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ORIGINAL RESEARCH

Infection Prevalence at a Tertiary Hospital in Hail, Saudi Arabia: A Single-Center Study to Identify Strategies to Improve Antibiotic Usage

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Objective: Identifying the burden of disease and the condition of the Saudi population is in high demand from both a surveillance and analytical standpoint. The objective of this study was to determine the most prevalent infections among hospitalized patients (both community-acquired and hospital-acquired), the antibiotics prescribing pattern, and their relationship with patient characteristics like age and gender.

Methods: A retrospective study was conducted comprising 2646 patients with infectious diseases or complications admitted to a tertiary hospital in the Hail region of Saudi Arabia. A standardized form was used to collect information from patient's medical records. Demographic data such as age, gender, prescribed antibiotics, and culture-sensitivity tests were included in the study.

Results: Males represented about two-thirds (66.5%, n = 1760) of the patients. Most patients (45.9%) who suffered from infectious diseases were between the ages of 20 and 39. The most prevalent infectious ailment was respiratory tract infection (17.65%, n = 467). Furthermore, the most common multiple infectious diseases were gallbladder calculi with cholecystitis (40.3%, n = 69). Similarly, COVID-19 had the greatest impact on people over 60. Beta-lactam antibiotics were the most commonly prescribed (37.6%), followed by fluoroquinolones (26.26%) and macrolides (13.45%). But performing culture sensitivity tests were rather uncommon (3.8%, n = 101). For multiple infections, beta-lactam antibiotics (such as amoxicillin and cefuroxime) were the most commonly prescribed antibiotics (2.26%, n = 60), followed by macrolides (such as azithromycin and Clindamycin) and fluoroquinolones (eg, ciprofloxacin and levofloxacin).

Conclusion: Respiratory tract infections are the most prevalent infectious disease among hospital patients, who are primarily in their 20s. The frequency of performing culture tests is low. Therefore, it is important to promote culture sensitivity testing in order to support the prudent use of antibiotics. Guidelines for anti-microbial stewardship programs are also highly recommended.

Keywords: antibiotics, infections, prescribing pattern, Hail region, Saudi Arabia

Introduction

Infectious diseases remain a prominent source of mortality and morbidity worldwide, amounting to nearly 8 million fatalities in 2016.[1] Infectious diseases are the second highest cause of fatality and disability-adjusted life years globally.[2] According to WHO estimates, there are 300–500 million instances of malaria, 333 million cases of sexually transmitted diseases (syphilis, gonorrhea, and chlamydia), 33 million infections of HIV/AIDS, 14 million people suffering from tuberculosis, and 3–5 million people infected with cholera.[3] Even though infectious diseases are more prevalent in the non-industrialized sector, infection in industrialized nations is still relatively high for specific infectious diseases. In the

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United States, roughly 48 million episodes of diarrhea result in 128,000 hospitalizations and 3000 fatalities related to diarrheal infections each year.[4] Not unexpectedly, there is a significant disparity in infectious illness death rates between non-industrialized and industrialized countries. Infectious diseases are responsible for one out of every three deaths worldwide. In 1990, approximately 17 million people died from infectious diseases, malnutrition, and maternal and perinatal ailments, with the poor accounting for nearly all of these deaths.[3]

