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Original Article

Prescribing Pattern of Antibiotics among Hospitalized Geriatric Patients at a Private Academic Health System in the United Arab Emirates

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ABSTRACT

Background: Antibiotics are crucial for treating infections in older adults, but misuse can lead to drug-resistant bacteria, posing a global health challenge requiring urgent action. This study aimed to analyze the prescribing pattern of antibiotics among hospitalized older adults and identify factors influencing antibiotic use. **Materials and Methods:** This retrospective cross-sectional study focused on older adults hospitalized at Thumbay University Hospital, Ajman, UAE, for a period of 12 months. Patients with a hospital stay over 24 hr, receiving at least one antibiotic, were included. Data were collected using a standardized tool from electronic medical records and analyzed using classifications like Charlson Comorbidity Index and various WHO classifications, including AWaRe and INRUD prescribing indicators. **Results:** The study included 102 patients who received a total of 338 antibiotics. The most frequently prescribed class was systemic antibacterials, specifically cephalosporins and penems (41.25%). Piperacillin-tazobactam was the most used individual agent. High antibiotic prescribing rates related to skin and soft tissue infections (18.63%), pneumonia (18.04%), sepsis (17.75%), urinary tract infection (10.35%), and fracture and injury (8.57%). Patients generally received an average of 3.31 antibiotic agents. Most antibiotics prescribed were broad spectrum (81.95%), with 72.78% falling under the WHO AWaRe "Watch" group, indicating potential for resistance. Most antibiotics were from the national Essential Medicines List (82.24%) and prescribed using generic names (55.02%). The study also identified the total number of medications prescribed during hospital stay was found to correlate with the number of antibiotics prescribed. **Conclusion:** The study unveiled a divergence from the WHO antibiotic prescribing guidelines. It recommends conducting large-scale surveillance studies along with instituting institutional and national guidelines to curb antibiotic misuse and overuse in tertiary care hospitals.

Keywords: Antibiotics, Geriatric population, Prescribing indicators, Prescribing pattern, Resistance, United Arab Emirates.

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INTRODUCTION

Aging is a gradual process that occurs in the human body, associated with a variety of detrimental changes that heighten the likelihood of disease and mortality.[1] These changes are especially noticeable in individuals over the age of 65, often referred to as the geriatric population.[2] In the United Arab Emirates (UAE), the national policy for senior Emiratis sets the cutoff age for geriatric classification at 60 years or older.[3] As of 2020, global data suggests that there are 1 billion individuals aged 60 years and above. This figure is anticipated to rise to 1.4 billion by 2030, and by 2050, the global population of older adults is expected to reach 2.1 billion.[4]

In the UAE, the geriatric demographic stood at 2% in 2015, and is predicted to increase nine-fold by the end of 2050.[5] The growth in the older population can be attributed to a steady decline in fertility rates coupled with increased life expectancy.[4]

Despite advancements in healthcare prolonging life expectancy, the aging population continues to grapple with a multitude of complex health issues.[4] Among these health issues is an increased susceptibility to infectious diseases, due to age-related physiological changes in the body. Factors such as immune system decline, changes in skin and mucosal barriers, degeneration of bone and cartilage, and decreased respiratory function contribute to this heightened risk.[6] Furthermore, geriatric care facilities often harbor multi-drug-resistant organisms and other nosocomial pathogens, further exacerbating the risk of infections.[4] In the UAE, there were 68 recorded cases of infectious diseases for every hundred thousand patients aged 65 years or older in the third

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quarter of 2018, which saw a 50% increase in the first quarter of 2019.[7] Despite the fact that many of these infectious diseases in older adults can be averted through improved personal hygiene, vaccination, and better environmental sanitation, antibiotic drugs remain a key treatment strategy.[8] For over 50 years, antibiotics have been instrumental in human medicine, both as preventive measures and therapeutic treatments, greatly benefiting public health. Unfortunately, in recent years, the pervasive usage, misuse, and improper prescribing of these therapies have markedly reduced the effectiveness of antibiotic drugs, resulting in the emergence of drug-resistant bacteria. This poses a significant health concern that is particularly critical in the geriatric population, who often require antibiotic treatment due to their increased susceptibility to infections.[9]

Antibiotic resistance is a pressing global health concern. Literature indicates a positive correlation between the use of antibiotics and the level of resistance. It suggests that wise and rational use of these drugs can mitigate resistance.[10] However, infections caused by resistant organisms is increasing, outpacing the rate of new antibiotic discovery and synthesis. When infections become resistant to first-line treatments, they necessitate more expensive second-line therapies, resulting in prolonged illness and hospital stays, causing increased healthcare costs and burdening families and societies. Antibiotic resistance also hampers public health efforts to control infectious diseases through specific disease control programs that rely on antibiotics for control and prevention.[9] The World Health Organization (WHO) 2014 global surveillance report on antibiotic resistance indicates that this issue of antibiotic resistance is no longer a future threat; it is a current global problem, which will hinder our capacity to treat common infections in communities and hospitals. Unless immediate, coordinated action is taken, we risk entering a post-antibiotic era where even common infectious diseases could become untreatable and fatal.[11]

Hospitals account for over two-thirds of all antibiotic usage, according to the WHO, making them the most commonly prescribed medications in these settings worldwide.[10,12] It is essential to understand the prescribing patterns of antibiotics to promote their rational and effective use in hospitals. However, despite numerous studies conducted at the community and outpatient levels across the UAE, there is a noticeable gap in research addressing the inpatient prescribing patterns, particularly within the geriatric population.[13,14] The escalating challenge of antibiotic resistance, combined with a slowdown in the development of new antibiotics, intensifies the need to study and streamline antibiotic usage. This urgency underscores the objective of our study, which aims to describe the pattern of antibiotic use among hospitalized older adults and identify associated factors, in order to pinpoint priority areas for future interventions.

MATERIALS AND METHODS

Study design, study setting, and study period

A retrospective cross-sectional study was conducted for 12 months at Thumbay University Hospital, Ajman, UAE. As the largest private academic hospital in the Middle East, Thumbay University Hospital provides a wide range of healthcare services to a diverse patient population. This state-of-the-art medical facility, with a 350-bed capacity, advanced technology, and highly skilled medical professionals, is known for its patient-centered healthcare services.

Study population and sampling

All older adults admitted to Thumbay University Hospital from January to December 2021, who met the eligibility criteria, constituted our source population. We used a convenience sampling technique to select patients, and evaluated their electronic medical records to retrieve the necessary data.

Eligibility criteria

The inclusion criteria for this study encompassed patients of both genders aged 60 years and older who had been hospitalized for a minimum duration of 24 hr and had been prescribed at least one antibiotic for either treatment or prophylactic purposes during their hospitalization. Conversely, the exclusion criteria comprised patients who were receiving care on an outpatient basis, ensuring that the study focused specifically on the inpatient population within the specified age group.

Study instruments

Through an extensive literature review, a standardized data collection tool was designed to gather and document all pertinent data. This tool encompassed all relevant details, including the patients' socio-demographic and clinical data, laboratory and diagnostic investigations, and medication profiles. The designed tool was checked for completeness through expert review with an infectious disease specialist. A pilot study was also conducted to test the tool's reliability in extracting all relevant information. Following the pilot study, necessary corrections were made to the data collection tool, which was then used to retrieve data for the study.

