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RESEARCH

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Consumption of systemic antibiotics in a tertiary care hospital in Northern Sri Lanka: a five-year trend analysis

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Abstract

Background Surveillance of antimicrobial consumption helps to understand the pattern of antibiotic utilisation and plays an essential role in tackling antimicrobial resistance. However, a lack of an established surveillance system is a major challenge in combating antimicrobial resistance in low- and middle-income countries (LMICs). This study aimed to determine the pattern of systemic antibiotic consumption at the Teaching Hospital, Jaffna, using the World Health Organization (WHO) methodology for surveillance of antimicrobial consumption.

Methods A descriptive study of systemic antibiotic consumption was conducted at the Teaching Hospital, Jaffna, from 2018 to 2022. Supply data were analysed using the Anatomical Therapeutic Chemical (ATC)/defined daily dose (DDD) methodology. Antibiotic consumption volume was expressed in DDD, while outpatient and inpatient consumption rates were expressed as DDD/100 patients and DDD/100 admissions, respectively. The AWaRe (Access, Watch, and Reserve) classification and Drug Utilisation-90% (DU90%) were used to assess consumption patterns. Trends were assessed using curve estimation analysis. The Wilcoxon signed-rank test and Friedman test were performed to determine the significance of changes between years and over five years, respectively. A p value ≤ 0.05 was considered statistically significant.

Results Compared with 2018, overall antibiotic consumption showed a declining trend except in 2019. Oral antibiotics accounted for more than 80% of total consumption, and amoxicillin/clavulanic acid remained the most commonly consumed antibiotic. Access antibiotics accounted for over 70% of total consumption, with an Access-to-Watch ratio > 2 throughout the study period. The DU90% segment remained largely consistent, comprising 11–12 antibiotics. Curve estimation analysis showed non-linear trends in Access and Watch antibiotic consumption. Despite the decline in total antibiotic consumption, the inpatient antibiotic consumption significantly increased in 2021 compared with 2020 ($p < 0.001$).

Conclusion Analysis of antibiotic supply data showed that the overall pattern of antibiotic consumption remained consistent over a five-year period despite the changes that occurred during the COVID-19 pandemic. Establishing

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routine monitoring of antibiotic consumption using available data sources in hospitals provides basic information and insights into the problems. These findings could help to plan strategies to improve the antibiotic utilisation in LMICs.

Keywords Antibiotic consumption, ATC/DDD methodology, AwaRe, DU90%

Background

Antimicrobial resistance (AMR) is an urgent global health issue causing public health as well as socioeconomic problems [1, 2]. Antimicrobial resistance makes the treatment of infections less effective and may prolong the illness and increase mortality. Furthermore, infections with resistant organisms increase the cost of treatment, as they require additional investigations, a longer duration of treatment or hospital stay, and more expensive medicines [3, 4]. Inappropriate use of antibiotics is the major driver of AMR [2]. It is well documented that global consumption of antibiotics is on the rise, particularly in the low- and middle-income countries (LMICs). The use of broad-spectrum and last resort antibiotics has also increased [2, 3, 5–7]. Furthermore, the COVID-19 pandemic influenced the pattern of antibiotic consumption. Several studies reported an increase in antibiotic use during the pandemic, particularly among antibiotics belonging to the Watch group [7–9]. As the development of AMR is strongly associated with the level of antibiotic use, optimising antibiotic use will reduce the risk of developing bacterial resistance [1, 10]. The major barriers for optimising the use of antibiotics in LMICs are lack of surveillance capacity and comprehensive evidence-based guidance [6, 11]. The World Health Organization (WHO) launched the methodology for a global programme on surveillance of antimicrobial consumption (AMC) in 2016 to provide a global platform to monitor AMC and introduced the Access, Watch and Reserve (AWaRe) categorisation of antibiotics in 2017 with the aim of optimising the use of antibiotics. The WHO has set a target of at least 60% of the antibiotic consumption from the Access group by 2023 [3, 11, 12].

Sri Lanka, a lower-middle-income South Asian nation, has shown a higher rate of consumption of broad-spectrum antibiotics [13, 14]. In line with the WHO's Global Action Plan on AMR, Sri Lanka has launched the National Strategic Plan (NAP) for Combating AMR in 2017 [15]. Though NAP includes surveillance of antibiotic utilisation, a sustainable system for surveillance of AMC is lacking in Sri Lanka [14, 16]. Surveillance of AMC at the national, regional, and hospital levels provides a better understanding of the pattern of AMC. As the density of antibiotic use in hospital settings is higher, the surveillance of antibiotic consumption in hospitals plays an essential role in antibiotic stewardship. Monitoring antibiotic consumption at the hospital level helps to plan and monitor the interventions to optimise antibiotic use at the institutional level [17]. Antibiotic consumption data is derived from aggregated data sources, which are often easily accessible. Though these sources do not provide patient-level information, consumption data serves as a proxy estimate of the antibiotic use and helps to understand the pattern of antibiotic consumption [3, 18]. Antimicrobial consumption was quantified using two key metrics: the volume of consumption, expressed in defined daily doses (DDD), and the consumption rate (consumption density). The consumption rate is a standardised measure that accounts for hospital activity indicators such as admissions, discharges, bed-days, and outpatient visits and is commonly reported as DDD per 100 admissions or DDD per 100 patients [17, 19].