A study was conducted in a tertiary hospital based in Germany (2015–2020) on infections regarding the genomic analysis of carbapenem-resistant *P. aeruginosa* specimens. The study concluded that ST111 VIM-2 *P. aeruginosa* was the main carbapenemase-producing strain that spread in the hospitals.[5] In Thailand, a study revealed that two *N. gonorrhoeae* isolates in heterosexual subjects had reduced susceptibility to ceftriaxone. The study isolated around 134 isolates of *N. gonorrhoeae*, and they found that two isolates NG-083 and NG-091 were not susceptible to ceftriaxone. Molecular docking revealed that they had occupied the penicillin-binding sites.[6] Similar studies have been conducted in the United Kingdom, Netherlands, and the United States of America, revealed by molecular epidemiology data.[6] Infections by *Klebsiella pneumoniae* that causes catheter-related biofilm infections in hospitals have been critical. A study suggested that colistin and EDTA had reduced the biofilm formation of *Klebsiella pneumoniae* (colistin-resistant) by the combination of colistin and EDTA. This combination can reduce the eradication of infections in hospitals[7] In Iran, the prevalence of infections by *C. hominis* transmission occurs in hospital subjects via anthroponotic transmission.[8] Due to a lack of effective antibiotics against resistant *Acinetobacter baumannii*, a new combination of colistin plus sulbactam has demonstrated a synergistic effect against *Acinetobacter baumannii*-resistant strains than sulbactam which is an excellent strategy to curb the deadly infections[9] A study conducted in Germany on the Blood-stream Infection Due to Multi-Drug Resistant Organisms on Risk Factors and Clinical Outcomes (BLOOMY) concluded that BLOOMY scores demonstrated and good discrimination and the predictive values and could support the progress of procedures to manage infections in blood-stream and help to estimate the short- and long-term infection burdens in blood-stream.[10] A study was conducted in Brazil on the clonal spread of infections by ArmA and OXA-23-co-producing *Acinetobacter baumannii*. The study found that the rapid spread of the carbapenem-resistant *Acinetobacter baumannii* clone was majorly responsible for the large outbreak in a hospital in Brazil. It is suggested that prospective and continuous vigilance is warranted to estimate the influence of this clone on hospitals.[11]

The intensity and duration of infections are determined by several parameters, such as the pathogenicity of the invading organism's strain and the individual's resilience, which may be weakened by starvation or concurrent sickness.[12] A few major contributors to this issue are environmental modifications caused by human activities, greater worldwide movement, inadequate community healthcare systems, and microbial adaptability.[13] The background of infectious disease medicine is littered with remarkable achievements. The successful identification, diagnosis, and therapeutic approaches of infectious diseases have altered society's fabric, resulting in significant social, economic, and political benefits.

There is immense demand from both surveillance and analytical method point of view for documenting the influence of disease and conditions on the Saudi population.[14–16] So a comprehensive effort needs to quantify the global population's health so that it can tell us suitable methods to compare different places, regions, and periods.[17] It is reported that the global burden of diseases (GBD) in Saudi Arabia from 1990 to 2017 decreased the age-associated death rate because of improved health facilities.[17] However, infections, substance use disorders, neoplasms, and neurological disorders continue to rise from 1990 to 2017. Respiratory infections and tuberculosis have hiked annually because of poor management in the clinical settings in Saudi Arabia.[17]

The objective of this study was to determine the most prevalent infections among hospitalized patients (both community-acquired and hospital-acquired), the antibiotics prescribing pattern, and their relationship with patient characteristics like age and gender. The outcomes of the present research can help to better understand the single-center epidemiology of illnesses, guide infection control strategies, and enhance surveillance and public health practices.

Methods

Study Design

This study is cross-sectional and retrospective in nature. The study was accomplished from March 2021 to November 2021 in a tertiary care hospital in Hail, Saudi Arabia. Two thousand six hundred and forty-six medical records of hospitalized patients were examined for infectious diseases, and administered medications, and microbial culture sensitivity test reports.

Data Collection

Data collectors approached the General Directorate of Health Affairs, Hail region, and the hospital administrator to seek permission before collecting the data. A standardized form was used to gather data from patient medical records for those who were admitted to the hospital between March 2021 and November 2021 due to infectious diseases or complications. The information included demographic data such as age, gender, medication prescribed, and culture-sensitivity test reports. The information and details acquired were treated with confidentiality. There was no personal information utilized in this study. This was a secondary examination of anonymized data from routine monitoring.

