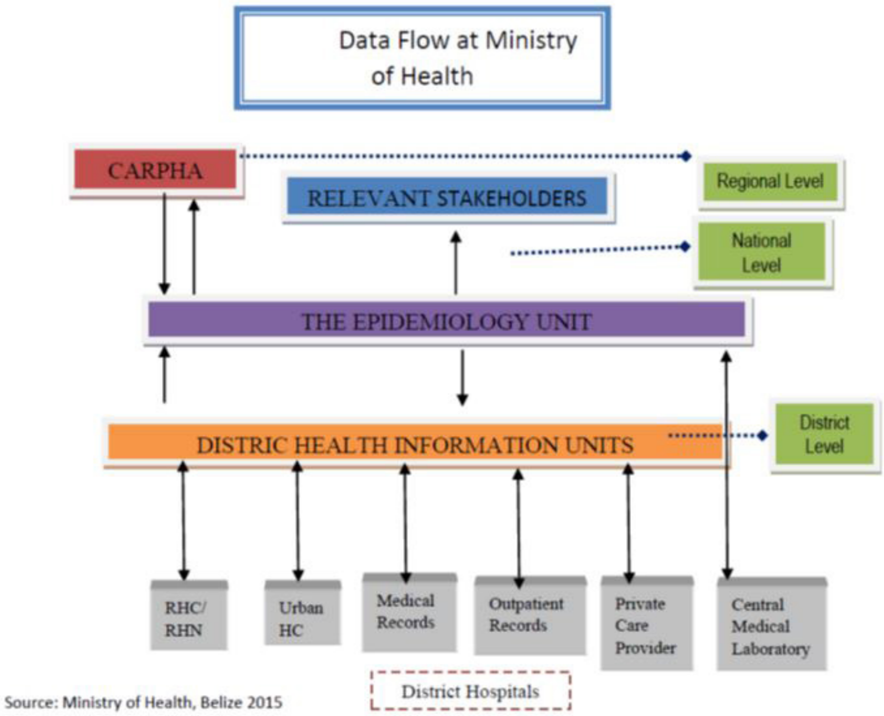


Figure 1: A graphical view on data collection through Belize Health Information System

Study Population

The study population included any person who visited any of the public medical facilities and underwent any type of surgical procedure during the period 2009-2017 and acquired an infection 30 days after the procedure. Data included selected Surgical Site Infections, namely Abscess, Amputation, Appendectomy, Cesarean, Delivery, Fracture reduction, Laparotomy, Hysterectomy, Foreign body removal, Cholecystectomy, Endoscopy.

Analysis

After raw data was collected, and extracted the initial data cleaned out and verified for any repetition or duplication. The Raw data was provided in a Microsoft Excel spread sheet with no order or arrangement since it came from different centers in a chronological order. The data was sorted, compiled and arranged in an orderly manner. Duplicate entries, pseudo entries, missing data and any other atypical errors caused by errors of data entry were removed. Data used for antibiotic susceptibility testing were sorted and cases with no antibiogram results were discarded for this section of the analysis. Statistical analysis using Microsoft excel and SPSS version 16.0 was carried out. Univariate descriptive analysis of the dataset was conducted on various epidemiological and demographical variables for the time period. General statistics such as frequency tables, rates, and proportions were carried out and depicted in graphs. Cross tabs were carried out in SPSS to analyze the susceptibility patterns of pathogens to the different antibiotics.

Results

Data compiled for analysis was collected through the Belize Health Information Unit. A total of 630 infections resulting from surgical procedures were recorded for the period 2009 to 2017.This comprised of 630 infections for the period 2009- 2017. From the total of 630 cultures only 50% (315) cases where pathogens were isolated from SSIs and the remaining 50% (315) had no organisms isolated. Descriptive analysis was carried out with data set of 315 surgical site infections that were positive for isolates for several variables, including distribution per year, gender, age-group, pathogens isolated and susceptibility analysis of isolates to antimicrobials. An increase in the number of infections can be seen throughout the years, with the year 2013, 2014 and 2015 accounting for the biggest proportion of infections through the nine-year period, with 21.4%, 14.3% and 15.5% respectively (Table 1).

Year	# of infections
2009	15
2010	17
2011	33
2012	67
2013	135
2014	90
2015	98
2016	86
2017	89
Grand Total	630

Table 1: Number of Surgical Site Infections for 2009-2017

Female patients outnumbered male patients with 67.9 % being female, while males accounted for only 32.1% (Table 2). Since many of the cases were reproductive system related illnesses including caesarian, hysterectomy, etc.

Gender	Frequency	(%)
Male	101	32.1
Female	214	67.9
Total	**315**	**100.0**

Table 2: Sex Distribution of Patients

The age-group with the highest number of isolates from the 315 culture samples collected were those from 20-29 year with 94 (29.8 %), followed by those in the age-group 10-19 years with 50 (15.9%), and those with 65+ years with 41(13%) (Table 3). This also due to the fact females in the age group of 20 to 29 were the reproductively active group as many of the surgeries are related to delivery and related issues.

Age group	No.	(%)
0-9	26	8.3
10-19	50	15.9
20-29	94	29.8
30-39	37	11.7
40-49	39	12.4
50-59	28	8.9
65+	41	13.0
Total	**315**	**100**

Table 3: Age-group of patients from whom pathogens were isolated

Table 4 shows the geographic distribution of patients Belize district comprised of the majority of cases with 45.4% (143), followed by the Cayo district with 30.2% (95) and Stann Creek district with 10.2% (32). 58.4% being from urban communities and 41.58% from the rural communities. Since Belize City is the major population center in the country with more than 20% of the people live in the City, it is expected to have more number of patients.