Several other instruments were also utilized in the study for comprehensive data analysis. The documented diagnoses of patients were classified according to the WHO International Classification of Diseases (ICD-10). To anticipate the mortality risk from comorbid diseases, the Charlson Comorbidity Index was utilized. The WHO Anatomical Therapeutic Chemical (ATC) Classification was employed to categorize the prescribed antibiotics based on the organ systems they act upon, along with their therapeutic, pharmacologic and chemical properties. Furthermore, the WHO AWaRe Classification was used to distribute antibiotics into AWaRe categories: Access, Watch, and

Table 1: Socio-demographic characteristics of the study participants.

Variables	Category	Frequency (*N*=102)	Percentages
Age	60-69	75	73.52%
	70-79	16	15.68%
	≥80	11	10.78%
	Mean, SD	67.77, 7.9177	
Gender	Male	77	75.49%
	Female	25	24.50%
BMI	<18.5	8	7.84%
	18.5-24.9	45	44.11%
	25-29.9	31	30.39%
	≥30	18	17.64%
	Mean, SD	25.62, 6.1355	
Nationality	South Asia	35	34.31%
	Southeast Asia	8	7.84%
	Middle East	33	32.35%
	Africa	23	22.54%
	North America	2	1.96%
	Europe	1	0.98%
Smoking behaviour	Current smokers	18	17.64%
	Ex-smokers	3	2.94%
	Never smokers	81	79.41%
Drinking behaviour	Current drinkers	7	6.86%
	Abstainers	95	93.13%

Abbreviations: BMI: Body Mass Index; SD: Standard Deviation.

Reserve. Lastly, the prescribing pattern of the healthcare system was assessed using the WHO and International Network for the Rational Use of Drugs (INRUD) prescribing indicators.

Data collection procedure

On a weekly basis, the trained research student reviewed the electronic medical records of patients who met the study's inclusion-exclusion criteria. Using the data collection tool, the research student extracted relevant patient data from the hospital information system. This included baseline socio-demographic characteristics such as age, gender, and Body Mass Index (BMI), as well as clinical and outcome characteristics like admission diagnosis, presumed infectious diagnosis, previous hospitalization, duration of hospitalization, death, discharge, and laboratory procedures for the diagnosed infection such as culture and susceptibility testing. Additionally, information regarding previous antibiotic therapy within the last 30 days and current antibiotic use, including the type and number of antibiotics administered, dose, dosage form, route of administration, frequency, indication, and duration of administration, etc. were collected.

Data quality management

To maximize the quality of data, the research student was trained on how to fill out the data collection instrument and extract the necessary information. The principal investigator regularly reviewed and supervised the collected data for quality and accuracy. After data collection, the data was cleaned, categorized, compiled, and checked for completeness and accuracy before statistical analysis. Any identified errors were immediately corrected.

Data interpretation and statistical analysis

The collected data was coded and exported into Statistical Package for Social Sciences (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY, USA) for analysis. Mean and standard deviation were used to describe continuous variables, while categorical variables were summarized using frequencies and percentages. Chi-square tests were employed to examine the association between the prescribing pattern and explanatory variables (such as age, gender, number of comorbid and infectious conditions, length of stay, previous hospitalization, medication count during hospitalization, and prior 30-day antibiotic use).

Table 2: Clinical characteristics of the study participants.

Variables	Category	Frequency (*N*=102)	Percentages
Presence of past medical history.	Yes	62	60.78%
	No	40	39.21%
Number of past diseases (N=62).	1-4	46	74.19%
	≥5	16	25.80%
	Mean, SD	2.06, 2.4746	
Number of admission diagnosis.	1-4	50	49.01%
	≥5	52	50.98%
	Mean, SD	5.08, 3.0575	
Number of healthcare-associated infections diagnosed following hospital admission (N=80).	1	48	60.00%
	2	29	36.25%
	3	3	3.75%
	Mean, SD	1.12, 0.7793	
Charlson comorbidity scoring system based on newly diagnosed medical conditions.	12-month mortality rate Low Medium High Very high	 34 38 21 9	 33.33% 37.25% 20.58% 8.82%
	10-year survival rate 0-20 21-40 41-60 61-80 81-100 Mean, SD	 25 12 14 19 32 53.23, 36.9571	 24.50% 11.76% 13.72% 18.62% 31.37%
Previous hospitalization in last 30 days.	Yes	44	43.13%
	No	58	56.86%
Length of hospital stay.	≤5	0	0.0%
	6-10	6	5.88%
	≥11	96	94.11%
	Mean, SD	30.37, 19.3134	
Required intensive care admission during hospitalization.	Yes	19	18.62%
	No	83	81.37%
Outcome of treatment.	Recovered	70	68.62%
	Dead	6	5.88%
	Refered	23	22.54%
	Discharged against medical advice	3	2.94%

Abbreviations: SD: Standard Deviation.

Ethical consideration

Prior to commencing the study, approval was obtained from the Institutional Ethics Committee of Gulf Medical University and Thumbay University Hospital (with Institutional Ethical Clearance reference number IRB/COP/STD/30/Dec-2021). The approval letter was subsequently communicated to the hospital administrator before initiating the study. Since this was a retrospective study, written informed consent was waived. The information collected from medical records was strictly used for academic and research purposes. To ensure patient confidentiality, no names or other identifying information of the patients were collected. The data collected was securely stored in electronic format with password protection, further safeguarding patient privacy.

RESULTS

Over the study period, 424 geriatric patients were hospitalized. Of these, 146 were on at least one antibiotic. However, 27 patients were excluded due to being transferred/discharged/died within 24 hr, and 17 were excluded due to readmission with the same medical diagnosis, to avoid data duplication, leaving 102 patients included in the study.

Sociodemographic and clinical characteristics of study patients

Of 102 patients in the study, 77 (75.49%) were males and 25 (24.50%) females. The average age was 67.77 years, with more than two-thirds falling under the young-old age group of 60-69 years. Most respondents had a normal BMI (44.11%) and were of 26 different nationalities, predominantly South Asian (34.31%). Most had never smoked (79.41%) or drunk alcohol or had stopped drinking altogether (93.13%) (Table 1).

A total of 40 patients (39.21%) had no prior illnesses. Among those with past conditions, 74.19% had 1-4 illnesses, and 25.80% had five or more. Post-admission, patients with five or more illnesses increased to 50.98%. Around 60.00% and 36.25% were diagnosed with one or two infectious diseases after admission. Concerning the Charlson comorbidity index, 33.33% had a low 12-month mortality rate, while most had an 81-100% 10-year survival rate (31.37%). Around 94.11% stayed for 11 days or more days (average 30.37 days). About 43.13% had a history of hospitalization in the previous 30 days. Only 18.62% required intensive care during hospitalization. Of all, 68.62% recovered, while 2.94% discharged against medical advice, 5.88% died, and 22.54% were transferred (Table 2). Analysis of patients' diagnosis revealed the most prevalent were circulatory (18.16%) and endocrine, nutritional, and metabolic (13.57%) diseases. Genitourinary (9.56%) and respiratory (8.60%) diseases were third and fourth, followed by nervous system diseases (7.07%) (Table 3). A detailed ICD-10 diagnostic table is in supplementary material (Table S1).