Sample Analysis

Biological sample analysis (Blood, Urine, Throat swabs, Stool sample, Spinal tap) was formerly performed in accordance with internal policy and procedure (IPP) at the Department of Microbiology laboratory, Hail General Hospital, Hail, Saudi Arabia. Final recorded results from the medical file were taken for our study's purpose.

Ethical Approval

The study was conducted in accordance with the Declaration of Helsinki and the Institutional Review Board (IRB), approved the study, General Directorate of Health Affairs, Hail region (Protocol number H-08-L-074). The details and information gathered are kept confidential. The ethics committee approved our study stating no need for consent from participants since it is a retrospective data analysis.

Statistical Analysis

The data were analyzed using GraphPad Prism 9.0. Descriptive statistics were used where needed, such as variable frequencies, mean, standard deviation, and cross-tabulations. The data were analyzed statistically using the chi-square test measuring the association between the most frequent infection with gender and the trend of performing culture sensitivity tests. A $P < 0.05$ was considered significant throughout the analyses.

Results

About two-thirds (66.5%, n = 1760) of the patients were represented by males and the remaining (33.5%, n = 886) were females. The majority (45.9%) of the patients were 20 to 39 years old, followed by 40 years and above (33.8%). The patients' median age (interquartile range) was 32 (21.5 to 46.5) years. The analysis by age group reveals that patients from the age of 20 years to 39 years suffered the most from infectious diseases. Furthermore, the patients aged 20 years to 29 years had a higher fraction of infection (eg, respiratory tract infections and gastroenteritis along with colitis); whereas UTI, calculus of gall bladder, renal colic, and cholecystitis were more prevalent in patients with the age group of 30 years to 39 years. Similarly, COVID-19 affected patients above 60 years the most (Table 1).

Respiratory tract infection (17.65%; n = 467) was found to be the most common infectious ailment for which patients visited the hospital followed by renal colic (10.24%; n = 271), gastroenteritis and colitis (7.02%; n = 186), and UTI (6.72%; n = 178) Table 2. A chi-square test revealed a significant association between gender and infectious diseases diagnosed in hospitals ($p < 0.001$). Calculus of gallbladder with cholecystitis was found to be the most frequent multiple infectious diseases diagnosed among hospitalized patients in the top ten list with a percentage of 40.3% (n = 69) followed by gastroenteritis and colitis of infectious origin with 25.7% (n = 44). The remaining represented 29.01% (n = 50) Table 3.

Table 1 Distribution of the Ten Most Frequent Infectious Diseases Among Hospitalized Patients by Age Group

Disease/ Infection	Age (in Years)							
	0–2	3–12	13–19	20–29	30–39	40–49	50–59	60 and Above
Respiratory infection	18	17	25	66	33	20	14	7
Gastroenteritis and colitis	32	50	46	92	50	28	12	8
UTI	0	13	7	30	39	26	21	31
COVID-19	6	1	3	5	23	6	20	40
Pharyngitis	1	19	13	23	19	9	5	3
Nasopharyngitis	1	9	14	25	18	7	14	6
Calculus of gallbladder	0	0	4	6	26	18	8	5
Tonsilitis	8	15	13	30	27	11	6	2
Renal colic	0	0	10	63	89	38	44	25
Cholecystitis	0	0	6	13	31	23	15	7
Others	37	53	106	255	349	105	88	145
Total number	103	177	247	608	704	281	247	279
Percent	3.89	6.69	9.33	22.98	26.61	10.62	9.33	10.54

Table 2 The Ten Most Frequent Infectious Diseases Diagnosed Among Hospitalized Patients and Their Association with Gender

Diagnoses	Frequency(n)	Percent	P value*
Renal colic	271	10.24	< 0.001
Gastroenteritis and colitis	186	7.02	
Urinary tract infections	178	6.72	
Upper respiratory infection	170	6.42	
COVID-19	125	4.72	
Acute tonsillitis	109	4.11	
Otitis externa	106	4	
Cholecystitis	105	3.96	
Pharyngitis	96	3.6	
Nasopharyngitis	92	3.47	

Notes: *Chi-square test; The data were analyzed statistically using the chi-square test measuring association between the ten most frequent infectious diseases diagnosed among hospitalized patients and their gender. A P<0.05 was considered significant throughout the analyses.