This study aimed to evaluate the pattern of systemic antibiotic consumption over a period of five years at the Teaching Hospital, Jaffna, which is the largest tertiary care hospital in the Northern Province of Sri Lanka. The findings of this study would help to determine the trends and patterns of antibiotic consumption at the Teaching Hospital, Jaffna.

Methods

Study design and setting

This was a descriptive study of antibiotic consumption at the Teaching Hospital, Jaffna, over a period of five years from 2018 to 2022, following the STROBE statement (Supplementary file 5). The Teaching Hospital, Jaffna, is a public-sector tertiary care hospital that provides primary, secondary, and a wide range of specialised care to the public. Like all other public sector healthcare facilities in Sri Lanka, the Teaching Hospital, Jaffna, also delivers the services to the public free of charge [20]. We analysed the consumption of systemic antibiotics at the Teaching Hospital, Jaffna, using the WHO methodology for surveillance of antimicrobial consumption [17, 18].

Inclusion and exclusion criteria

The J01 group (antibacterials for systemic use) of the Anatomical Therapeutic Chemical (ATC) classification consumed at the Teaching Hospital, Jaffna, from 2018 to 2022 was analysed in this study. The analysis included systemic antibiotics administered via oral and parenteral routes. Parenteral antibiotics included intravenous, intramuscular and subcutaneous formulations. Antituberculosis and antileprosy medicines were excluded.

Data source and data collection

We obtained the supply data of antibiotics from the pharmacy store database of the Teaching Hospital, Jaffna.

The hospital pharmacy store is the central point of the pharmacy network of the institution. Supply data was the record of the items issued by the pharmacy store to the internal pharmacies, namely the indoor pharmacy, the outpatient pharmacy, and the clinic pharmacy. The indoor pharmacy supplies the inpatient units, including wards, intensive care units, and operating theatres. The outpatient pharmacy and clinic pharmacy dispense the medicines to the outpatients who visit the outpatient department (OPD) and monthly follow-up clinics, respectively. We extracted the information on antimicrobial supply to the internal pharmacies for a period of five years from 2018 to 2022 using the WHO template for data collection and calculation of antimicrobial consumption estimates [17]. The first author had cross-checked the extracted data to ensure that all the relevant supply data were accurately extracted from the database.

Metrics for the quantification of antibiotic consumption

In this study the metrics used to quantify the antibiotic consumption were consumption volume and consumption rate [17, 19, 21]. Consumption volume and consumption rate were calculated for each year for each antibiotic product. We extracted the supply data of antibiotics in the J01 group (antibacterials for systemic use) of the ATC classification [22] from the hospital pharmacy database. The amount of each antibiotic at ATC level 5 was consolidated for each year in grams. The consumption volume of antibiotics was expressed in defined daily doses (DDD). The number of DDDs was calculated using the ATC/DDD system of the WHO Collaborating Centre for Drug Statistics Methodology (WHO CC) [17] as follows:

$$Number\,of\,DDD = \frac{Total\,number\,of\,grams\,of\,the\,antibiotic\,concumed\,in\,a\,year}{DDD\,value\,of\,the\,antibiotic\,in\,grams\,assigned\,by\,WHO\,CC}$$

The number of outpatients who visited the OPD and clinic for the year was the outpatient hospital activity indicator (denominator) for the calculation of the outpatient antibiotic consumption rate. The number of outpatients for each year was obtained from the outpatient registry and the clinic registry. Outpatient antibiotic consumption rate was expressed in DDD/100 patients [17, 19], which was calculated as follows:

$$Cosumption\,rate = \frac{Number\,of\,DDD\,of\,the\,antibiotic\,for\,the\,year \times 100}{Number\,of\,outpatients\,for\,the\,year}$$

In this study, the hospital activity indicator for inpatients (denominator) was the number of admissions. The number of admissions for each year was obtained from the hospital admission registry. Inpatient antibiotic consumption rate was expressed in DDD/100 admissions [17, 19], which was calculated as follows:

$$Cosumption\,rate = \frac{Number\,of\,DDD\,of\,the\,antibiotic\,for\,the\,year \times 100}{Number\,of\,admissions\,for\,the\,year}$$

Methods used to assess the pattern of antibiotic consumption

AWaRe classification of antibiotics The WHO AWaRe (Access, Watch, and Reserve) classification was used to determine the pattern of antibiotic consumption [3, 17]. The antibiotics were classified into Access, Watch and Reserve groups as per the 2021 WHO classification [23]. Antibiotics that were not categorised in the AWaRe classification were reported as "Other". We have used the Access-to-Watch ratio to determine the pattern of antibiotic consumption.