Table 3: Pattern of admission diagnosis among the study participants according to the Internation Classification of Diseases-10 code.

Variables	Frequency (*N*=523)	Percentages
Certain infectious and parasitic diseases (A00-B99).	29	5.54%
Neoplasms (C00-D49).	3	0.57%
Diseases of the blood and blood forming organs and certain disorders involving the immune mechanism (D50-D89).	7	1.33%
Endocrine, nutritional, and metabolic diseases (E00-E89).	71	13.57%
Mental, behavioral and neurodevelopmental disorders (F01-F99).	18	3.44%
Diseases of the nervous system (G00-G99).	37	7.07%
Diseases of the eye and adnexa (H00-H59).	6	1.14%
Diseases of the ear and mastoid process (H60-H95).	2	0.38%
Diseases of circulatory system (I00-I99).	95	18.16%
Diseases of respiratory system (J00-J99).	45	8.60%
Diseases of digestive system (K00-K95).	23	4.39%
Diseases of skin and subcutaneous tissue (L00-L99).	36	6.88%
Diseases of the musculoskeletal system and connective tissue (M00-M99).	17	3.25%
Diseases of genitourinary system (N00-N99).	50	9.56%
Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (R00-R99).	25	4.78%
Injury, poisoning, and certain other consequences of external causes (S00-T88).	34	6.50%
Codes for special purposes (U00-U85).	9	1.72%
External causes of morbidity (V00-Y99).	1	0.19%
Factors influencing health status and contact with health services (Z00-Z99).	15	2.86%

*Some patients had more than one admission diagnosis.

Table 4: Drug utilization characteristics among the study participants.

Variables	Category	Frequency (*N*=102)	Percentages
Past medication history.	Yes	62	60.78%
	No	40	39.21%
Number of past medications (*N*=62).	1-4	47	75.80%
	5-9	14	22.58%
	≥ 10	1	1.61%
	Mean, SD	2.30, 2.5438	
Number of medications prescribed during hospital stay.	1-4	0	0.0%
	5-9	19	18.62%
	≥ 10	83	81.37%
	Mean, SD	13.10, 3.7792	
Antibiotic use history in last 30 days.	Yes	12	11.76%
	No	90	88.23%
Number of antibiotics prescribed in last 30 days (*N*=12).	1	3	25.00%
	2	6	50.00%
	≥3	3	25.00%
	Mean, SD	0.11, 0.99	

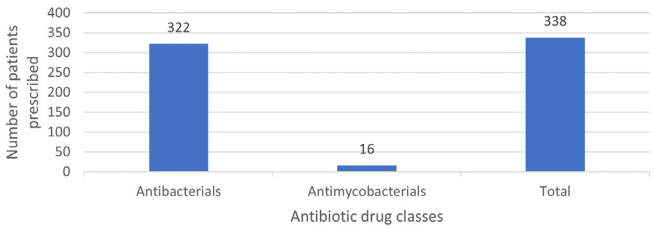

Figure 1: Spectrum of antibiotic usage among patients during hospital stay.

Prior to hospitalization, 60.78% of patients were on medications, with 75.80% using fewer than five chronic medicines. Approximately 22.58% had low-level polypharmacy (5-9 chronic medications), and only one patient had high-level polypharmacy (10 or more medications). In the hospital, 81.37% had high-level polypharmacy, while 18.62% had low-level. Among the patients, 88.23% had no recent antibiotic drug use, while 12 (11.76%) did. These 12 patients were prescribed 24 antibiotics in total, with most (50.00%) receiving two antibiotics (Table 4).

Prescribing pattern of antibiotics among study patients

The study participants were prescribed a total of 338 antibiotics, of which 322 (95.26%) were antibacterial agents, highlighting a much higher usage rate compared to the 16 (4.73%) antimycobacterial drugs (Figure 1). Of 338 antibiotics investigated, systemic antibacterials (94.67%) were most prescribed. Systemic antimycobacterials (4.73%) and topical antibacterials (0.59%) were rarely used. Within systemic antibacterials, cephalosporins and penems (41.25%) and penicillins (25.31%) were common. When considering individual agents, piperacillin-tazobactam was most frequently used (N=57) (Table 5). Disease wise antibiotic prescribing is detailed in supplementary material (Table S2). Antibiotics were mainly prescribed for skin and soft tissue infections (18.63%), pneumonia (18.04%), sepsis (17.75%), urinary tract infection (10.35%), and fracture and injury (8.57%). Penicillins were frequently used for skin and soft tissue infection (17.46%), pneumonia (24.59%) and sepsis (28.33%), except urinary tract infections (20.00%) and fractures (20.68%), where cephalosporins were preferred.

Most patients were given three or more antibiotics (61.76%), averaging 3.31 per patient. According to 2021 AWaRe classification, 72.78% of the antibiotics used fell under the 'Watch' group, while 'Reserve' group antibiotics constituted 8.28%. Broad-spectrum antibiotics were most ordered (81.95%), with 25.44% given as a combination therapy and 74.55% as a single antibiotic. The parenteral route was used in 86.09% cases. Most antibiotics were given thrice daily (31.95%), with an average treatment duration of 8.58 days. Cultures, primarily from urine, were available for 86.27% of patients. *Klebsiella pneumoniae* (15.15%), *Methicillin-resistant staphylococcus aureus* (12.12%), and *Pseudomonas aeruginosa* (11.11%) were the most common organisms isolated. Culture sensitivity was obtained before antibiotic initiation in 45.09% of patients. (Table 6). Around

Table 5: Pattern of antibiotics prescribed by class and agents among the study participants during hospital stay.

Antibiotic class	Type of individual antibiotic agent	ATC code	Number of cases	Total (%) (*N*=338)
Dermatologicals				
Antibiotics and chemotherapeutics for dermatological use				2 (0.59)
Antibiotics for topical use				2 (100.0)
Other antibiotics for topical use	Mupirocin	D06AX09	2	2 (100.0)
Antiinfectives for systemic use				
Antibacterials for systemic use				320 (94.67)
Tetracyclines				9 (2.81)
Tetracyclines	Doxycycline	J01AA02	4	9 (100.0)
	Tigecycline	J01AA12	5	
Beta-lactam antibacterials, Penicillins				81 (25.31)
Penicillins with extended spectrum.	Ampicillin	J01CA01	1	1 (1.23)
Beta-lactamase resistant penicillins.	Flucloxacillin	J01CF05	3	3 (3.70)
Combinations of penicillins, including beta-lactamase inhibitors.	Amoxicillin-clavulanic acid	J01CR02	20	77 (95.06)
	Piperacillin-tazobactam	J01CR05	57	
Other beta-lactam antibacterials				132 (41.25)
Second-generation cephalosporins.	Cefuroxime	J01DC02	25	25 (18.93)
Third-generation cephalosporins.	Ceftriaxone	J01DD04	51	55 (41.66)
	Ceftazidime-avibactam	J01DD52	4	
Fourth-generation cephalosporins.	Cefepime	J01DE01	3	3 (2.27)
Carbapenems	Meropenem	J01DH02	37	46 (34.84)
	Ertapenem	J01DH03	9	
Other cephalosporins and penems.	Ceftolozane-tazobactam	J01DI54	3	3 (2.27)
Sulfonamides and trimethoprim				2 (0.62)
Combinations of sulfonamides and trimethoprim, including derivatives.	Sulfamethoxazole-trimethoprim	J01EE01	2	2 (100.0)
Macrolides, lincosamides and streptogramins				10 (3.12)
Macrolides	Erythromycin	J01FA01	1	6 (60.00)
	Azithromycin	J01FA10	5	
Lincosamides	Clindamycin	J01FF01	4	4 (40.00)
Aminoglycoside antibacterials				4 (1.25)
Other aminoglycosides	Gentamicin	J01GB03	2	4 (100.0)
	Amikacin	J01GB06	2	
Quinolone antibacterials				35 (10.93)
Fluoroquinolones	Ciprofloxacin	J01MA02	8	35 (100.0)
	Levofloxacin	J01MA12	26	