The trend of performing culture sensitivity tests was found quite uncommon (3.8%, n = 101). However, acute cholecystitis due to gallbladder calculus and COVID-19 got a bit more attention compared to other diseases in executing the culture sensitivity tests (Table 4). There was a significant relationship between the infectious diseases diagnosed and the trend of performing culture sensitivity tests ($p < 0.001$).

Table 3 The Ten Most Frequent Multiple Infectious Diseases Diagnosed Among the Hospitalized Patients

Infections	Frequency(n)	Percent
Calculus of gallbladder with cholecystitis	69	40.3
Gastroenteritis and colitis of infectious origin	44	25.7
Appendicitis with peritonitis	10	5.8
Orchitis and epididymitis	10	5.8
Pneumonia and COVID-19	08	4.6
Abscess of anal and rectal regions	07	4.09
Gastritis, Gastroduodenitis	06	3.5
Upper respiratory infection, COVID-19	04	2.33
Gastritis and renal colic	03	1.75
Gastritis, gastric ulcer	02	1.16

Table 4 Relationships Between Infectious Diseases and the Trend of Performing Culture Sensitivity Tests

Infectious Disease	Frequency	Percent	P value*
Calculus of gallbladder with acute cholecystitis	27	1.02	< 0.001
COVID-19	17	0.64	
Urinary tract infection, site not specified	14	0.52	
Septic shock	11	0.41	
Other sepsis	9	0.34	
Bronchopneumonia, unspecified	5	0.18	
COVID-19, identified (Infectious Disease & Notifiable Disease)	4	0.15	
Bacterial pneumonia, not elsewhere classified	4	0.15	
Gastroenteritis and colitis of unspecified origin	4	0.15	
Pneumonia, organism unspecified	3	0.11	
Pneumonia, unspecified	3	0.11	

Notes: *Chi-square test; The data were analyzed statistically using the chi-square test measuring the association between the infectious diseases diagnosed and the trend of performing culture sensitivity tests. A P<0.05 was considered significant throughout the analyses.

Beta-lactam antibiotics were highly prescribed (37.6%), followed by fluoroquinolones (26.26%), macrolides (13.45%), and miscellaneous antibiotics (22.69%) (Table 5). The prescription pattern of most often used antibiotics for more than one infection among hospitalized patients is given below (Table 6). It was found that amoxicillin was the most commonly administered antibiotic across all diagnosed categories, followed by cefuroxime and azithromycin, and all were consistent with the primary diagnosis.

Although the use of an antibiotic in more than one infection among the hospitalized patients was very rare (3.84%, n = 102), beta-lactam antibiotics (eg, amoxicillin and cefuroxime) represented the topmost prescribed antibiotics (2.26%, n = 60) followed by macrolides (eg, azithromycin and clindamycin) and fluoroquinolones (eg, ciprofloxacin and levofloxacin) Figure 1.

Table 5 The Most Prescribed Antibiotics for Infectious Diseases Among Hospitalized Patients

Antibiotics	Frequency	Percent
Sulfamethoxazole	25	0.94
Meropenem	30	1.13
Omacillin	30	1.13
Rifampicin	46	1.73
Clindamycin	46	1.73
Gentamicin	50	1.88
Doxycycline	51	1.92
Cefalexin	59	2.22
Levofloxacin	85	3.21
Cefuroxime	86	3.25
Levofloxacin	89	3.36
Ceftriaxone	98	3.70
Azithromycin	310	11.71
Ciprofloxacin	521	19.69
Amoxicillin	692	26.15

Table 6 Antibiotics Prescribed for More Than One Infection Among Hospitalized Patients