District	No.	(%)
Corozal	6	1.9
Orange Walk	17	5.4
Belize	143	45.4
Cayo	95	30.2
Stann Creek	32	10.2
Toledo	22	7.0
Total	**315**	**100**

Table 4: Cases Distributed by District of Residence

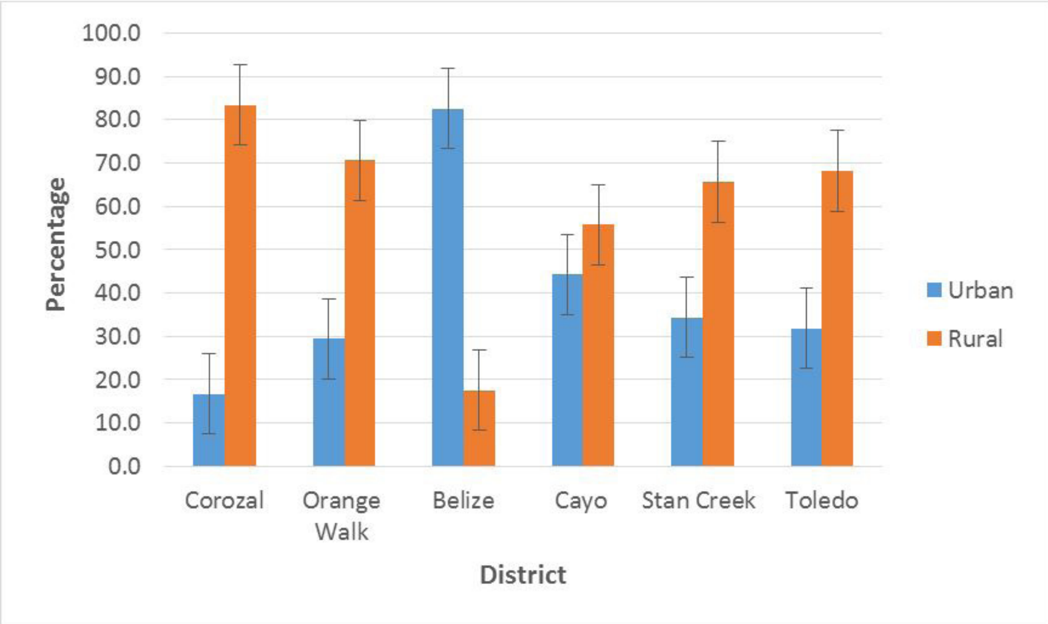


Figure 2: Percentage Distribution of Cases by Urban and Rural Communities per District

In the Belize district the highest proportion of cases were from the urban area with 82.5% and the remaining 17.5% cases from rural Belize. In five of the six districts the majority of cases were from people who reside in rural communities (Figure 2).

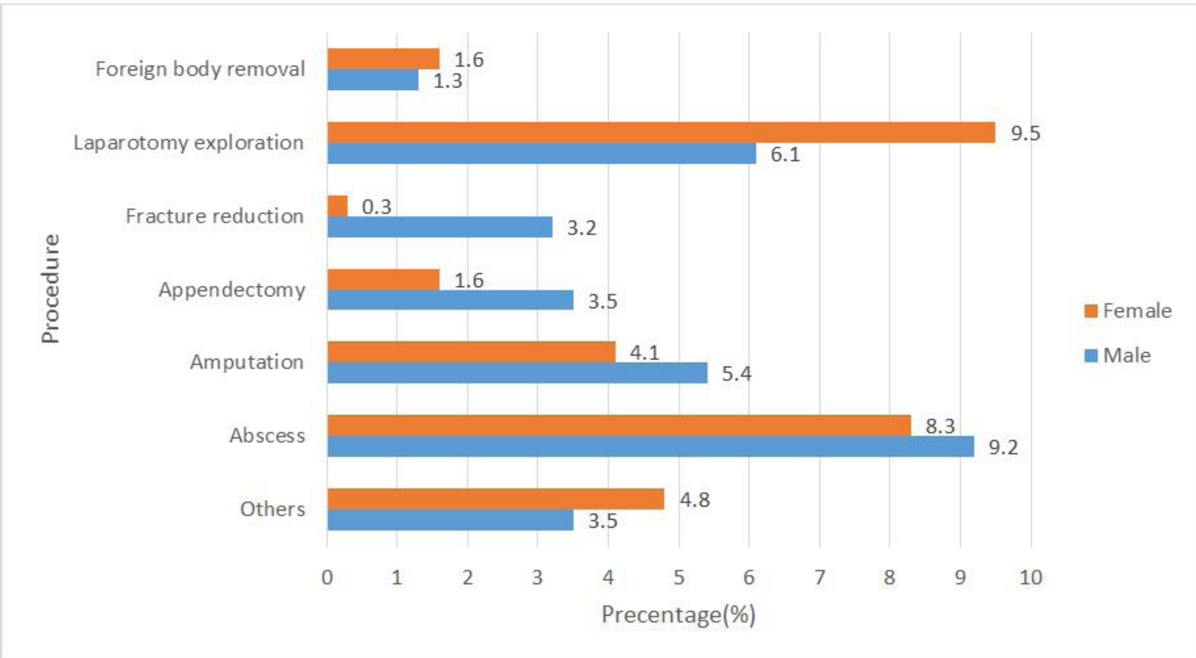


Figure 3: Type of Surgical Procedure by Gender

Abscess accounted for 17.5 % (55) of the positive infected surgical procedures, Laparotomy exploration with 15.6 % (49) and Amputations with 9.5% (30). Males accounted for a higher percentage of the Abscess infections than females with 9.2% of a total 17.5%. However when looking at Laparotomy exploration, females accounted for a higher percentage of 9.5% of a total 15.6% and this is due to the fact reproductive system related surgeries were more frequent in female population than in males (Figure 3). In infected Amputations, males accounted for the highest proportion with 5.4% of a total 9.5%. In Fracture reduction males accounted for the majority of infected cases with 3.2% while females accounted for 0.3%.

