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Original Research Article

The Increasing Incidence of ESKAPE Pathogens in Surgical Site Infections (SSI) of a Tertiary Care Referral Centre

Syed Quibtiya Khursheed[1], Bushra Rashid Sahaf[2], Talat Masoodi[3]*, Azhar Shafi[4], Adil Hussain Shah[5]

[1]Assistant Professor, Department of General Surgery, SKIMS Medical College, Srinagar.
[2]Assistant Professor, Department of Pathology, SKIMS Medical College, Srinagar.
[3]*Assistant Professor, Department of Microbiology, SKIMS Medical College, Srinagar
[4]PhD Scholar, Department of Microbiology, SKIMS Medical College, Srinagar
[5]MSc, Department of Microbiology, SKIMS Medical College, Srinagar

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Corresponding Author: Dr. Talat Masoodi
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Abstract:

Background: Healthcare facilities, especially tertiary care referral centres, have a serious problem with surgical site infections (SSI). The increasing number of Enterococcus faecium, Staphylococcus aureus, Klebsiella pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa, and Enterobacter (ESKAPE) pathogens being isolated from Surgical Site Infections (SSI) is the rising concern for healthcare practitioners. The reason behind this being their capability of causing serious infections which are resistant to the standard medications. It warrants further research since it poses a serious threat to public health care systems.

Research Question: what is the incidence of ESKAPE pathogens related to SSI in the setting of a tertiary care referral centre and what are the risk factors linked with the presence of these pathogens?

Aim: Within the context of a tertiary care referral centre, this study aims to ascertain the prevalence of ESKAPE infections in SSI and their associated risk factors. According to our hypothesis, ESKAPE bacteria are often found in surgical site infections (SSI) at our tertiary care referral centre, and we believe that the presence of these pathogens is connected with specific patient and surgical characteristics.

Materials & methods: Over a period of one year, from January 4, 2023, to January 3, 2024, we examined the prevalence of ESKAPE bacteria in SSI at a tertiary care referral centre. The Microbiology and the General Surgery departments provided observations. Patients or their legal guardians provided written consent to use their data, and the research was authorised by the Institutional Review Board and the ethics committee.

Results: The study found that 67.4% of surgery site infections were in male patients and 32.6% were in female patients. Most cases were aged 20-40, with a mean age of 38.4. The study found that 30.1% of surgical wound samples grew bacteria, with 10.8% having double bacterial infections. The total number of bacteria isolates was 417, from ten genera. The most common bacteria were Staphylococcus aureus, K. pneumoniae, Coagulase Negative Staphylococcus, and P. aeruginosa, with a gram-positive to gram-negative ratio of 0.782:1. The study found that men accounted for 64.9% of isolated pathogens, while women post-surgical patients, accounted for 35.1%. The majority were male, with no significant gender and culture positivity link. The majority lived in rural areas.

Conclusion: Due to antibiotic resistance and improper drug administration, ESKAPE bacteria are increasingly causing SSIs, challenging the healthcare setup. To tackle this, healthcare facilities must emphasize prevention, the intelligent use of antibiotics, and ground-breaking therapies.

Keywords: Surgical site infections; Enterococcus faecium; Staphylococcus aureus; Klebsiella pneumoniae; Acinetobacter baumannii; Pseudomonas aeruginosa; Enterobacter species.

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Introduction

With their high incidence, longer hospital stays, and exorbitant expenditures, surgical site infections (SSIs) are one of the biggest concerns in healthcare today. Worldwide, SSIs rank high among healthcare-associated infections (HAI), despite advances in surgical techniques, infection control, and effective antibiotic therapy. The increasing prevalence of drug-resistant ESKAPE infections is a major contributor to the problem. Many common hospital-acquired infections are caused by bacteria that are able to evade the effects of antibiotics. These include Enterococcus faecium, Staphylococcus

aureus, Klebsiella pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa, and Enterobacter species [1-4].” In tertiary care referral centres, where patients frequently have significant health conditions, the incidence of ESKAPE infections in SSIs, as well as the impact of these pathogens, are particularly worrying [1-3]. Infections are more likely to occur at these centres because they deal with patients who go through high-risk procedures and people who have other underlying health problems and comorbidities [1]. Because of the growing prevalence of ESKAPE pathogens in SSI, there are growing concerns regarding the efficacy of therapies, the management of diseases, and overall patient outcomes [4,5].