Drug Utilisation-90% (DU90%) The DU90% is a method used to assess the pattern of drug utilisation. The DU90% segment represents the number of drugs that account for 90% of the total consumption [17, 24, 25]. To determine the DU90%, antibiotics were ranked at the ATC level 5 according to the volume of consumption, and the antibiotics that accounted for 90% of the total consumption were identified for each year. The number of AWaRe antibiotics contributed to DU90% segments being determined.

Data analysis

Results were summarised in DDD, percentage, mean, and standard deviation (SD). An Access-to-Watch ratio > 2 and a greater number of Access antibiotics in the DU90% segment were considered desirable antibiotic consumption. Percent change was used to describe the changes in the consumption of total, Access, and Watch antibiotics over a period of five years, taking 2018 values as baseline. The Wilcoxon signed-rank test and Friedman test were performed to determine the significance of changes between years and over a period of five years, respectively. A p value ≤ 0.05 was considered statistically significant. Curve estimation analysis was carried out to determine the trend of antibiotic consumption. Sensitivity analysis of antibiotic consumption was performed by comparing consecutive years. Sensitivity ratios for Access, Watch, and total antibiotic consumption were calculated separately for outpatient and inpatient settings. The sensitivity ratios were calculated based on the percentage change in hospital activity (outpatient visits or admissions) and the corresponding percentage change in antibiotic consumption for each period using the following formula:

$$Sensitivity\,ratio = \frac{\begin{array}{c}Percent\,change\,in\\ antibiotc\,concumption\end{array}}{\begin{array}{c}Percent\,chenge\,in\,outpatient\\ visits\,or\,admissions\end{array}}$$

As the Reserve and other category antibiotics contributed to less than 1% of the total antibiotic consumption, they were excluded from the analysis of changes over a period of time. This approach was adopted to ensure that the analysis focused on categories with sufficient volume to meaningfully assess changes over time.

Approvals

Approval was obtained from the Ethics Review Committee, Faculty of Medicine, University of Jaffna, Sri Lanka (J/ERC/22/134/NDR/0273), and administrative approvals were obtained from relevant authorities. We collected secondary data from the pharmacy store database of the Teaching Hospital, Jaffna, and we did not collect any information from patients.

Results

Background information

We analysed the consumption of systemic antibiotics at the Teaching Hospital Jaffna from 2018 to 2022. During this period, a total of forty-two antibiotic products (ATC level 5) were consumed. The number of oral, parenteral, and AWaRe categories of antibiotics was almost consistent throughout the five-year period (Table 1).

Volume of antibiotic consumption

Table 2 shows the volume of consumption of antibiotics in DDD. More than two-thirds of the volume was consumed in the OPD and clinics. Oral antibiotics contributed to more than 80% of the total volume. Almost all the antibiotics consumed in the OPD and clinics were oral antibiotics, and almost all the parenteral antibiotics were consumed by the inpatient units. Consumption of oral (45% – 50%) and parenteral (50% – 55%) antibiotics was almost equal in inpatient units. The majority of antibiotics belonged to the Access group (69% – 78%), and the Watch group accounted for less than one-third (22% – 31%) of the total volume. A drop in antibiotic consumption was observed in 2020 and 2021. The change in the volume of consumption over a period of five years was significant for oral antibiotics ($p = 0.0497$) but not for total ($p = 0.540$) or parenteral ($p = 0.412$) antibiotics.

When considering the antibiotic subgroups, penicillins were the most consumed subgroup, and beta-lactam antibiotics contributed to almost two-thirds (60% – 66%) of the antibiotic consumption throughout the five-year period (Table 3).

Trend of antibiotic consumption

There was a progressive increase in the consumption of the Access group up to 2021, and a drop was observed in 2021. Reciprocal changes were observed in the consumption of the Watch group (Fig. 1A). Curve estimation analysis indicated a non-linear trend (dotted lines) in the consumption of Access (linear $R^2 = 0.003$, quadratic $R^2 = 0.46$) and Watch (linear $R^2 = 0.0003$, quadratic $R^2 = 0.44$) group antibiotics over a five-year period. The Access-to-Watch ratio was > 2 (ranged between 2.3 and 3.6) in all five years. When compared to 2018, total antibiotic consumption had dropped except in 2019. Changes in the Access group were not consistent, whereas consumption of Watch group had declined (Fig. 1B).

Table 1 Background information

Description	2018	2019	2020	2021	2022
Number of outpatient visits	640,267	631,563	433,214	303,767	358,735
Number of admissions	87,224	122,143	102,972	86,587	136,073
Number of antibiotics consumed (ATC level 5)	39	41	39	39	37
Access antibiotics	16	16	15	16	15
Watch antibiotics	18	19	18	17	16
Reserve antibiotics	01	02	02	02	02
Other antibiotics	04	04	04	04	04
Number of oral antibiotics	24	24	23	23	22
Outpatients	20	21	21	19	21
Inpatients	23	24	20	22	21
Number of parenteral antibiotics	27	29	27	27	26
Outpatients	02	10	1	0	10
Inpatients	27	29	27	27	26