Antibiotic class	Type of individual antibiotic agent	ATC code	Number of cases	Total (%) (*N*=338)
	Moxifloxacin	J01MA14	1	
Other antibacterials				47 (14.68)
Glycopeptide antibacterials.	Vancomycin	J01XA01	13	19 (40.42)
	Teicoplanin	J01XA02	6	
Polymyxins	Colistimethate	J01XB01	6	6 (12.76)
Imidazole derivatives	Metronidazole	J01XD01	11	11 (23.40)
Nitrofuran derivatives	Nitrofurantoin	J01XE01	1	1 (2.12)
Other antibacterials	Linezolid	J01XX08	10	10 (21.27)
Antimycobacterials				16 (4.73)
Drugs for treatment of tuberculosis				16 (100.0)
Antibiotics	Rifampicin	J04AB02	4	4 (25.00)
Hydrazides	Isoniazid	J04AC01	4	4 (25.00)
Other drugs for treatment of tuberculosis.	Pyrazinamide	J04AK01	4	8 (50.00)
	Ethambutol	J04AK02	4	

*Some patients received multiple antibiotics for treatment.

82.24% of the antibiotics were prescribed from the national essential medicines list (EML), and 55.02% using generic names. Antibiotics were empirically prescribed in 57.84% of cases, and 65.68% had targeted therapy based on culture results. Around 20.58% received prophylactic therapy, and 13.72% for unknown reasons (Table 7).

Factors associated with prescribing antibiotics among study patients

Under chi-square test, the number of medications prescribed during hospital stay (p=0.0026) was associated with the number of antibiotics prescribed. Patients who were prescribed 10 or more medications overall during their hospital stay were significantly more likely to have been prescribed more than two antibiotics during their stay, as compared to those who were prescribed fewer medications (Table 8).

DISCUSSION

In this study, all older patients were prescribed at least one antibiotic, as we included only those patients who were on antibiotics. The most frequently prescribed antibiotic classes were cephalosporins and penems (41.25%), followed by penicillins (25.31%). This corroborates earlier studies which found cephalosporins to be the preferred choice, due to their broad-spectrum activity, less frequent dosing, and better safety profile.[12,15,16] However, a study conducted in Saudi Arabia by Alanazi *et al.* found penicillins to be the most prescribed class.[17] Comparable findings were reported by previous local studies done by Mohajer *et al.*[18] and Oqal *et al.*[19] Considering individual agents, piperacillin/tazobactam was most used, followed by ceftriaxone. These results were generalizable to another retrospective cross-sectional study conducted at a tertiary care hospital in Oman, which also observed piperacillin/tazobactam to be the most commonly prescribed antibiotic agent.[20] Our results also echo the ARMed study, which demonstrated that broad-spectrum penicillin, along with first-generation cephalosporin, accounted for the bulk of antibiotics prescribed, constituting at least one-third of the total usage in 15 of 25 hospitals in the Mediterranean region.[21] Conversely, ceftriaxone was observed to be the most prescribed antibiotic in several studies conducted in developing nations.[10,12,22]

Our study found that only 14.79% of antibiotics used were from the 'Access' group, which was significantly lower compared to the standard set by the WHO AWaRe Classification, which recommends at least 60% of institutional antibiotic consumption should be from this group.[23] This finding was consistent with a global survey demonstrating varied regional use of 'Access' antibiotics, ranging from 28.4% in West and Central Asia to 57.7% in Oceania,[24] with an average of 34.5% in four developing countries.[25] Furthermore, we observed an overuse of 'Watch' group antibiotics, with 72.78% of the prescribed antibiotics falling into this category. This observation was much higher than the figures reported by Dechasa *et al.*, who showed that nearly 66% of antibiotics used were from the 'Watch' group of antibiotics.[12] Similarly, a survey done in West and Central Asia[24] and in four low- and middle-income countries[25] reported a 'Watch' group antibiotic usage count of 66.1% and 64.4% respectively. There is substantial evidence that adhering to a shortlist of essential medicines in any healthcare environment can enhance the pattern of drug utilization, thereby improving patient care.[26] Although the WHO recommends that all prescribed antibiotics should be on the national EML, only 82.24% in our study were, echoing deviations seen in studies from countries like Lesotho (79.0%),[27]

Table 6: Antibiotic utilization pattern among the study participants during hospital stay.

Variables	Category	Frequency (*N*=102)	Percentages
Number of antibiotics at a time.	1	13	12.74%
	2	26	25.49%
	≥3	63	61.76%
	Mean, SD	3.31, 1.7404	
AWaRe classification (*N*=338).	Access	50	14.79%
	Watch	246	72.78%
	Reserve	28	8.28%
	Not classified	14	4.14%
Spectrum of activity (*N*=338).	Broad	277	81.95%
	Narrow	61	18.04%
Type of antibiotic treatment (*N*=338).	Monotherapy	252	74.55%
	Combination therapy	86	25.44%
Route of administration (*N*=338).	Oral	45	13.31%
	Injectable	291	86.09%
	Topicals	2	0.59%
Frequency of administration (*N*=338).	Once daily	63	18.63%
	Two times daily	104	30.76%
	Three times daily	108	31.95%
	Four times daily	63	18.63%
Antibiotic days (*N*=338).	≤3 days	38	11.24%
	4-5 days	63	18.63%
	6-7 days	109	32.24%
	>7 days	128	37.86%
	Mean, SD	8.58, 4.5134	
Culture available.	Yes	88	86.27%
	No	14	13.72%
Specimen for culture (*N*=203).	Blood	64	31.52%
	Urine	68	33.49%
	Stool	10	4.92%
	Sputum	35	17.24%
	Wound	14	6.89%
	Others	12	5.91%
Culture results (*N*=203).	Positive	99	48.76%
	Negative	104	51.23%
Organisms commonly isolated (*N*=99).	*Acinetobacter baumannii*	3	3.03%
	Acinetobacter calcoaceticus	2	2.02%
	Bacteroides fragilis	1	1.01%
	Candida albicans	11	11.11%
	Citrobacter koseri	1	1.01%
	Cutibacterium acnes	2	2.02%
	Enterococcus faecalis	4	4.04%

Variables	Category	Frequency (*N*=102)	Percentages
	Escherichia coli	9	9.09%
	Klebsiella oxytoca	1	1.01%
	Klebsiella pneumoniae	15	15.15%
	Methicillin-resistant staphylococcus aureus	12	12.12%
	Proteus mirabilis	3	3.03%
	Pseudomonas aeruginosa	11	11.11%
	Serratia marcescens	1	1.01%
	Staphylococcus aureus	3	3.03%
	Staphylococcus capitis	1	1.01%
	Streptococcus anginosus	3	3.03%
	Streptococcus pneumoniae	8	8.08%
	Mixed microbes	8	8.08%
Culture sensitivity test available prior to initiating antibiotics.	Yes	46	45.09%
	No	56	54.90%

Abbreviations: AWaRe: Access, Watch, and Reserve; SD: Standard Deviation.