Organisms	**No.**	**(%)**
Acinetobacter spp	3	0.88
Citrobacter spp	3	0.88
Enterobacter spp	22	6.45
Enterococcus fecalis	6	1.76
Esherichia coli	60	17.60
Klebsiella spp	46	13.49
Morganella morgana	5	1.47
Proteus spp	18	5.28
Providencia spp	7	2.05
Pseudomonas aeruginosa	33	9.68
Serratia marcessens	1	0.29
Staphylococcus aureus	106	31.09
Staphylococcus epidermidis	17	4.99
Streptococcus group B	2	0.59
Other Bacterial Pathogens	10	2.93
Grand Total	**339**	**99.41**

Table 5: Bacterial Isolates Recovered From Surgical Site Infections

From the 315 positive culture samples, a single pathogen was isolated from 294 (93.3%) patients and multiple pathogens were identified from 21(6.7%) cases. A total of 341 pathogenic isolates were cultured from the infections, comprising of 15 different organisms. *Staphylococcus aureus* was the pathogen that was most frequently isolated with 31.09%. *Escherichia coli, Klebsiella spp, Pseudomonas aeruginosa* and *Enterobacter spp*. accounted for 17.6%, 13.49%, 9.68% and 6.45% of the total number of isolates respectively (Table 5).

Organism	**No**	**(%)**
Enterococcus fecalis	6	1.76
Staphylococcus aureus	106	31.09
Staphylococcus epidermidis	17	4.99
Streptococcus group B	2	0.59
	131	**38.42**

Table 6: Aerobic Gram Positive Organisms

Organism	**No**	**(%)**
Esherichia coli	60	17.60
Pseudomonas aeruginosa	33	9.68
Klebsiella spp	46	13.49
Morganella morgana	5	1.47
Proteus spp	18	5.28
Providencia spp	7	2.05
Serratia marcessens	1	0.29
Enterobacter spp	22	6.45
Citrobacter spp	3	0.88
Acinetobacter spp	3	0.88
	198	58.06

Table 7: Aerobic Gram Negative Organisms

Aerobic gram positive bacteria accounted for 38.42% (131) of the total number of organisms isolated (341) (Table 6). *Staphylococcus aureus* constituted of 80.9% of the gram positive pathogens. Aerobic gram negative bacteria accounted for 58.06% of the total number of isolates. *Escherichia coli, Klebsiella spp* and *Pseudomonas aeruginosa* constituted 30.3%, 23.2% and 16.7% of the gram negative pathogens respectively. Other bacterial pathogens isolated accounted for 2.3%.

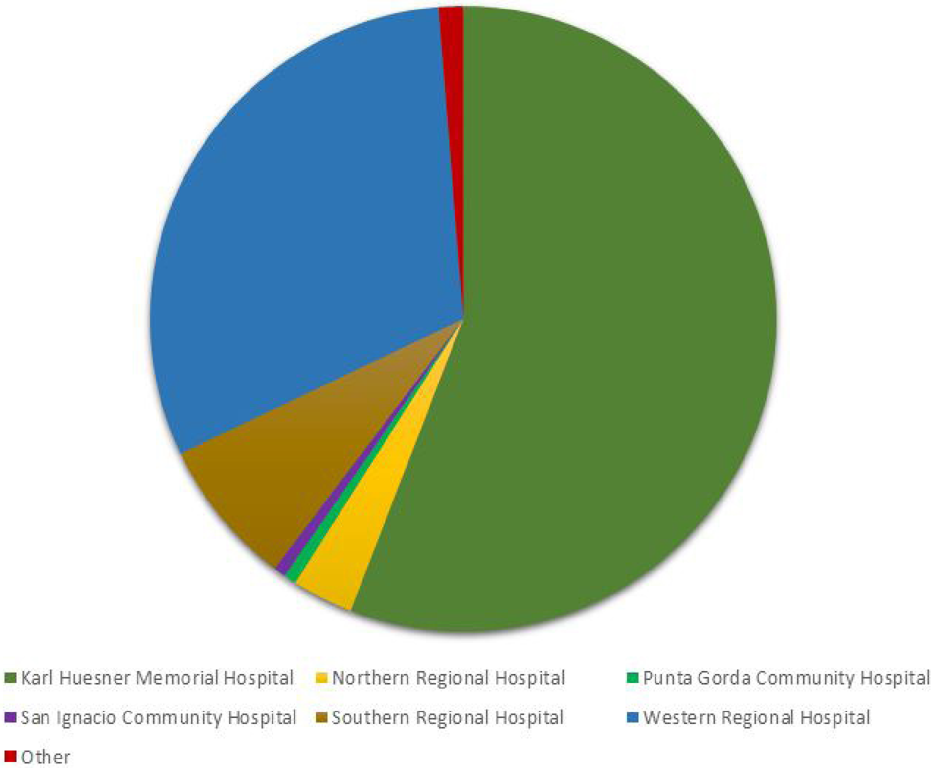


Figure 4: Positive Culture Samples by Facility

Karl Huesner Memorial Hospital and Western Regional Hospital accounted for highest percent of positive samples collected with 55.9% (176) and 30.8% (97) respectively (Table 7). The smallest proportion of samples are seen in the community hospitals, being Punta Gorda Community hospital, San Ignacio Community Hospital. Under the "other" category, BCVI and Matron Roberts Health center was included with two samples each contributing to 1.3% (4) of the positive samples (Figure 4).