ATC, Anatomic Therapeutic Classification

Table 2 Volume of consumption of antibiotics in Defined Daily Dose

Description	DDD *n* (%)				
	2018	**2019**	**2020**	**2021**	**2022**
Total consumption	1212995.8 (100.0)	1301399.2 (100.0)	1119255.9 (100.0)	954264.8 (100.0)	1124770.3 (100.0)
Outpatients	914445.3 (75.4)	969503.6 (74.5)	847082.4 (75.7)	665108.2 (69.7)	787523.8 (70.0)
Inpatients	298550.4 (24.6)	331895.6 (25.5)	272173.5 (24.3)	289156.6 (30.3)	337246.5 (30.0)
Oral antibiotics	1054708.6 (87.0)	1133728.9 (87.1)	968512.5 (86.5)	799450.5 (83.8)	951096.7 (84.6)
Outpatients	913760.3 (75.3)	966543.24 (74.3)	847070.8 (75.7)	665108.2 (69.7)	784953.2 (69.8)
Inpatients	140948.2 (11.6)	167185.67 (12.8)	121441.7 (10.9)	134342.3 (14.1)	166143.5 (14.8)
Parenteral antibiotics	158287.2 (13.0)	167670.3 (12.9)	150743.5 (13.5)	154814.3 (16.2)	173673.6 (15.4)
Outpatient	685.0 (0.1)	2960.4 (0.2)	11.7 (0.001)	0.0 (0.0)	2570.6 (0.2)
Inpatients	157602.2 (13.0)	164709.9 (12.7)	150731.8 (13.5)	154814.3 (16.2)	171103.0 (15.2)
Assess groups	840162.7 (69.3)	960028.2 (73.8)	872019.5 (77.9)	660706.0 (69.2)	797379.9 (70.9)
Watch groups	370330.3 (30.5)	337293.8 (25.9)	241813.9 (21.6)	287445.0 (30.1)	317456.4 (28.2)
Reserve groups	67.5 (0.01)	183.9 (0.01)	423.1 (0.04)	298.8 (0.03)	140.8 (0.01)
Other antibiotics	2435.3 (0.20)	3893.4 (0.30)	4999.5 (0.45)	5815.0 (0.61)	9793.2 (0.87)

DDD, defined daily dose

Table 3 Consumption of different classes of antibiotics over a period of five years

ATC code	Subgroup of antibiotics at ATC level 3	DDD *n* (%)				
		2018	**2019**	**2020**	**2021**	**2022**
J01A	Tetracyclines	88700.0 (7.3)	99000.0 (7.6)	88400.0 (7.9)	61900.0 (6.5)	74400.0 (6.6)
J01B	Amphenicols	0.7 (< 0.001)	8.3 (< 0.001)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
J01C	Beta-lactam antibacterials, penicillins	510921.1 (42.1)	674330.9 (51.8)	612917.2 (54.8)	430203.9 (45.1)	522189.6 (46.4)
J01D	Other beta-lactam antibacterials	214301.5 (17.7)	181698.8 (14.0)	124689.1 (11.1)	140060.3 (14.7)	158413.6 (14.1)
J01E	Sulfonamides and trimethoprim	52000.0 (4.3)	29000.0 (2.2)	53000.0 (4.8)	67002.5 (7.0)	82000.0 (7.3)
J01F	Macrolides, lincosamides and streptogramins	119394.2 (9.8)	119087.9 (9.2)	69691.1 (6.2)	87183.2 (9.1)	107694.0 (9.6)
J01G	Aminoglycoside antibacterials	3051.4 (0.3)	3345.4 (0.3)	4452.6 (0.4)	5920.1 (0.6)	7378.3 (0.6)
J01M	Quinolone antibacterials	83507.0 (6.9)	72119.5 (5.5)	68519.5 (6.1)	78011.5 (8.2)	91798.5 (8.2)
J01X	Other antibacterials	141120.0 (11.6)	122808.4 (9.4)	97586.4 (8.7)	83983.3 (8.8)	80896.3 (7.2)

ATC, Anatomic Therapeutic Classification, DDD, defined daily dose

A significant reduction ($p < 0.001$) in the consumption of the Access group was observed in 2021 compared to baseline (2018). Changes observed in the Watch group were not statistically significant.

Table 4 presents the sensitivity analysis of antibiotic consumption over a period of five years. In the pre-COVID-19 year (2019), a slight reduction (-1%) in OPD visits was observed, while the consumption of the Access group increased by 13.7%. In contrast, the consumption of the Watch group decreased by (-15.4%). Among inpatients during the pre-COVID-19 period, both admissions and antibiotic consumption increased; however, the increase in admissions (40%) was substantially greater than the increase in antibiotic consumption (11.2%).