Antibiotics	Infection
Amoxicillin	Open wound with infection, Acute tonsillitis, Other diseases of upper respiratory tract, Acute sinusitis, Abdominal and pelvic pain, Abscess of anal and rectal regions, Anal abscess, Otitis externa, Cholecystitis, Cutaneous abscess, furuncle and carbuncle
Cefuroxime	Other acute upper respiratory infections of multiple sites, Acute abdomen, Acute appendicitis, Acute cholecystitis, Calculus of gallbladder with acute cholecystitis, Urinary tract infection, Gastroenteritis, Chronic cholecystitis, Calculus of gallbladder with acute cholecystitis
Azithromycin	COVID-19, Fever of other and unknown origin, COVID-19, Not Identified (Infectious Disease & Notifiable Disease), Acute upper respiratory infection, Other acute gastritis, Acute upper respiratory infection
Ciprofloxacin	Renal colic, Gastroenteritis and colitis of unspecified origin, Urinary tract infection, Calculus of gallbladder with acute cholecystitis
Levofloxacin	Calculus of gallbladder with acute cholecystitis, Irritable bowel syndrome, Other acute gastritis, Other gonococcal infections, Abdominal and pelvic pain, Acute appendicitis, Orchitis and epididymitis, Urinary tract infection following delivery
Clindamycin	Acne vulgaris, Urinary tract infection, Cellulitis of lower limb, Acute bronchiolitis, Acne

Discussion

Infectious diseases continuously emerging, leading to resistance to the available antibiotic therapy.[18] As antibiotic resistance increases, understanding the pattern of infection and antibiotic prescription in Hospitals is of utmost importance. Thus, we conducted a retrospective analysis at a tertiary care hospital in Saudi Arabia's Hail region to investigate infection prevalence and the antibiotics prescribed. Infectious diseases are a growing public health concern worldwide, and managing them rationally is another challenge.[19] The COVID-19 era is a witness to how an infectious disease affects the whole world.[14,20,21] Even though the conditions are still worse despite the availability of different

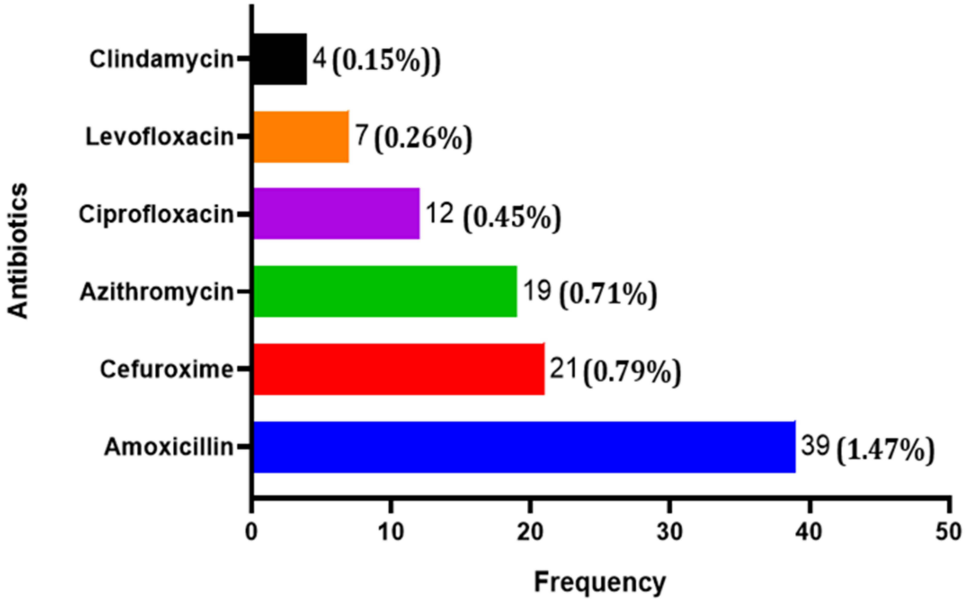

Figure 1 Antibiotics prescribed for more than one infection among hospitalized patients.