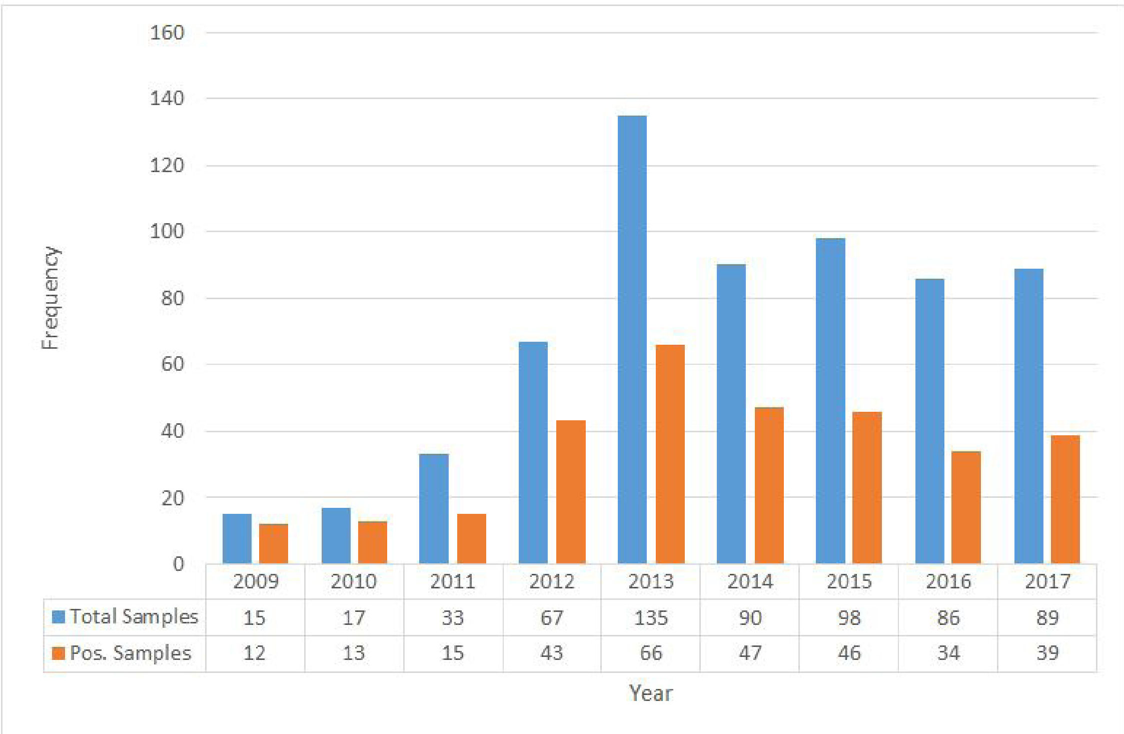


Figure 5: Total Number of Samples versus Number of Positive Samples

For the year 2009, 80 % (12) of the infections were positive, in 2010 76.5% (13), in 2011 45.5% (15), in 2012 64.2% (43), in 2013 48.9 % (66), in 2014 52.2% (47), in 2015 46.9% (46), in 2016 39.5% (34) and in 2017 43.8% (39). Although in the year 2013 accounts for the highest proportion of positive samples in the overall nine year period, the year 2009 and 2010 had the highest proportion of positive culture samples when compared to samples collected per year (Figure 5).

Antimicrobial Sensitivity Analysis

From the 341 different isolates of pathogens 5.9% (20) had no results for sensitivity analysis therefore, for the purpose of sensitivity results unscreened isolates were disregarded and the data set for pathogen sensitivity encompassed 321 isolates.

Organism	No. of Isolates	No. Isolates resistant (No. tested) % resistant									
		Ami	Amx/Cl	Cefa	Cipr	Eryt	Gent	Imip	Tetra	Trim/ Sulph	Vanc
Acinetobacter spp	3	1(3) 33.3%	---	3(3) 100%	2(2) 100%	---	1(2) 50%	0(3) 0%	0(3) 0%	2(2) 100%	---
Citrobacter spp	3	0(3) 0%	0(1) 0%	0(3) 0%	0(2) 0%	---	0(3) 0%	0(2)	---	---	---
Enterobacter spp	22	1(22) 4.5%	10(10) 100%	7(16) 43.8%	4(17) 23.5%	---	4(19) 21.1%	0(13) 0%	1(5) 20%	8(14) 57.1%	---
Enterococcus fecalis	6	---	---	---	1(4) 25%	1(3) 33.3%	2(2) 100%	---	4(6) 66.7%	---	0(3) 0%
Esherichia coli	60	3(56) 5.4%	2(25) 8%	2(34) 5.9%	26(54) 48.1	1(1) 100%	14(52) 26.9%	0(35) 0%	15(22) 68.2%	16(31) 51.6%	---
Klebsiella spp	46	2 (43) 4.7%	7(21) 33.3%	1(22) 4.5%	15(44) 34.1%	---	23(41) 56.1%	0(29) 0%	6(9) 66.7%	20(32) 62.5%	---
Morganella morgana	5	0(5) 0%	1(1) 100%	1(5) 20%	0(4) 0%	---	0(5) 0%	0 (4) 0%	1(1) 100%	2(4) 50%	---
Proteus spp	18	0(17) 0%	1(9) 11.1%	0(15) 0%	1(14) 7.1%	0(1) 0%	2(16) 12.5%	0(12) 0%	3(3) 100%	2(11) 18.2%	---
Providencia spp	7	0(7) 0%	5(5) 100%	0(6) 0%	2(7) 28.6%	---	0(5) 0%	0(4) 0%	1(2) 50%	1(4) 25%	---
Pseudomonas aeruginosa	33	4 (32) 12.5%	3(3) 100%	7(30) 23.3%	1(30) 3.3%	---	5(28) 17.9%	1(20) 5%	3(3) 100%	1(1) 100%	---
Serratia marcessens	1	0(1) 0%	---	0(1) 0%	0(1) 0%	---	0(1) 0%	0(1) 0%	---	---	---
Staphylococcus aureus	106	1 (8) 12.5%	9(16) 56.3%	---	36(94) 38.3%	64(103) 62.1%	11(95) 11.6%	3(5) 60%	21(92) 22.8%	7(88) 8%	5(93) 5.4%
Staphylococcus epidermidis	2	---	---	---	1(1) 0%	2(2) 100%	1(1) 100%	---	1(2) 50%	0(1) 0%	0(2) 0%
Other Bacterial Pathogens	9	1 (4) 25%	0(1) 0%	2(5) 40%	3(5) 60%	2(3) 66.7%	1(5) 20%	0(1) 0%	3(5) 60%	2(6) 33.3%	0(2) 0%
Total	**321**	**13(201) 6.5%**	**38(92) 41.3%**	**23(140) 16.4%**	**92(279) 33%**	**70(113) 62%**	**64(275) 23.3%**	**4(129) 3.1%**	**59(153) 38.6%**	**61(194) 31.4%**	**5(100) 5%**