Changes in antibiotic consumption during the COVID-19 pandemic (2020 and 2021) were inconsistent. During the early COVID-19 period (2020), marked reductions in OPD visits (-31.4%), admissions (-15.7%), and total antibiotic consumption (-12.6%) were observed. The reduction was greater for the Watch group (-37.6%) than for the Access group (-5.5%). This pattern changed in the second COVID-19-year (2021), when further reductions were observed in OPD visits (-29.9%), admissions (-15.9%), and the consumption of the Access group in

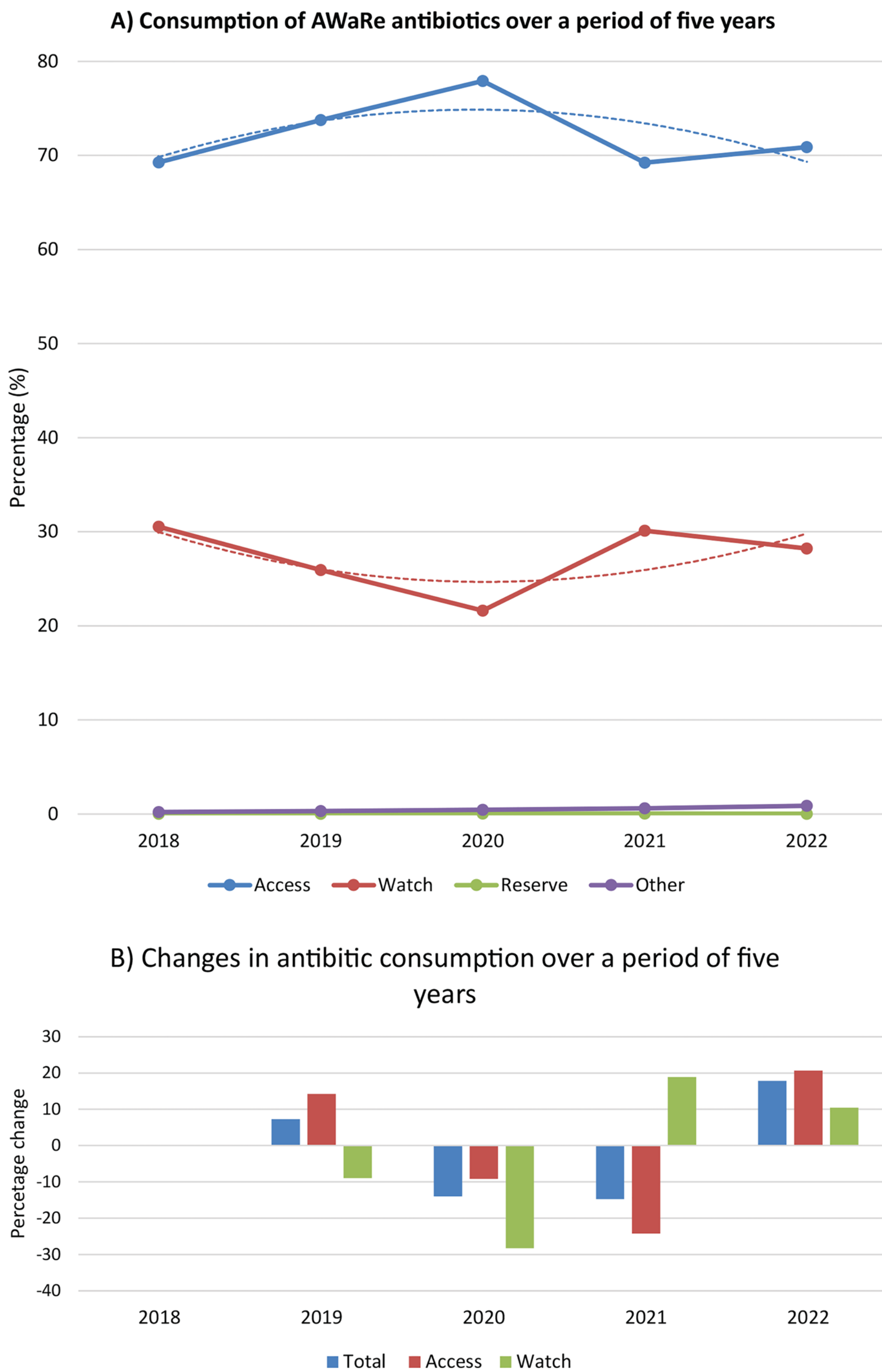

Fig. 1 Trend of consumption of antibiotics over a period of five years

both outpatient (-28.3%) and inpatient (-8.3%) settings. In contrast, Watch group consumption increased with a greater increase among inpatients (39.4%) than outpatients (8.0%).

In the post-COVID-19 year (2022), OPD visits and admissions increased by 18.1% and 57.2%, respectively. A corresponding increase in antibiotic consumption was also observed. The increase was more pronounced for the Access group than Watch group in both outpatient (22.2% vs. 13.2%) and inpatient (21.1% vs. 5.5%) settings.