Table 7: WHO prescribing indicators for antibiotics among the study participants during hospital stay.

Variables	Frequency	Percentages
Average number of drugs prescribed per patient.	13.11, 3.7792	
Average number of antibiotics prescribed per patient.	3.31, 1.7404	
Percentage of antibiotics prescribed from national EML.	278	82.24%
Percentage of antibiotics prescribed by generic name.	186	55.02%
Percentage of antibiotics prescribed in injection form.	291	86.09%
Percentage of antibiotics prescribed in oral form.	45	13.31%
Average duration of days antibiotics was prescribed in hospital stay.	8.58, 4.5134	
Percentage of patients who received antibiotics for therapeutic purposes.	67	65.68%
Percentage of patients who received antibiotics for prophylaxis.	21	20.58%
Percentage of patients who received antibiotics for unknown purpose.	14	13.72%
Percentage of patients who received antibiotics for empiric therapy.	59	57.84%

Abbreviations: EML: Essential Medicine List.

India (84.8%),[28] and Pakistan (98.8%).[29] Conversely, studies from Ethiopia[10] and Eritrea[30] exhibited complete adherence, with 100% of prescribed antibiotics coming from the national EML.

Our study found that only 55.02% of antibiotics were prescribed by their generic names, despite a 100% target. The WHO indicators suggest that prescribing antibiotics by their generic names is a significant marker of the adoption of low-cost antibiotics, given it prevents confusion from multiple names for the same product, thereby minimizing the risk of drug replication. This practice should be fully adopted in institutional settings to prevent dispensing errors and redundant treatments.[16] Our finding was also substantiated in studies by Ahmed *et al.*[31] (49.3%) and Mudenda *et al.*[32] (56.1%), however, falls significantly short compared to studies from Cameroon (98.36%),[9] Ethiopia (97.6%),[22] Eritrea (97%),[30] and India (98.0%).[33] Furthermore, 81.95% of the antibiotics in our study were prescribed as broad spectrum, which is also evident from earlier studies.[22,29,34]

The study revealed an average of 3.31 antibiotics prescribed per patient, significantly higher than the WHO's recommended 1.6-1.8, hinting at potential overuse of antibiotics. Our finding exceeded the average antibiotic count reported by Patel *et al.*,[28] Amaha *et al.*,[30] and Gutema *et al.*[34] While efforts should be made to keep the prescription count as low as possible, a higher number may be justified in hospital settings where clinical cases are complicated. The literature indicates a correlation between an increased antibiotic count and the inappropriateness of prescription practices, with the understanding that the higher the number of antibiotics per patient, the more inappropriate the

Table 8: Factors associated with the prescription of antibiotics among the study participants during hospital stay.

Variables	Category	Number		Chi-square P value
		≤2 antibiotics	>2 antibiotics	
Age	60-69	27	48	0.7380
	70-79	7	9	
	≥80	5	6	
Gender	Male	29	48	0.8344
	Female	10	15	
Presence of comorbid conditions.	Yes	23	39	0.7683
	No	16	24	
Number of admission diagnosis.	1-4	21	29	0.4429
	≥5	18	34	
Number of healthcare-associated infections diagnosed following hospital admission.	≤1	31	39	0.0629
	≥2	8	24	
Length of hospital stay.	≤10	3	3	0.5410
	≥11	36	60	
Previous hospitalization in last 30 days.	Yes	16	28	0.7347
	No	23	35	
Number of medications prescribed during hospital stay.	≤9	13	6	0.0026*
	≥ 10	26	57	
Antibiotic use history in last 30 days.	Yes	4	8	0.7098
	No	35	55	

*The result is statistically significant at $p<0.05$ using Chi-square test.

prescription practice becomes. This escalation may also lead to polypharmacy, raising the risk of complications from drug-drug interactions and adverse reactions.[10] Parenteral administration was the primary delivery route in this study, accounting for 86.09% of cases, far exceeding the WHO's 13.4% to 24.1% reference range.[35] This trend could be attributed to the late hospital presentation of critically ill patients, as parenteral administration provides rapid symptomatic benefits and is often reserved for such patients. The results of our study align to the study by Demoz *et al.*[22] (84.8%), Amaha *et al.*[30] (81.4%%), and Gutema *et al.*[34] (82.4%), who noticed frequent prescription of parenteral antibiotics. However, it is important to note that overprescription of parenteral antibiotics can burden patients financially and is considered inappropriate antibiotic use, emphasizing the need for de-escalation of prescriptions based on strict necessity.[29]

Literature states that culture and sensitivity tests should be performed prior to antibiotic prescription, in order to aide prescribers in selecting curative antibiotics. Empirically ordered antibiotics tend to be less appropriate than those prescribed based on culture and susceptibility report data.[36] Despite this recommendation, 57.84% of patients received empirical antibiotics without identification of the causative micro-organism. Approximately, 65.68% received targeted therapy based on culture results, 20.58% received antibiotic prophylactic therapy, and for 13.72%, the reasons for antibiotic usage remained unclear. This differs from the findings of Gandham *et al.*,[26] where a higher percentage of study population received antibiotics empirically (44.80%) followed by curatively (34.70%), and prophylactically (20.40%). Studies by Alemkere *et al.*,[15] Ayele *et al.*,[37] and Sileshi *et al.*,[38] also found a predominance of empiric therapy. Another finding in this study showed that antibiotics were prescribed for an average duration of 8.58 days, longer than averages observed in Ethiopia[10] (6.4 days) and Eritrea[30] (6.36 days). Given the lack of consensus on the ideal duration of therapy for most infectious diseases, it is advisable to treat patients for a minimum of 7-10 days.[33] Prescribing antibiotics for durations either shorter or longer than necessary in the hospital setting requires careful examination and can be managed by implementing institutional guidelines. Shorter courses of treatment may contribute to the emergence of resistant micro-organisms, while prolonged exposure raises the risk of adverse drug reactions, antibiotic resistance, and unnecessary expenditure on antibiotics.[39]

In terms of organisms, *Klebsiella pneumoniae* (15.15%), *Methicillin-resistant Staphylococcus aureus* (12.12%), and *Pseudomonas aeruginosa* (11.11%) were commonly isolated from the study sample specimens. However, in the study conducted by Aly *et al.*, which examined the prevalence of antibiotic resistance in clinical isolates from various Gulf Corporation Council (GCC)

countries, *Escherichia coli* was the most prevalent microorganism, followed by *Klebsiella pneumoniae, Pseudomonas aeruginosa, Methicillin-resistant Staphylococcus aureus*, and *Acinetobacter*.[21] Using chi-square analysis, we observed a significant association between the total number of medications prescribed during hospital stay and the number of antibiotics prescribed (p=0.0026). On the contrary, Abdalla *et al.*[16] and Bansal *et al.*[40] identified a significant link between prescribing pattern and hospital stay duration. Abdalla *et al*. also reported a statistically significant association between number of antibiotics prescribed and type of medical diagnosis.[16]

Limitations of the Study

The study's limitations include its single hospital setting, affecting the generalizability of results due to potential variation in patient characteristics, prescribing patterns, and microbiology resistance patterns across different hospitals. The data collection relied solely on electronic medical records, potentially missing insights from direct interaction with prescribers or patients. The study's retrospective design might have overlooked certain medication details. Lastly, the relatively small sample size could affect the statistical power and generalizability of the findings.