(--- not tested for antibiotic) Amikacin (Amik), Amoxicillin /Clavulanate (Amx/Cl), Ceftazidime (Cefa), Ciprofloxacin (Cipr), Erythromycin (Eryt), Gentamicin (Gent), Imipenem (Imip), Tetracycline (Tetra), Trimethoprim/Sulphamethoxzole (Trim/Sulph), Vancomycin enterococci (Vanc)

Table 8: Sensitivity Profile of Bacterial Isolates from Surgical Site Infections

The sensitivity of the pathogens varied, with most being multi-drug resistant, with the exception of *Serratia marcessens* and *Citrobacter spp*, which were not resistant to any of the antibiotics screened (Table 8).

S. aureus has 51 (49.1%) isolates that show resistance to 2 or more antibiotics, while 54.3% of Klebsiella spp and 19 of E. coli isolates were resistant to two or more of antibiotics tested.

The highest percentage of isolates were resistant to Erythromycin (62%), followed by Amoxicillin /Clavulanate (41.3%). More than 30% of the isolates were resistant to Ciprofloxacin, Tetracycline and Trimethroprim/Sulphamethoxzole (Table 9).

No Antibiotics Resistant	E. coli (n=60)	S. aureus (n=106)	Klebsiella spp (n=46)
2	9	31	12
3	6	14	7
4+	4	6	6
Total	**19**	**51**	**25**

Table 9: Multi-drug resistant strains of top three isolates

Organism	No. of Isolates	Imip	Tetra	Ami	Amx/Cl	Trim/ Sulph	Eryt	Cipr	Vanc
Enterobacter spp	22	0(13) 0%	1(5) 20%	1(22) 4.5%	10(10) 100%	8(14) 57.1%	---	4(17) 23.5%	---
Esherichia coli	60	0(35) 0%	15(22) 68.2%	3(56) 5.4%	2(25) 8%	16(31) 51.6%	1(1) 100%	26(54) 48.1%	---
Klebsiella spp	46	0(29) 0%	6(9) 66.7%	2(43) 4.7%	7(21) 33.3%	20(32) 62.5%	---	15(44) 34.1%	---
Pseudomonas aeruginosa	33	1(20) 5%	3(3) 100%	4(32) 12.5%	3(3) 100%	1(1) 100%	---	1(30) 3.3%	----
Staphylococcus aureus	106	3(5) 60%	21(92) 22.8%	1(8) 12.5%	9(16) 56.3%	9(16) 56.3%	64(103) 62.1%	36(94) 38.3%	5(93) 5.4%

Table 10: Sensitivity Analysis for Top Five Isolates

Sensitivity analysis showed that *Enterobacter spp* are resistant to Amoxicillin/Clavulanate with 100% isolates tested were resistant, followed by 57.1% isolates being resistant to Trimethroprim/Sulphamethoxzole. However this bacteria was less resistant to Imipenem and Amikacin with 0% and 4.5% isolates being resistant respectively (Table 10). *Escherichia coli* were resistant to Erythromycin and Tetracycline with 100% and 68.2% respectively. This bacteria were less resistant to Imipenem and Amikacin with 0% and 5.4% respectively. *Klebsiella spp* were resistant to Tetracycline and Trimethroprim/Sulphamethoxzole with 66.7% and 62.5% respectively. They were less resistant to Imipenem and Amikacin with 0% and 4.7% respectively. *Pseudomonas aeruginosa* were highly resistant to Tetracycline, Amoxicillin/Clavulanate and Trimethroprim/Sulphamethoxzole, testing 100% resistant for all isolates tested in each. However they were less resistant to Ciprofloxacin and Imipenem with 3.3% and 5% respectively. *Staphylococcus aureus*, sensitivity profile showed greater resistance to Erythromycin, Imipenem and Amoxicillin/Clavulanate with 62.1%, 60% and 56.3% respectively.