vaccines.[22–24] Antibiotics play a vital role in preventing infectious diseases and thus improving human health.[25] However, improper selection of antibiotics or their overuse may play a significant role in the development of antibiotic resistance, which poses a significant threat to infectious disease management. According to national monitoring of Saudia Arabia for Gram positive (+ve) cocci; 32% of *S. aureus* is MRSA, 33% of *S. pneumoniae* are penicillin G resistant, and 26% is erythromycin-resistant.[26] Additionally, the prevalence of ESBL (extended-spectrum beta-lactamase) in *E. coli* is growing, with 29% ESBL rates and 65% ESBL rates in *K. pneumoniae*.[27] This necessitates preventing the unnecessary use of antibiotics in the community and hospital settings and encouraging the sensible use of antibiotics[10,12]. The resistance towards carbapenems by gram-negative bacteria is increasing dramatically. A study on 360 antibacterial prescriptions was estimated, where it was concluded that the appropriateness of prescribing was high after anti-microbial restriction than before using anti-microbial restriction. These findings reveal that an anti-microbial restriction system can increase the appropriateness of prescribing antibiotics.[28]

The prevalence of infection was the highest in the age group 20–29 and 30–39. The finding is supported by the study conducted by Balkhy et al in Riyadh.[29] However, the latter study particularly highlighted the highest vulnerability of hospital-acquired infection (HAI) among patients above 50 years of age. This is due to weaker immunity among old-aged patients[29] due to opportunistic infections. Among different infections, respiratory tract infection (17.65%) was found to be the most common infectious ailment for which patients visited the hospital, followed by renal colic (10.24%), gastroenteritis, and colitis (7.02%), and UTI (6.72%). Our data on Renal colic are consistent with the study published by Safdar O.Y et al, 2021 among residents of Saudi Arabia.[30] Also, our previous study demonstrated that the major UTIs causing organism is *E. coli* in Tertiary Hospital in Al-Baha Region, Saudi Arabia.[31]

In multiple infectious diseases, calculus of the gallbladder with cholecystitis was the most frequent among hospitalized patients with 40.3%, followed by gastroenteritis and colitis of infectious origin with 25.7%. The trend of performing culture sensitivity tests was quite uncommon (3.8%). In executing the culture sensitivity tests, acute cholecystitis related to gallbladder calculus and COVID-19 received more attention than other diseases. In the case of antibiotic prescription, Beta-lactam antibiotics were the most highly prescribed (37.6%), followed by fluoroquinolones (26.26%), macrolides (13.45%), and miscellaneous antibiotics (22.69%). Amoxicillin was the most preferred antibiotic across all diagnosed categories, followed by cefuroxime and azithromycin, and all were consistent with the primary diagnosis. For multiple infections, beta-lactam antibiotics (eg, amoxicillin and cefuroxime) are top on the list (2.26%), followed by macrolides (eg, azithromycin and clindamycin) and fluoroquinolones (eg, ciprofloxacin and levofloxacin).

The infection prevalence was reported in a study conducted in Hail Hospital of Saudi Arabia, where it was observed that pneumonia (27.2%), Urinary tract infections (20.2%), and blood-stream infections (10.5%) were the most common infections. It was also observed that around 19.2% of infections were healthcare-associated infections or hospital-acquired infections (HAI).[32] The Gram-negative bacteria collected from UTI patients in Ha'il exhibited strong amikacin sensitivity, which is consistent with findings from a similar study in Al-Jouf,[33,] and Al Baha region, Saudi Arabia.[34] As a result, amikacin is one of the potential choices for usage as a first-line medicine to treat patients with UTIs in the Saudi Arabian provinces of Hail and Al-Jouf, as well as other places with comparable characteristics. Amikacin is also considered as a first line of drug for UTIs.[35,36] However, there is a significant danger that amikacin will cause kidney and hearing problems. Our earlier study observed that *E. coli* is the main etiological agent for UTIs in Al Baha region of Saudi Arabia. The most prescribed antibiotic was ciprofloxacin (20.29%) and cefuroxime (16.14%), followed by ceftriaxone (12.96%) and then tazocin (8.80%). But the most sensitive antibiotics were imipenem, meropenem, amikacin, vancomycin, tigecycline, linezolid, and colistin.[34]