CONCLUSION

In summary, this study focuses on the antibiotic prescribing pattern among older adults hospitalized at Thumbay University Hospital in Ajman, UAE. The findings reveal that the antibiotic prescribing pattern deviated from the recommended WHO standards. Addressing this issue necessitates the implementation of ongoing interventions, conducting regular audits at all levels of healthcare, and developing hospital guidelines and policies that promote better antibiotic utilization. These measures are vital for proper, responsible antibiotic prescribing practices, not just locally but on a larger scale.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

ABBREVIATIONS

ATC: Anatomical Therapeutic Chemical; **BMI:** Body Mass Index; **EML:** Essential Medicines List; **GCC:** Gulf Corporation Council; **ICD:** International Classification of Diseases; **INRUD:** International Network for the Rational Use of Drugs; **UAE:** United Arab Emirates; **WHO:** World Health Organization.

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Table S1: Admission diagnosis among the study population according to the Internation Classification of Diseases-10 code.

ICD code	ICD chapter title	Disease category	Number of cases	Total (%) (*N*=523)
A00-B99	Certain infectious and parasitic diseases.	Infectious gastroenteritis and colitis, unspecified.	2	29 (5.54)
		Respiratory tuberculosis, unspecified.	2	
		Other tuberculosis of specified organs.	1	
		Acute military tuberculosis of multiple sites.	1	
		Sepsis, unspecified organism.	19	
		Other specified viral infections of central nervous system.	1	
		Human immunodeficiency virus (HIV) disease.	2	
		Staphylococcal aureus as the cause of diseases classified elsewhere, unspecified site.	1	
C00-D49	Neoplasms	Multiple myeloma, without mention of complete remission.	1	3 (0.57)
		Neoplasm of uncertain behavior of brain, supratentorial.	1	
		Myelodysplastic syndrome, unspecified.	1	
D50-D89	Diseases of the blood and blood forming organs and certain disorders involving the immune mechanism.	Iron deficiency anemia, unspecified.	4	7 (1.33)
		Vitamin B12 deficiency anemia, unspecified.	2	
		Pancytopenia, unspecified.	1	
E00-E89	Endocrine, nutritional, and metabolic diseases.	Subclinical iodine-deficiency hypothyroidism.	1	71 (13.57)
		Hypothyroidism, unspecified.	1	
		Nontoxic multinodular goiter.	1	
		Type 2 diabetes mellitus with ketoacidosis without coma.	1	
		Type 2 diabetes mellitus with diabetic nephropathy.	3	
		Type 2 diabetes mellitus with diabetic neuropathy, unspecified.	1	
		Type 2 diabetes mellitus with diabetic peripheral angiopathy without gangrene.	9	
		Type 2 diabetes mellitus with foot ulcer.	4	
		Type 2 diabetes mellitus with other specified complications.	1	
		Type 2 diabetes mellitus without complications.	22	
		Drug-induced hypoglycemia without coma.	1	
		Vitamin D deficiency, unspecified.	1	
		Morbid (severe) obesity due to excess calories.	1	
		Hyperlipidemia, unspecified.	17	
		Hypo-osmolality and hyponatremia	6	
		Acidosis, unspecified.	1	
F01-F99	Mental, behavioral and neurodevelopmental disorders.	Unspecified dementia without behavioral disturbance.	7	18 (3.44)
		Delirium due to known physiological condition.	1	

ICD code	ICD chapter title	Disease category	Number of cases	Total (%) (*N*=523)
		Unspecified delirium.	1	
		Psychotic disorder with delusions due to known physiological condition.	1	
		Alcohol dependence with withdrawal, delirium.	2	
		Other psychoactive substance use, unspecified with psychoactive substance-induced psychotic disorder, unspecified.	2	
		Depression, unspecified.	3	
		Unspecified intellectual disability.	1	
G00-G99	Diseases of the nervous system.	Bacterial meningoencephalitis and meningomyelitis, not elsewhere classified.	1	37 (7.07)
		Encephalitis and encephalomyelitis, unspecified.	2	
		Amyotrophic lateral sclerosis.	1	
		Parkinson's disease.	4	
		Striatonigral degeneration.	1	
		Essential tremor.	1	
		Alzheimer's disease, unspecified.	5	
		Epilepsy, unspecified, not intractable, without status epilepticus.	11	
		Migraine, unspecified, not intractable, without status migrainosus.	1	
		REM sleep behavior disorder.	1	
		Hemiplegia, unspecified affecting unspecified site.	5	
		Quadriplegia, unspecified.	1	
		Hydrocephalus, unspecified.	1	
		Anoxic brain damage, not elsewhere classified.	1	
		Myalgic encephalomyelitis/chronic fatigue syndrome.	1	
H00-H59	Diseases of the eye and adnexa.	Unspecified age-related cataract	2	6 (1.14)
		Exudative age-related macular degeneration, bilateral.	1	
		Peripheral retinal degeneration, unspecified.	1	
		Unspecified glaucoma.	1	
		Subjective visual disturbances.	1	
H60-H95	Diseases of the ear and mastoid process.	Diffuse otitis externa, left ear.	1	2 (0.38)
		Unspecified hearing loss, bilateral.	1	
I00-I99	Diseases of circulatory system	Essential (primary) hypertension.	38	95 (18.16)
		Hypertensive emergency.	1	
		Chronic ischemic heart disease, unspecified.	11	
		Pulmonary embolism with acute corpulmonale.	1	
		Nonrheumatic mitral valve disorder, unspecified.	1	
		Nonrheumatic aortic (valve) stenosis	1	
		Cardiomyopathy, unspecified.	2	
		Atrioventricular block, complete.	1	
		Bifascicular block.	1	