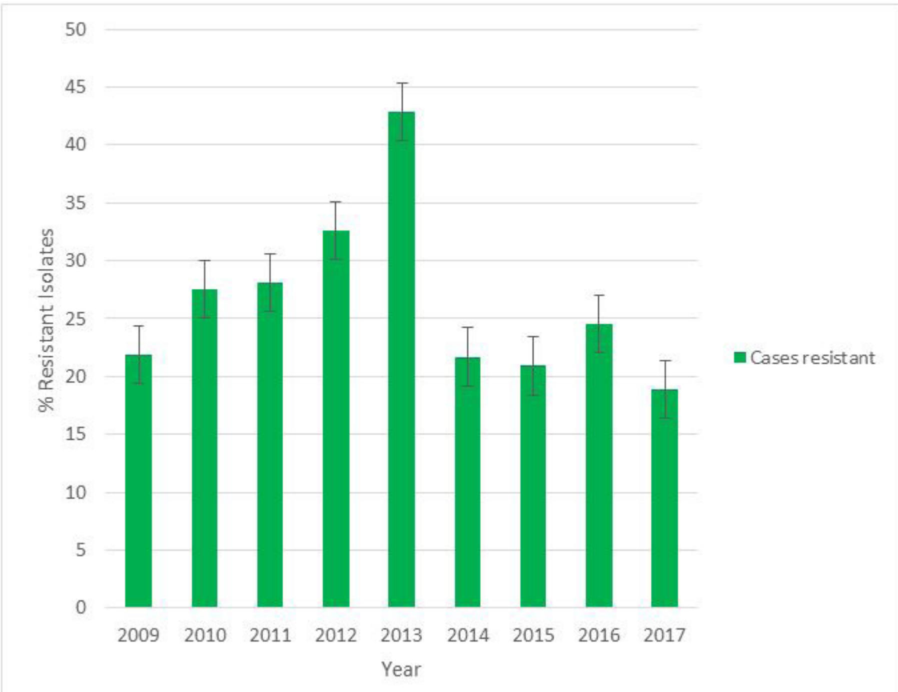
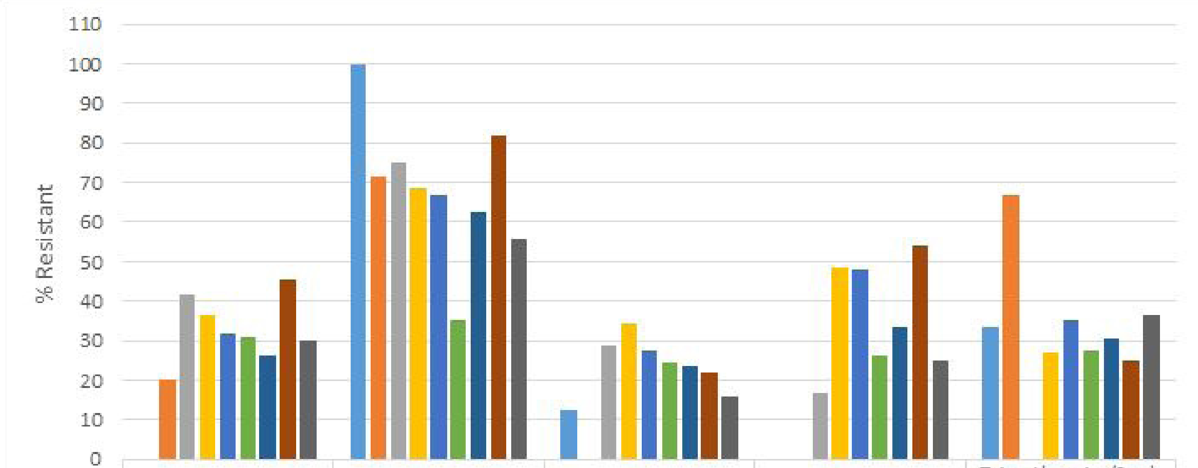


Figure 6: Percentage Pathogens Resistant per Year

A gradual increase in percentage of isolates resistant to antibiotics screened can be seen from 2009-2013 with a peak in 2013, however from 2014-2017, no such increase is observed (Figure 6).



	Ciprofloxacin	Erythromycin	Gentamicin	Tetracycline	Trimethoprim/Supha
2009	0	100	12.5	0	33.3
2010	20	71.4	0	0	66.7
2011	41.7	75	28.6	16.7	0
2012	36.6	68.4	34.5	48.3	26.9
2013	31.8	66.7	27.3	48	35
2014	30.8	35	24.3	26.1	27.3
2015	26.2	62.5	23.7	33.3	30.3
2016	45.5	81.8	21.9	53.8	25
2017	30	55.6	15.8	25	36.4

Figure 7: Percentage Isolates Resistant to Diverse Antimicrobials per Year

The number of isolates resistant to antimicrobials showed fluctuation over the study period with some inreases and decreases over the years (Figure 7). A larger percentage of microbes are resistant to Erythromycin ranging from 100% resistant to 35% resistant, in the case of the antibiot0ic Trimethoprim/ sulphamethoxaloe percentage of pathogens resistant range from 66.7 to 0% resistant. Percentage pathogens resistant to Ciprofloxacin range from 45.5 to 0% resistant. Tetracycline ranges from 53.8 to 0% resistant and Gentamicin percentage resistant range from 34.5 to 0% accounting for the smallest percentage of isolates resistant. From the year 2010 to 2017 more than 20% of isolates were resistant to Ciprofloxacin. More than 35% of isolates were resistant to Erythromycin through the entire 9 year period of study (Figure 7). The reason for such a drastic resistance to Erythromycin could be due to either due to erythromycin induced or constitutive resistance mechanism [22].

From 2011 to 2017 an increase in proportion of isolates were resistant to Gentamicin, with over 15% of isolates testing resistant. From 2011 to 2017 an increase in resistance to tetracycline is seen. With the exception of the year 2011, over 25% of isolates were resistant to Trimethroprim.