The term "ESKAPE" alludes to the distinctive manner in which these bacteria conceal themselves from antimicrobials, further complicating the efficiency of treating them and thus contributing to a high percentage of Health care associated infections. [1-5]. Some of the factors which promotes their proliferation includes the use of invasive equipment like catheters, drains, and mechanical ventilation on a regular basis, long hospital stays, and intensive care management.

It is becoming increasingly difficult to treat SSIs caused by ESKAPE pathogens as the efficacy of antibiotics against them is progressively decreasing day by day, which might potentially reduce the success of future attempts to treat them. [6-9]. A holistic strategy that involves strong efforts to avoid infections, prudent use of antibiotics, and continuing exploration of different approaches to treat ESKAPE pathogens is required to meet this problem's requirements [8-12]. Therefore, this study aims to ascertain the incidence of ESKAPE infections in SSI at a tertiary care referral centre and the risk factors associated with these pathogens..

Materials & Methods

For this study, observations were gathered from the microbiology department and the General surgery department at a tertiary care referral centre. The study also looked back at previous historical occurrences. From January 4, 2023, until January 3, 2024, the research was conducted over one year to investigate the frequency with which ESKAPE bacteria were found in SSI. Before embarking on the data-gathering process, the project was granted clearance from the Institutional Review Board and the ethical committee. Those who participated in the trial, either as patients or as legal guardians, provided written consent for the researchers to utilize their health information.

The study population consisted of SSI patients who had to stay in the hospital after undergoing different types of surgery. Inclusion in the trial was contingent upon patients meeting inclusion criteria and receiving a SSI diagnosis according to CDC guidelines that is within 30 days of surgery or one year for patients with prosthetic devices. A minimum age of 18 was required to participate in the study. The research did not include patients who had superficial skin infections unrelated to surgery, illnesses that were not classified as surgical site infections, or patients who refused to provide their consent.

At the same institution, a pilot investigation found that ESKAPE infections were responsible for twenty per cent of the SSIs that were reported. We utilized this to establish the size of the sample. Considering this rate of occurrence and a confidence interval of 95%, we concluded that the group would consist of around 200 instances. We used convenience sampling as our technique. We included all patients who met the study's inclusion criteria throughout the examination. Two ways we gathered information were by looking through medical records and by checking for microbiology registers. The demographic information of each patient, including their age and gender, and their clinical history, including the underlying conditions, kind of surgery, length of operation, and post-operative results, were documented. We made a note of the signs and symptoms, including fever, wound dehiscence, erythema, and purulent fluid, as well as the kind of surgical site infection (superficial, deep, or organ space), the time it started, and the type of SSI.

Aseptic wound swabs or tissue samples were taken from persons clinically suspected of having SSI. We obtained samples by either swabbing the region with clean cotton swabs or taking biopsies of the tissue, depending on the kind of infection and the extent of the illness when we took the samples. We immediately dispatched these samples to the microbiology laboratory for analysis.