Our study has observed antibiotic susceptibility patterns and the most common antibiotics prescribed against diverse infections. The study also noticed that amoxicillin was one of the highly prescribed drugs for most infections. It is also the preferred antibiotic for many bacterial infections.[37] The other antibiotics preferred as per the guidelines are cefdinir, cefpodoxime, moxifloxacin, levofloxacin, and these antibiotics were also prescribed for many infections, as described above in Table 5.[37] Antibiotics like clindamycin, levofloxacin, azithromycin, cefuroxime, and ciprofloxacin were the most common antibiotics prescribed to in-hospital patients. Amoxicillin was one of the most highly prescribed antibiotics for hospital inpatients.

However, respiratory tract infections were common among the 20–29 age group, with the highest prevalence of azithromycin/amoxicillin as prescribed antibiotics. Our results are consistent with the study by Iven et al, 2018. It is observed that one in five adults suffered from respiratory tract infection in primary care in 11 European countries.[38] Further, there is a need to conduct multicentric studies at different locations in Saudi Arabia to get more information on the prevalence of infectious diseases and antibiotic prescribing behavior in other geographical regions in Saudi Arabia.

The main issue with anti-microbial resistance is increased death rate, morbidity, and cost.[39] Antibiotic resistance can be decreased by following the guidelines of ASPs (anti-microbial stewardship programs) and several other things like pharmacodynamic and pharmacokinetic parameters of the antibiotics, AST (anti-microbial susceptibility testing), clinical response, alteration of microbiota, new antibiotics, and diagnostic testing. The regulated usage of antibiotics in foods might also reduce resistance. There should be awareness programs for children and healthcare professionals regarding antibiotic resistance and bacterial infections. Everyone needs to come forward and ensure all members of society are concerned and responsible for taking measures against antibiotic resistance.[40] The most important thing is to control and prevent the dissemination of resistant strains.[39]

Conclusion

Respiratory tract infection was the most common infectious condition for which patients went to the hospital, especially among those in their 20s. The use of beta-lactam antibiotics is still the top choice of prescribers. The trend of performing culture sensitivity tests is uncommon in the hospital except for acute cholecystitis owing to gallbladder calculus and COVID-19. However, in order to promote sensible antibiotic use, culture sensitivity testing should be encouraged in hospitals. Among the recommendations are instructing residents how to properly classify antibiotic prescriptions, reducing the use of prescriptions with a double anaerobic cover, and reviving the custom of sending culture reports. Guidelines for surgery prophylactic treatment can be improved by limiting the use of some broad-spectrum antibiotics for the same conditions and limiting the duration of surgical prophylaxis to one day.

Recommendations

- ASPs should be followed to enhance clinical outcomes, optimize anti-microbial therapy, and decrease cost and toxicity.
- The prescribers should have thorough knowledge regarding the antibiotics while prescribing.
- To control and prevent the dissemination of resistant strains.

- To conduct awareness programs for children and healthcare professionals regarding antibiotic resistance and bacterial infections.
- To maintain hygiene to reduce the occurrence of infections.
- To develop novel antibiotics.
- To reduce the use of antibiotics in agriculture.

Data Sharing Statement

Available on request from the corresponding author. The data are not publicly available to maintain privacy and adhere to the guidelines of the ethics protocol.

Ethical Approval

The study was conducted in accordance with the Declaration of Helsinki and the Institutional Review Board (IRB), approved the study, General Directorate of Health Affairs, Hail region (Protocol number H-08-L-074). The details and information gathered are kept confidential. The ethics committee approved our study stating no need for consent from participants since it is a retrospective data analysis.

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Disclosure

The authors declare no conflict of interest.

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