On the graphs below, the analysis of resistance pattern of *E.coli* and *S. aureus* to Gentamicin, Ciprofloxacin and Trimethroprim/ Sulphaethozaloe show no defined patterns of resistance, as it a constant fluctuates can be seen thought the years (Figure 7).

Discussion

The study provides an insight of the major causative pathogens of post-operative surgical site infections and their sensitivity profile for Belize from 2009 to 2017. For bacterial infections to be successfully managed, early identification of bacterial pathogens along with the selection of effective antibiotic are key. Antibiotics are one of the main players in modern medical care as it plays a major role as both prophylaxis and treatment of infectious diseases [6]. Findings showed that the year with the highest proportion of surgical infections was in the year 2013 with the highest surgical site infections accounting for 21.4% of the infections for the 9 year period of study. Throughout this study period an increase on the number of surgeries that resulted in an infection can be seen. However, this could be attributed to an increase in the number of surgeries in that year. Of the total number of culture samples that were collected and tested 50% were positive for isolates, with the next half yielding no bacterial growth. Past studies show that potential causes of culture-negative surgical site infections could be attributed to prior antimicrobial therapy; the presence of fastidious or slowgrowing microorganisms such as mycobacteria, *Mycoplasma* spp., and *Legionella* spp.; common infection caused by bacteria may be dismissed as contaminants of samples [23]. However, they may be the actual causative agent of the infection at surgical sites. Most of the infections had a single pathogen isolated (93.3%) while 6.7% were polymicrobial infections. However another study showed that 43.8% of the infections in their study were polymicrobial in origin [7].

Staphylococcus aureus and Escherichia coli were the most frequently isolated organisms from SSIs with 31.9% and 17.6% respectively. These findings are similar to those of other studies which reported *Staphylococcus aureus* and Escherichia coli as the primary microorganism infecting surgical wounds. Another study done in Africa reported 24.3% and 23.4% of their SSIs were positive for *Escherichia coli* and *Staphylococcus aureus* respectively [24]. Furthermore another study reported that 48% of the SSIs in their study were due to *S. aureus,* thus accounting for the most frequent isolate in their study [25]. The abundance of Staphylococcus aureus in SSIs can be attribute to the invasive properties of the bacteria. The fact that *S. aureus* is a normal microbiota of the skin, could be a major contributor for the entry of the pathogen into the surgical wound during a procedure.

The surgical procedure which constituted for the highest number of infections was cesarean-section followed by abscess and amputations. Female related procedures, such as cesarean section, delivery and hysterectomy accounted for 37.8% of SSIs. This can be directly correlated to the fact that the highest proportion of cases was females which accounted for 67.9% of the study population. The age group that was mostly affected was those from 20-29 years. The current findings showed that 58.06% of SSIs were due to Gram negative bacteria and 38.4% of SSIs were due to Gram positive bacteria showing a predominance of Gram negative bacterial isolates in SSIs. A gradual increase in percentage of isolates resistant to antibiotics screened was observed from 2009-2013. However, from 2014-2017, no such increase is observed. This could be associated, increase in personal therefore more monitoring, as well as changes in polices and treatment processes undertaken by the Ministry of Health. There is no clear trend in antibiotic susceptibility/ resistance patterns for the pathogens studied during the period of study in Belize, antimicrobial sensitivity of pathogens varied, however results showed that majority isolates were multi-drug resistant, with most of the isolates being resistant to at least five of the antibiotics used during antimicrobial sensitivity testing. The highest percentage of resistance was seen for Erythromycin (62%) of isolates screened. Followed by 41.3% being resistant to β-Lactam antibiotic, Amoxicillin /Clavulanate. This resistance patterns are similar to those obtained in other studies, were similar resistance patterns are seen for β-Lactam antibiotics with 59.3% resistance in a previous study [5]. Additionally, more than 30% of the isolates were resistant to Ciprofloxacin, Tetracycline and Trimethroprim / Sulphamethoxzole.

The study showed that many of the isolates of *Staphylococcus aureus* were resistant to a range of antibiotics used in this study, with 51(49.1%) being resistant to two or more antibiotics. This is of concern as Methicillin-resistant *Staphylococcus aureus* is a major risk factor to many infections. The highest proportion or *S. aureus* were resistant to Erythromycin 62.1% and Imipenem 60%. This is similar to an earlier study where 60% of the isolates were resistant to Erythromycin [22, 26]. All the isolates of *Escherichia coli* were resistant to Erythromycin and 68.2% of the isolates were resistant to Tetracycline. However all E. coli isolates tested in this study were susceptible to Imipenem. *Pseudomonas aeruginosa* isolates showed high percentage (100%) resistance to Tetracycline, Amoxicillin/ Clavulanate and Trimethroprim /Sulphamethoxzole. Though, this bacterial isolates were less resistant to Ciprofloxacin with 3.3%. The sensitivity patterns were somewhat different for this isolated when compared to other studies [8], where results showed *E. coli* exhibited lower resistance of 19% to Trimethoprim/sulfamethoxazole and zero resistance to Amikacin and carbapenems. Since this study is based on secondary data from the public health data base, there are some gaps in the data for certain antibiotics for specific years (Figure 7).