We cultured the samples from wounds by growing them on the appropriate solid medium, such as blood agar, MacConkey agar, and chocolate agar and simultaneously in Brain heart infusion broth. Then the samples were then incubated at 37 degrees Celsius for twenty-four to forty-eight hours. The cultures were monitored throughout for the growth of the bacteria. Traditional biochemical methods, such as Gram staining, catalase, coagulase, and other biochemical assays, were used to characterize any growth that had occurred on the culture plates. The identification of Gram-negative bacteria was further achieved by the use of supplementary assays, such as the sugar fermentation, citrate utilisation, urease test and the triple sugar iron test. We used VITEK 2 Compact technology to identify the isolates to the species level. The Kirby-Bauer disc diffusion technique was used to determine the Antibiotic Susceptibility Testing (AST) of the organisms, according to the guidelines set forth by the Clinical and Laboratory Standards Institute (CLSI). A wide range of antibiotics from different

classes were tested including carbapenems, aminoglycosides, beta-lactams, beta lactam - beta lactamase inhibitor combinations and fluoroquinolones. The data was categorised as susceptible, intermediate, or resistant based on the CLSI breakpoints. In this study, the ESKAPE pathogens which comprise species of Enterococcus faecium, Staphylococcus aureus, Klebsiella pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa, and Enterobacter were examined. Infections in healthcare facilities and the fact that these bacteria exhibited resistance to several drugs led to their classification as ESKAPE.

Statistical Analysis: To analyze the data, it was first imported into Microsoft Excel, and then SPSS version 26 was utilized. Descriptive figures displayed demographic information, clinical characteristics, and microbiological data. It was determined how many SSIs were brought on by ESKAPE pathogens. Then, a comparison was made between that number and the number of SSIs brought on by other bacteria. We utilized chi-square testing to investigate the relationship between patient-related characteristics (such as age, comorbidities, and sort of operation) and the incidence of SSI caused by ESKAPE bacteria. To determine statistical significance, a p-value of less than 0.05 was used.

Results

We looked into 123 eligible patients from the General Surgery Department during the study period. The patients had undergone one or the other elective abdominal surgeries or emergency surgeries on patients admitted with poly trauma due to road traffic or any other accidents. Men accounted for 67.4% (83/123) of these surgery site infections. Possible reason of which could be related to their vulnerable occupations like work in transportation, construction, farming, and day labor. Most of the cases (45.5%) were between the ages of 20 and 40, with 38.4 years old as the mean (standard deviation: 17.1). 3.2% of patients were illiterate and from a low socioeconomic stratum, while more than half had finished high school or college. Figure 1 shows that about 58% of the people who participated were from rural places.

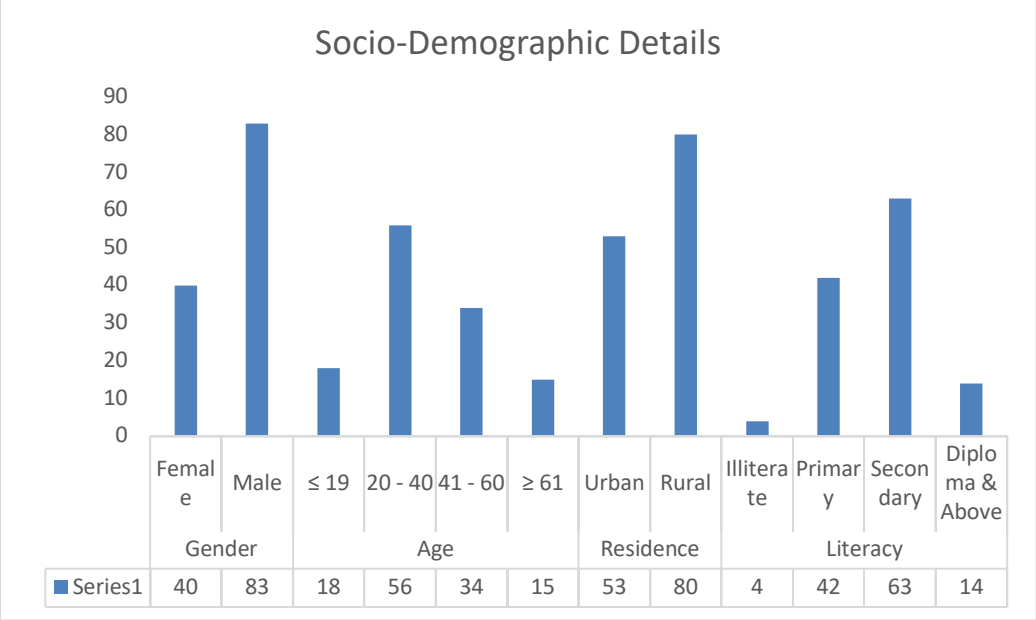

Figure 1: Demographic details of the study population (n=123)