ICD code	ICD chapter title	Disease category	Number of cases	Total (%) (*N*=523)
		Cardiac arrest, cause unspecified.	1	
		Unspecified atrial fibrillation.	6	
		Diastolic (congestive) heart failure.	1	
		Heart failure, unspecified.	2	
		Nontraumatic intracerebral hemorrhage, unspecified.	8	
		Cerebral infarction due to thrombosis of precerebral arteries.	6	
		Cerebral infarction, unspecified.	4	
		Cerebrovascular disease, unspecified.	3	
		Peripheral vascular disease, unspecified.	2	
		Embolism and thrombosis of thoracic aorta.	1	
		Chronic embolism and thrombosis of unspecified deep veins of lower extremity, bilateral.	1	
		Varicose veins of lower extremities, unspecified.	1	
		Gangrene, not elsewhere classified.	2	
J00-J99	Diseases of respiratory system.	Pneumonia, unspecified organism.	26	45 (8.60)
		Unspecified acute lower respiratory infection.	2	
		Chronic obstructive pulmonary disease, unspecified.	1	
		Unspecified asthma, uncomplicated.	3	
		Pneumonitis due to inhalation of food and vomit.	5	
		Acute pulmonary edema.	2	
		Pulmonary fibrosis, unspecified.	1	
		Interstitial pulmonary disease, unspecified.	1	
		Pleural effusion, unspecified.	4	
K00-K95	Diseases of digestive system.	Gastro-esophageal reflux disease without esophagitis.	1	23 (4.39)
		Gastritis, unspecified.	2	
		Acute appendicitis with generalized peritonitis.	1	
		Other and unspecified ventral hernia without obstruction or gangrene.	1	
		Acute (reversible) ischemia of large intestine.	1	
		Diverticulitis of large intestine without perforation or abscess without bleeding.	1	
		Diverticulitis of large intestine with perforation and abscess.	1	
		Functional diarrhoea.	1	
		Constipation, unspecified.	1	
		Haemorrhage of anus and rectum	1	
		Hemoperitoneum.	1	
		Other and unspecified cirrhosis of liver.	2	
		Abscess of liver.	1	
		Fatty (change of) liver, not elsewhere classified.	1	
		Calculus of gall bladder without cholecystitis, without obstruction.	1	

ICD code	ICD chapter title	Disease category	Number of cases	Total (%) (*N*=523)
		Acute cholecystitis.	1	
		Acute pancreatitis with infected necrosis, unspecified.	1	
		Acute pancreatitis, unspecified.	2	
		Alcohol induced acute pancreatitis without necrosis or infection.	1	
		Gastrointestinal haemorrhage, unspecified.	1	
L00-L99	Diseases of skin and subcutaneous tissue.	Cutaneous abscess of neck.	1	36 (6.88)
		Cutaneous abscess of unspecified hand.	1	
		Cutaneous abscess of foot.	2	
		Cellulitis, unspecified.	6	
		Local infection of the skin and subcutaneous tissue, unspecified.	4	
		Stevens Johnson syndrome.	1	
		Rosacea, unspecified.	1	
		Hidradenitis suppurativa.	1	
		Decubitus (pressure) ulcer of unspecified site, unspecified stage.	10	
		Granulomatous disorder of the skin and subcutaneous tissue, unspecified.	1	
		Non-pressure chronic ulcer of unspecified part of unspecified lower leg, with unspecified severity.	8	
M00-M99	Diseases of the musculoskeletal system and connective tissue.	Direct infection of elbow in infectious. and parasitic diseases classified elsewhere.	1	17 (3.25)
		Osteoarthritis of knee, unspecified.	2	
		Foot drop, unspecified foot.	1	
		Unspecified acquired deformity of hand, right hand, unspecified site.	1	
		Pain in unspecified elbow.	1	
		Systemic involvement of connective tissue, unspecified.	1	
		Other intervertebral disc displacement, lumbar region.	1	
		Dorsalgia, unspecified.	1	
		Contracture of muscle, unspecified	2	
		Other muscle spasm.	1	
		Adhesive capsulitis of shoulder.	1	
		Pain in unspecified ankle and joints of unspecified foot.	2	
		Age-related osteoporosis without current pathological fracture, unspecified site.	2	
N00-N99	Diseases of genitourinary system.	Acute kidney failure, unspecified.	4	50 (9.56)
		Chronic kidney disease, unspecified	15	
		Calculus of kidney.	1	
		Acute cystitis without hematuria.	3	
		Neuromuscular dysfunction of bladder, unspecified.	2	

ICD code	ICD chapter title	Disease category	Number of cases	Total (%) (*N*=523)
		Rupture of bladder, nontraumatic.	1	
		Urinary tract infection, site not specified.	20	
		Urinary incontinence, unspecified.	1	
		Benign prostatic hyperplasia without lower urinary tract symptoms.	3	
R00-R99	Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified.	Cough, unspecified.	1	25 (4.78)
		Hypoxemia.	1	
		Unspecified abdominal pain.	1	
		Vomiting without nausea.	1	
		Dysphagia, pharyngeal phase.	2	
		Left upper quadrant abdominal swelling, mass and lump.	1	
		Localized swelling, mass and lump, lower limb, bilateral.	1	
		Ataxic gait.	1	
		Anuria and oliguria.	1	
		Other amnesia.	1	
		Disorientation, unspecified.	1	
		Strange and inexplicable behavior.	1	
		Aphasia	1	
		Fever, unspecified	2	
		Weakness	1	
		Syncope and collapse.	1	
		Post traumatic seizures.	2	
		Shock, unspecified.	2	
		Other symptoms and signs concerning food and fluid intake.	1	
		Cachexia.	1	
		Abnormality of albumin.	1	
S00-T88	Injury, poisoning, and certain other consequences of external causes.	Superficial injury of unspecified body region.	1	34 (6.50)
		Traumatic subdural hemorrhage.	2	
		Diffuse traumatic brain injury without loss of consciousness.	4	
		Contusion and laceration of cerebrum, unspecified, without loss of consciousness, initial encounter.	2	
		Fracture of thoracic vertebra.	1	
		Multiple fracture of ribs, right side, initial encounter for open fracture.	1	
		Multiple fracture of ribs, unspecified side, initial encounter for closed fracture.	1	
		Wedge compression fracture of first lumbar vertebra, initial encounter for closed fracture.	1	
		Multiple fracture of pelvis without disruption of pelvis ring	2	

ICD code	ICD chapter title	Disease category	Number of cases	Total (%) (*N*=523)
		Fracture of pubis.	1	
		Nondisplaced fracture of anterior wall of right acetabulum, initial encounter for closed fracture.	1	
		Fracture of other parts of pelvis, initial encounter for closed fracture.	1	
		Laceration of liver, unspecified degree, initial encounter.	1	
		Fracture of clavicle.	1	
		Fracture of unspecified part of scapula, left shoulder, initial encounter for closed fracture.	1	
		Unspecified fracture of upper end of left humerus, initial encounter for closed fracture.	1	
		Unspecified open wound of right elbow, initial encounter.	1	
		Unspecified fracture of shaft of right ulna, initial encounter for closed fracture.	1	
		Traumatic rupture of left radial collateral ligament.	1	
		Displaced intertrochanteric fracture of left femur.	1	
		Displaced comminuted fracture of right patella.	1	
		Displaced bicondylar fracture of left tibia, initial encounter for closed fracture.	1	
		Sprain of posterior cruciate ligament of right knee, initial encounter.	1	
		Tear of anterior cruciate ligament of right knee, initial encounter.	1	
		Unspecified multiple injuries.	1	
		Disruption of wound, unspecified.	2	
		Infection and inflammatory reaction due to percutaneous endoscopic gastrostomy (PEG) feeding tube.	1	
U00-U85	Codes for special purposes.	Coronavirus infection, unspecified.	9	9 (1.72)
V00-Y99	External causes of morbidity.	Person injured in unspecified motor-vehicle accident, traffic.	1	1 (0.19)
Z00-Z99	Factors influencing health status and contact with health services.	Acquired absence of right great toe.	1	15 (2.86)
		Acquired absence of limb, unspecified.	3	
		Tracheostomy status.	7	
		Presence of prosthetic heart valve.	1	
		Coronary angioplasty status.	1	
		Dependence on respirator, status.	2	

Table S2: Pattern of antibiotics prescribed by selected diseases and conditions during hospital stay.