DU 90% segment antibiotics

Eleven to twelve antibiotics (ATC level 5) accounted for 90% of the consumption each year. Over the period of five years, a total of 14 different antibiotic products contributed to 90% of the antibiotic consumption (Fig. 2). Of

Table 4 Sensitivity analysis of antibiotic consumption over a period of five years

Periods compared	%Δ visits/ admission	Access group		Watch group		Total	
		%Δ	SR	%Δ	SR	%Δ	SR
Outpatients (visits)							
2018 and 2019	-1.4	13.7	-10.1	-15.4	11.4	6.0	-4.4
2019 and 2020	-31.4	-10.1	0.3	-22.2	0.7	-12.6	0.4
2020 and 2021	-29.9	-28.3	0.9	8.0	-0.3	-21.5	0.7
2021 and 2022	18.1	20.2	1.1	13.2	0.7	18.4	1.0
Inpatients (admissions)							
2018 and 2019	40.0	16.6	0.4	3.1	0.1	11.2	0.3
2019 and 2020	-15.7	-5.5	0.4	-37.6	2.4	-18.0	1.1
2020 and 2021	-15.9	-8.9	0.6	39.4	-2.5	6.2	-0.4
2021 and 2022	57.2	22.1	0.4	6.5	0.1	16.6	0.3

%Δ, percent change, SR, sensitivity ration

them, the majority were Access group antibiotics ($n=9$), and the rest were Watch group antibiotics ($n=5$). Amoxicillin/clavulanic acid was the most commonly consumed antibiotic throughout the five-year period.

Figure 3 shows the cumulative change of DU90% segment antibiotics over the five-year period. Among the 14 antibiotics that contributed to 90% of the consumption, a net increase in consumption was observed in six antibiotics, and a net reduction was observed in eight antibiotics (Fig. 3). Of the six antibiotics that showed a net increase, four belonged to the Access group and two belonged to the Watch group. Flucloxacillin showed the highest net increase (56175 DDD). Among the eight antibiotics that showed net reduction, five were Access group antibiotics and three were Watch group antibiotics. The highest reduction was observed in amoxicillin (-66487 DDD).

The top five antibiotics with the highest mean consumption rates in outpatient units were amoxicillin/clavulanic acid, flucloxacillin, amoxicillin, cefuroxime, and doxycycline, and those of inpatient units were amoxicillin/clavulanic acid, metronidazole, cefuroxime, azithromycin, and flucloxacillin. Amoxicillin/clavulanic acid had the highest consumption rate throughout the five years in both outpatients and inpatients. A progressive increase in the rate of consumption of amoxicillin/clavulanic acid in outpatient units from 38.0 DDD/100 patients per day (2018) to 67.2 DDD/100 patients per day (2022) was observed. The changes in the rate of consumption of amoxicillin/clavulanic acid in inpatient units were inconsistent, and the highest rate (81.1 DDD/100 admissions per day) was observed in 2021, and the lowest rate (57.6 DDD/100 admissions per day) was observed in 2019.

Antibiotic consumption rates

Figure 4 shows the consumption rates of total, Access, and Watch antibiotics for outpatients and inpatients with nonlinear trendlines indicated by dotted lines. Curve estimate analysis of antibiotic consumption rate of outpatients showed that the quadratic model fitted slightly better than the linear model for total (R^2, 0.94 vs. 0.92), Access (R^2, 0.86 vs. 0.95), and Watch (R^2, 0.74 vs. 0.67) antibiotics. Similarly, the quadratic model showed a slightly better fit than the linear model among the inpatients for total (R^2, 0.23 vs. 0.21), Access (R^2, 0.19 vs. 0.16), and Watch (R^2, 0.37 vs. 0.25) antibiotics.

Outpatient antibiotic consumption rate

Mean outpatient antibiotic consumption was 186.1 ± 32.3 DDD/100 patients, while the mean consumption rate of oral antibiotics was 185.8 ± 32.3 DDD/100 patients, accounting for 99.9% of the total consumption. Mean consumption rates of Access and Watch antibiotics were 142.7 ± 24.6 DDD/100 patients per day (77%) and 43.2 ± 9.8 DDD/100 patients (23%), respectively. Total and oral antibiotic consumption rates in outpatients showed a progressive increase over the five-year study period (Fig. 4). However, the difference in antibiotic consumption between 2021 (219 DDD/100 patients) and 2022 (220 DDD/100 patients) was minimal. Changes in outpatient antibiotic consumption rates between consecutive years were not statistically significant.

Inpatient antibiotic consumption rate

The mean inpatient antibiotic consumption rate was 292.0 ± 38.4 DDD/100 admissions. The mean consumption rate of oral antibiotics was 138.7 ± 17.3 DDD/100 admissions (48% of the total consumption rate), while that of parenteral antibiotics was 153.3 ± 22.6 DDD/100 admissions (52% of the total consumption rate). Mean consumption rates of Access and Watch group antibiotics were 174.1 ± 17.1 DDD/100 admissions (60%) and 113.3 ± 25.6 DDD/100 admissions (39%), respectively. A declining trend was observed in the total inpatient antibiotic consumption rate except in 2021 (Fig. 4). Significant changes in inpatient antibiotic consumption rates between consecutive years were observed in 2018/2019 ($p=0.015$), 2020/2021 ($p<0.001$), and 2021/2022 ($p=0.004$).