We subjected all the 123 samples from wounds to aerobic bacteriological cultures. Bacteria grew in 30.1% (37/123) of them, and 10.8% (4/37) of those wounds had double bacterial infections.

This brought the total number of bacteria isolates to 208, which came from ten different genera. We double isolated one of each of the following four types of bacteria: Escherichia coli and Acinetobacter baumannii; Pseudomonas aeruginosa and Klebsiella pneumoniae; Coagulase Negative Staphylococcus and Psedomonas aeruginosa; and Staphylococcus aureus and K. pneumoniae. The ratio of gram-positive to gram-negative bacteria was 0.782:1. Gram-positive bacteria made up 43.9% (18/41) of the isolates, while Gram-negative bacteria made up 56.1% (23/41).

Saphylococcus aureus (268.8% or 11/41), Klebsiella pnemoniae (17.07%), Coagulase Negative Staphylococcus (12.2% or 5/41), and Pseudomonas aeruginosa (12.2% or 5/41) were the most frequently found bacteria. Men accounted for 64.9% (24/37) of the culture positive samples, while women patients, accounted for 35.1% (13/37). The gender distribution ratio of M: F was (1.84:1). However it

was found that there was no significant link between gender and culture positivity. 43.2% of cultured positive surgical wounds (16/37) were in people between the ages of 20 and 40. 54% of these patients with culture-positive samples lived in rural areas. While 55% of patients with only a secondary education had an infection at the site of their surgery. There was no significant link between sociodemographic factors and surgical site infections, though (Table 1).

Table 1: Association of Socio-Demographic details with Surgical Site Infections in the study population.

Parameters	Category	Culture result		Chi-Square test
		Positive (%)	Negative (%)	
Sex	Male	24	60	$X^2 = 0.181$
	Female	13	26	P = 0.66
Age	≤ 19	6	12	$X^2 = 0.222$ P = 0.97
	20 - 40	16	42	
	41 - 60	10	24	
	≥ 61	5	10	
Residence	Urban	13	40	$X^2 = 0.198$
	Rural	20	60	P = 0.61

Table 2: Showing the Percentage Sensitivity of the Isolates to Various Antibiotics

S/no.	Antibiotics	Organisms						
		Klebsiella spp	Acineto-bacter spp	Pseudo-monas spp	Entro-bacter spp	Antibiotics	Entero-coccus	MRSA
1	Amikacin (AK)	50%	40%	83%	100%	Vancomy-cin (VA)	100%	100%
2	Gentamy-cin(G)	50%	40%	83%	100%	Linezolid (LZ)	100%	100%
3	Ciprofloxacin (CIP)	0%	0%	0%	0%	Amikacin (AK)	50%	50%
4	Ceftazidime (CAZ)	0%	0%	0%	0%	Gentamy-cin (GEN)	50%	0%
5	Cefoperazone (CPZ)	0%	0%	0%	0%	Tetracy-cline (TE)	0%	0%
6	Ceftriaxone (CTR)	0%	0%	0%	0%	Teicoplanin (TEI)	100%	70%
7	Imipenem (IMP)	0%	40%	66%	100%	Clindamy-cin	0%	50%
8	Tobramycin (TOB)	0%	20%	66%	0%	Erythromy-cin	0%	20%
9	Polymyxin B (PB)	100%	100%	100%	100%	Azithromy-cin	0%	40%
10	Colistin (CL)	100%	100%	100%	100%	Cotrimoxa-zole	50%	70%
11	Piperacillin Tazobactam (PIT)	25%	20%	83%	0%	Amoxyclav	0%	50%
12	Levofloxa-cin(LE)	0%	0%	0%	0%	Ciprofloxa-cin	0%	50%
13	Cotrimoxa-zole(COT)	0%	0%	0%	0%	Levofloxa-cin	0%	50%
14	Cefepime	0%	0%	0%	0%			
15	Meropenem	0%	40%	66%	100%			
16	Cefoperazone sulbactam	0%	0%	0%	100%			
17	Tigecycline	100%	100%	100%	100%			
18	Cefotaxime	0%	0%	0%	0%			
19	Doripenem	0%	0%	0%	0%			