Type of antibiotic agent	Total prescribed number	Skin infection/ cellulitis and abscess/ gangrene/ ulcer/wound	Tuberculosis	Sepsis	Ear infection	CNS infection	URTI/LRTI	COPD	Pleural effusion	Pneumonia	Abdominal pain/dyspepsia	Abdominal abscess	Diarrhoea	Pancreatitis	UTI	Fracture/injury	Others
Mupirocin	2 (0.59)	2 (100.0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Doxycycline	4 (1.18)	1 (25.00)	1 (25.00)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (50.00)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Tigecycline	5 (1.47)	2 (40.00)	0 (0)	1 (20.0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (20.0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (20.0)
Ampicillin	1 (0.29)	1 (100.0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Flucloxacillin	3 (0.88)	2 (66.66)	0 (0)	1 (33.33)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Amoxicillin-clavulanic acid	20 (5.91)	11 (55.00)	0 (0)	0 (0)	1 (5.00)	0 (0)	0 (0)	0 (0)	0 (0)	1 (5.00)	0 (0)	0 (0)	0 (0)	2 (10.00)	2 (10.00)	1 (5.00)	2 (10.00)
Piperacillin-tazobactam	57 (16.86)	9 (15.87)	0 (0)	17 (29.82)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1.75)	15 (26.31)	2 (3.50)	2 (3.50)	0 (0)	2 (3.50)	5 (8.77)	3 (5.26)	1 (1.75)
Cefuroxime	25 (7.39)	7 (28.00)	0 (0)	3 (12.00)	0 (0)	0 (0)	1 (4.00)	0 (0)	0 (0)	1 (4.00)	2 (8.00)	0 (0)	0 (0)	1 (4.00)	2 (8.00)	6 (24.00)	2 (8.00)
Ceftriaxone	51 (15.08)	8 (15.68)	1 (1.96)	4 (7.84)	0 (0)	4 (7.84)	2 (3.92)	0 (0)	2 (3.92)	13 (25.49)	0 (0)	1 (1.96)	1 (1.96)	0 (0)	7 (13.72)	4 (7.84)	4 (7.84)
Ceftazidime-avibactam	4 (1.18)	1 (25.00)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (25.00)	0 (0)	0 (0)	0 (0)	0 (0)	1 (25.00)	1 (25.00)	0 (0)
Cefepime	3 (0.88)	1 (33.33)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (33.33)	1 (33.33)	0 (0)
Meropenem	37 (10.94)	4 (10.81)	0 (0)	10 (27.02)	0 (0)	1 (2.70)	0 (0)	0 (0)	0 (0)	8 (21.62)	1 (2.70)	1 (2.70)	0 (0)	1 (2.70)	4 (10.81)	4 (10.81)	3 (8.10)
Ertapenem	9 (2.66)	2 (22.22)	0 (0)	2 (22.22)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	2 (22.22)	0 (0)	1 (11.11)	0 (0)	0 (0)	1 (11.11)	1 (11.11)	0 (0)
Ceftolozane-tazobactam	3 (0.88)	0 (0)	0 (0)	3 (100.0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Sulfamethoxazole-trimethoprim	2 (0.59)	0 (0)	0 (0)	0 (0)	0 (0)	1 (50.0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (50.0)
Erythromycin	1 (0.29)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (100.0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Azithromycin	5 (1.47)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (20.0)	1 (20.0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (20.0)	1 (20.0)	1 (20.0)	0 (0)	0 (0)

Type of antibiotic agent	Total prescribed number	Skin infection/ cellulitis and abscess/ gangrene/ ulcer/wound	Tuberculosis	Sepsis	Ear infection	CNS infection	URTI/LRTI	COPD	Pleural effusion	Pneumonia	Abdominal pain/dyspepsia	Abdominal abscess	Diarrhoea	Pancreatitis	UTI	Fracture/injury	Others
Clindamycin	4 (1.18)	3 (75.00)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (25.00)	0 (0)
Gentamicin	2 (0.59)	1 (50.00)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (50.00)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Amikacin	2 (0.59)	0 (0)	0 (0)	2 (100.0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ciprofloxacin	8 (2.36)	2 (25.00)	0 (0)	1 (12.5)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (12.5)	1 (12.5)	3 (37.5)	0 (0)	0 (0)
Levofloxacin	26 (7.69)	2 (7.69)	0 (0)	1 (3.84)	0 (0)	0 (0)	2 (7.69)	0 (0)	1 (3.84)	12 (46.15)	0 (0)	0 (0)	0 (0)	0 (0)	5 (19.23)	2 (7.69)	1 (3.84)
Moxifloxacin	1 (0.29)	0 (0)	1 (100.0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Vancomycin	13 (3.84)	1 (7.69)	0 (0)	5 (38.46)	0 (0)	1 (7.69)	0 (0)	0 (0)	0 (0)	0 (0)	1 (7.69)	1 (7.69)	0 (0)	0 (0)	1 (7.69)	1 (7.69)	2 (15.38)
Teicoplanin	6 (1.77)	1 (16.66)	0 (0)	3 (50.00)	0 (0)	0 (0)	1 (16.66)	0 (0)	0 (0)	1 (16.66)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Colistimethate	6 (1.77)	0 (0)	0 (0)	2 (33.33)	0 (0)	1 (16.66)	0 (0)	0 (0)	0 (0)	1 (16.66)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (16.66)	1 (16.66)
Metronidazole	11 (3.25)	1 (9.09)	0 (0)	2 (18.18)	0 (0)	1 (9.09)	0 (0)	0 (0)	0 (0)	0 (0)	1 (9.09)	1 (9.09)	1 (9.09)	1 (9.09)	0 (0)	1 (9.09)	2 (18.18)
Nitrofurantoin	1 (0.29)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (100.0)	0 (0)	0 (0)
Linezolid	10 (2.95)	1 (10.00)	0 (0)	3 (30.00)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	3 (30.00)	0 (0)	0 (0)	0 (0)	0 (0)	1 (10.00)	2 (20.00)	0 (0)
Rifampicin	4 (1.18)	0 (0)	3 (75.00)	0 (0)	0 (0)	1 (25.00)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Isoniazid	4 (1.18)	0 (0)	3 (75.00)	0 (0)	0 (0)	1 (25.00)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Pyrazinamide	4 (1.18)	0 (0)	3 (75.00)	0 (0)	0 (0)	1 (25.00)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Ethambutol	4 (1.18)	0 (0)	3 (75.00)	0 (0)	0 (0)	1 (25.00)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Total	338	63 (18.63)	15 (4.43)	60 (17.75)	1 (0.29)	13 (3.84)	7 (2.07)	1 (0.29)	4 (1.18)	61 (18.04)	8 (2.36)	8 (2.36)	4 (1.18)	9 (2.66)	35 (10.35)	29 (8.57)	20 (5.91)

*Some patients received multiple antibiotics for treatment.