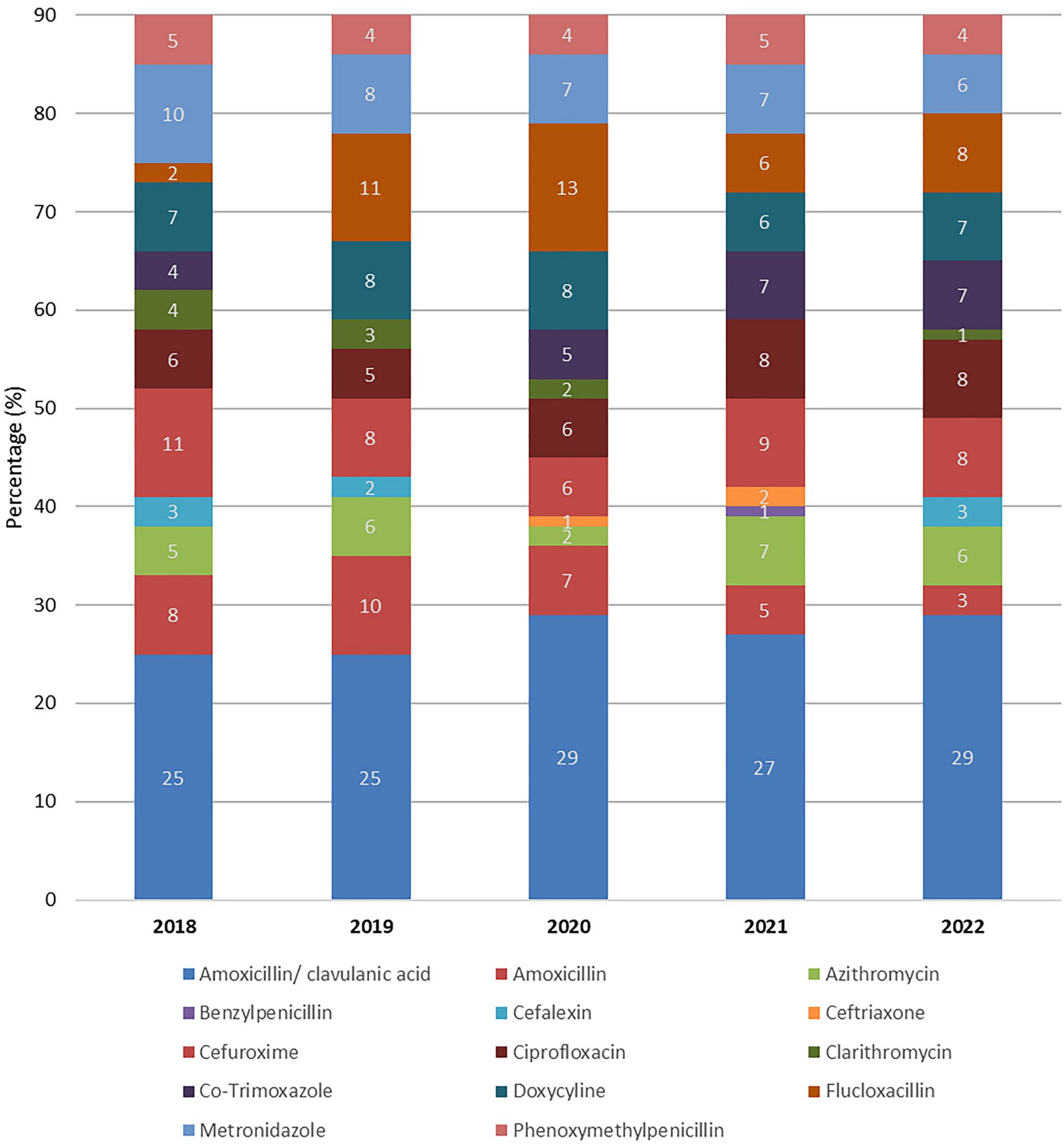

Fig. 2 Antibiotics contributed for 90% of the consumption. Numbers in the bars indicate the percentage of the total consumption of the individual antibiotic

Discussion

This paper describes the quantity and patterns of antibiotic consumption at the Teaching Hospital, Jaffna, a tertiary care hospital that provides a wide range of patient care, from primary to specialised, with around five hundred thousand outpatients and one hundred thousand inpatients annually. Overall, total antibiotic consumption remained relatively stable over the five-year period from 2018 to 2022. However, the findings also highlight notable shifts in consumption patterns associated with the COVID-19 pandemic and the concurrent economic crisis, such as an increase in the use of certain antibiotics to treat COVID-19-related infections and a decrease