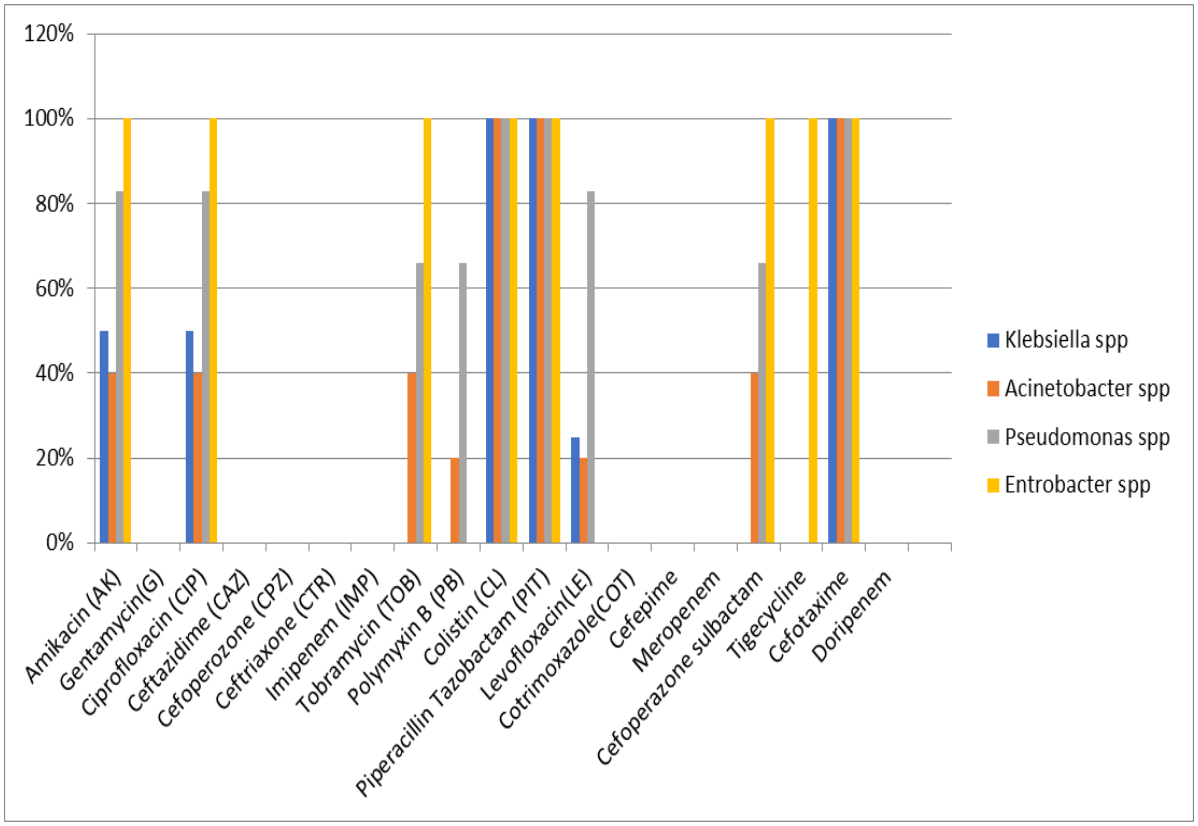

Figure 2: Showing the Percentage Sensitivity of Gram Negative Isolates to Various Antibiotics