Conclusion

The resistance patterns show a fluctuation in number of resistant isolates over the years. The antimicrobial resistant patterns of many pathogens showed that more than 20% of all isolates were resistant to most antibiotics in all the years of the study with some isolates were seen multidrug resistant. The most commonly isolated pathogens were *S. aureus* and *E. coli* followed by *Klebsiella spp* and *P. aeruginosa*. On antimicrobial susceptibility testing, Imipenem was the most effective drug, followed by Amikacin, and Gentamicin for overall bacterial isolates. More than 50% of all isolates during the study period showed resistance to erythromycin. This study give us an idea about the current incidence of SSIs throughout the country and the most common pathogens associated with this infections. The increasing number of infections equally alter the increase in antimicrobial resistant pathogens. The active number of isolates resistant to antibiotics is alarming and shows the need for actions. Although it is understandable that surgical site infections cannot be completely eliminated, a reduction in the infection rate to a minimal level can have significant benefits, such as a reduction in morbidity and mortality as well as a decrease in the cost of health care to both patient and health facility. Continuous surveillance of SSIs is essential to monitor the antibiotic sensitivity patterns of pathogens as this will help in the selection of proper treatment for infections. An overall reduction in antibiotic usage must also be targeted as this will help to minimize the development of antibiotic resistance. Further studies to look at the overuse and over prescription of antibiotics is key to understand the cause of growth in bacterial resistance.

References

1. Plowman R, Graves N, Griffin MA, Roberts JA, Swan AV, et al. (2001) The rate and cost of hospital-acquired infections occurring in patients admitted to selected specialties of a district general hospital in England and the national burden imposed. J Hosp Infect 47: 198-209.

2. Centers for Disease Control and Prevention (2013) Office of Infectious Disease Antibiotic resistance threats in the United States, USA.

3. World Health Organization (2014) Antimicrobial resistance global report on surveillance 2014, USA.

4. Barie PS (2002) Surgical Site Infections: Epidemiology and Prevention. Surg Infect 3: 9-21.

5. Bastola R, Parajuli P, Neupane A, Paudel A (2017) Surgical Site infections: Distribution Studies of Sample, Outcome and Antimicrobial Susceptibility Testing. J Med Micro & Diag 6: 1-7.

6. Abula T, Kedir M (2004) The pattern of antibiotic usage in surgical in-patients of a teaching hospital, northwest Ethiopia. Ethiopian J Health Dev 18: 35-8.

7. Akinkunmi EO, Adesunkanmi AR, Lamikanra A (2014) Pattern of pathogens from surgical wound infections in a Nigerian hospital and their antimicrobial susceptibility profiles. Afr Health Sci 14: 802-9.

8. Călina D, Docea AO, Rosu L, Zlatian O, Rosu AF, et al. (2017) Antimicrobial resistance development following surgical site infections. Mol Med Rep 15: 681-8.

9. Cantlon CA, Stemper ME, Schwan WR, Hoffman MA, Qutaishat SS (2006) Significant pathogens isolated from surgical site infections at a community hospital in the Midwest. Am J Infect Control 34: 526-9.

10. Kirby JP, Mazuski JE (2009) Prevention of Surgical Site Infection. Surgical Clinics of North America 89: 365-89.

11. Giacometti A, Cirioni O, Schimizzi AM, Del Prete MS, Barchiesi F, et al. (2000) Epidemiology and microbiology of surgical wound infections. J Clinical Microbiol 38: 918-22.

12. Read AF, Woods RJ (2014) Antibiotic resistance management. Evol Med Public Health 2014: 147.

13. Ventola CL (2015) The antibiotic resistance crisis: part 1: causes and threats. Pharmacy and Therapeutics 40: 277-83.

14. Luyt CE, Brechot N, Trouillet JL, Chastre J (2014) Antibiotic stewardship in the intensive care unit. Crit Care 18: 480.

15. Michael CA, Dominey-Howes D, Labbate M (2014) The antimicrobial resistance crisis: causes, consequences, and management. Front public health 2: 145.

16. Michael CA, Gillings MR, Holmes AJ, Hughes L, Andrew NR, et al. (2004) Mobile gene cassettes: a fundamental resource for bacterial evolution. Am Nat 164: 1-12.

17. Chang Q , Wang W , Regev-Yochay G, Lipsitch M, Hanage WP (2015) Antibiotics in agriculture and the risk to human health: how worried should we be . Evol Appl 8: 240-7.

18. Joshi S (2010) Hospital antibiogram: A necessity. Indian J Med Microbiol 28: 275-6.

19. Halstead DC, Gomez N, McCarter YS (2004) Reality of developing a community-wide antibiogram. J Clin Microbiol 42: 1-6.

20. O'Brien TF (1997) The global epidemic nature of antimicrobial resistance and the need to monitor and manage it locally. Clin Infect Dis 24: 2-8.

21. Hombach M, Zbinden R, Böttger EC (2013) Standardisation of disk diffusion results for antibiotic susceptibility testing using the sirscan automated zone reader. BMC Microbiol 13: 225.

22. Giovanni G, De Florio L, Lorino G, Fico L, Dicuonzo G (2009) Macrolide resistance genotypes and phenotypes among erythromycin-resistant clinical isolates of Staphylococcus aureus and coagulase-negative staphylococci, Italy. FEMS Immunol Med Microbiol 55: 62-7.

23. Rasnake MS, Dooley DP (2006) Culture-Negative Surgical Site Infections. Surgical Infect 7: 555-65.

24. Amare B, Abdurrahman Z, Moges B, Ali J, Muluken L, et al. (2011) Postoperative Surgical Site Bacterial Infections and Drug Susceptibility Patterns at Gondar University Teaching Hospital, Northwest Ethiopia. J Bacteriol Parasitol 2: 1-8.

25. Manian FA, Meyer PL, Setzer J, Senkel D (2003) Surgical Site Infections Associated with Methicillin-Resistant Staphylococcus aureus: Do Postoperative Factors Play a Role? Clin Infect Dis 36: 863-8.

26. Piatkowska E, Piatkowski J, Przondo-Mordarska A (2012) The strongest resistance of Staphylococcus aureus to erythromycin is caused by decreasing uptake of the antibiotic into the cells. Cell Mol Biol Lett 17: 633-45.

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