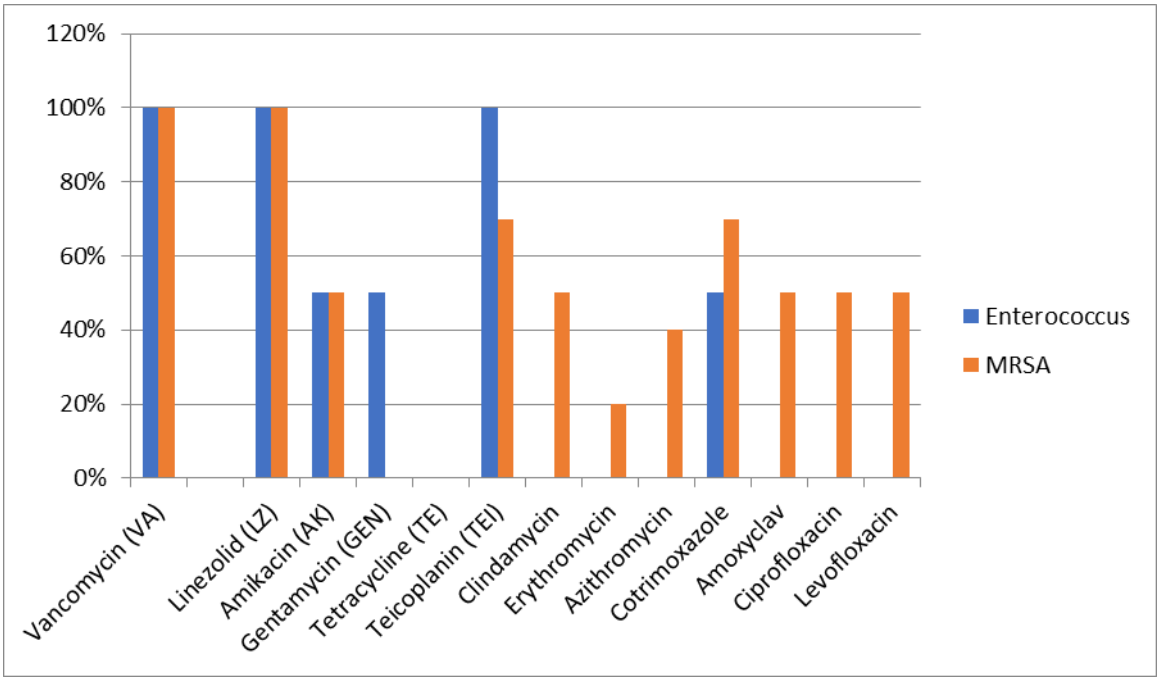

Figure 3: Showing the Percentage Sensitivity of Gram Positive Isolates to Various Antibiotics

Discussion

Surgical site infections rank among the most prevalent infections associated with healthcare. Nevertheless SSIs are becoming more common because of ESKAPE pathogens. Hospitals and clinics around the world are grappling with this serious issue. Enterococcus faecium, Staphylococcus aureus, Klebsiella pneumoniae, Acinetobacter baumannii, Pseudomonas aeruginosa, and Enterobacter species which constitute "ESKAPE" do not respond very well to the standard Antimicrobial Therapies.

These pathogens are notorious for being able to "escape" the effects of antibiotics, rendering them

severely difficult to treat. Concerningly, the number of SSI caused by these organisms has grown over the last decade as per various studies. This besides leads to increasing morbidity and mortality, resulting in extended hospital stays due to prolonged recovery and increased healthcare expenses. According to a report by a study [16], the number of HAI, including SSI, caused by ESKAPE pathogens has steadily increased from 2015 to 2019. Additionally, they observed a significant increase in drug resistance. Since majority of these infections are caused by MRSA, the efforts to curb MRSA infections has led to the emergence of other ESKAPE bacteria such as Acinetobacter baumannii and Klebsiella pneumoniae over time. This has further complicated the study of SSIs. Studies often find these pathogens on hospital surfaces, medical tools, and hands of healthcare workers during surveillance of Health care Associated Infections (HCAIs) . Therefore, individuals who are already compromised from various surgeries are more likely to contract infection from them [14, 15]. Antibiotics are not effective against ESKAPE pathogens because they have evolved many survival mechanisms. This further makes it difficult to treat SSIs caused by them. Pathogens such as Enterobacter species and Klebsiella pneumoniae make lactamases and carbapenemases, rendering beta lactam antibiotics and carbapenems ineffective to treat such infections. [12,13].

Pseudomonas aeruginosa and Acinetobacter baumannii use efflux pumps to pump out drugs and make them ineffective. [18]. Many ESKAPE bacteria, such as Staphylococcus aureus and Enterococcus faecium, are capable of forming biofilms. Biofilms make a wall around bacteria that protects them from both the host's immune system and antimicrobial agents, thus causing prolonged illnesses and relapses.[10]. Gene mutations and horizontal gene transfers: By altering or shifting genes from one location to another, these bacteria acquire DNA that confers resistance. Usually, gram-positive illnesses receive vancomycin as their final treatment. Since vancomycin has been rendered ineffective against Enterococcus faecium, due to the presence of the van A and van B genes [17].This has caused a worrying rise in the spread of ESKAPE bacteria in post-operative patients in recent years. Researchers have found a link between the spread of multidrug-resistant ESKAPE pathogens and the injudicious use of broad-spectrum antibiotics. This association is due to the selection pressure on MDR bugs in a hospital environment. [19] Another important trend is that ESKAPE bacteria are showing up in community-acquired SSIs refuting the belief that hospitals are the only places to find ESKAPE bacteria. Good examples are finding MRSA in the community among surgery patients who had never visited a hospital further complicating infection control [20]. Furthermore, the COVID pandemic exacerbated the challenge of infection control for hospitals, leading to an increase in HAIs, including SSI caused by ESKAPE microbes [7, 8]. Health care givers face numerous challenges in managing these SSIs. The Multi drug resistance has led to an increasing use of reserved drugs such as polymyxins, tigecycline, and linezolid as last resorts. This again has serious implications including unwanted side effects, and inability of pathogens to respond to them subsequently.[10]. As Hospitalized patients already have a compromised immune system, and are on invasive devices like catheters and surgical drains it further complicates the scenario of SSIs.

Healthcare centers have implemented multiple measures to decrease such infections. The focus should be on pre-surgery measures, ensuring skin cleanliness, UV light disinfection, administering antibiotics only if indicated before surgery, and managing wounds post-surgery. Since ESKAPE pathogens are so good at acclimatizing to the hospital environments, their prevalence continues to rise [11]. Central to these preventive strategies is Antimicrobial Stewardship, so as to optimize the use of antibiotics, reduce the selection pressure and halt the spread of multi drug resistant pathogens.[6] Researchers are also exploring intriguing futuristic solutions like bacteriophages to control such notoriously difficult to eradicate pathogens.[22, 23].

Conclusion

ESKAPE bacteria are increasingly causing SSI, posing a significant challenge to modern healthcare. These bacteria are adept at resisting antibiotics, limiting treatment options. The spread of these infections is exacerbated by injudicious antibiotic use and prolonged survival of these multidrug resistant bacteria in the hospital settings. To combat this growing threat, healthcare centers must focus on proper hospital infection prevention practices, judicious antibiotic use, and developing innovative treatments. Failure to do so could lead to an increase in SSI, increasing stress on healthcare systems and increasing the likelihood of patient morbidity and mortality.

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