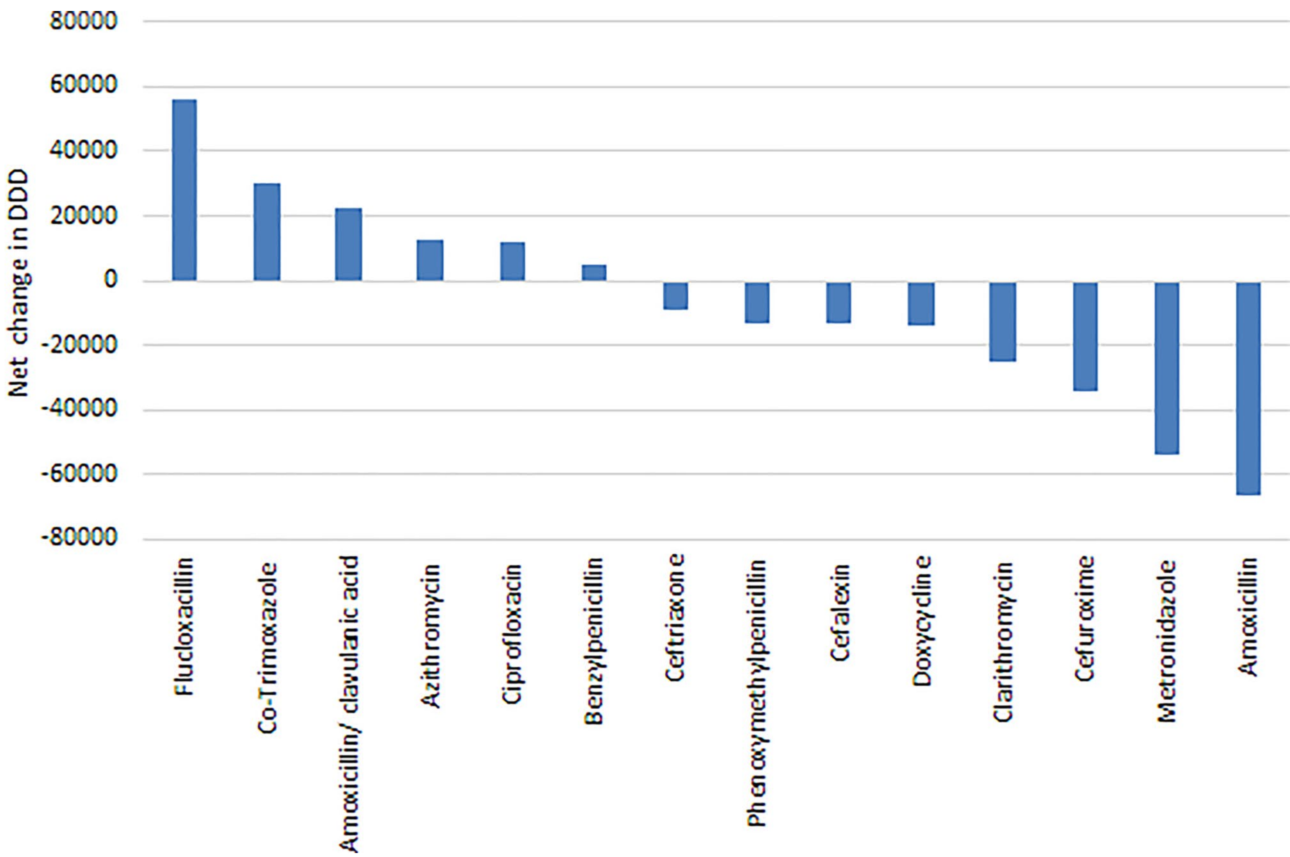

Fig. 3 Cumulative change in antibiotics that contributed to 90% of the consumption DDD. defined daily dose

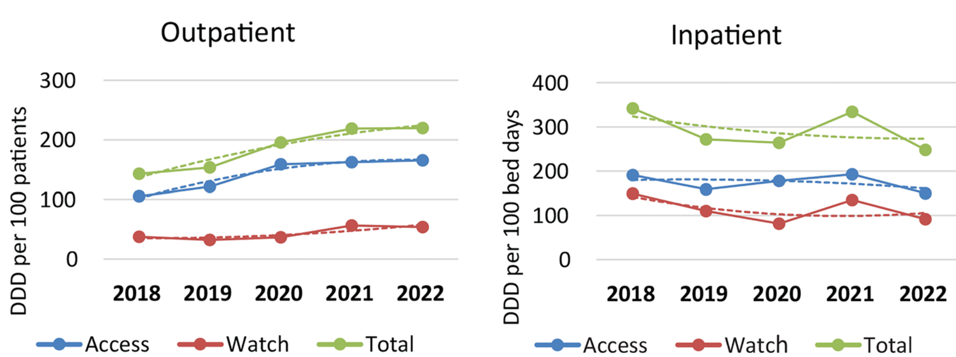

Fig. 4 Trends of total, Access and Watch antibiotic consumption rates of inpatient and outpatient units DDD. defined daily dose

in elective procedures that typically require antibiotic prophylaxis.

Findings of this study have shown inconsistent changes in the volume of antibiotic consumption, with the highest consumption in 2019 and the lowest consumption in 2021. When considering the consecutive years, a decreasing trend in the total volume of antibiotic consumption was observed in 2020 and 2021. A similar finding was reported in a study that described the antibiotic consumption over a period of six years (2016 to 2021) in a secondary healthcare facility in Ghana [19]. The study period included the years affected by the COVID-19 pandemic, which may have influenced antibiotic consumption patterns at the Teaching Hospital, Jaffna. A reduction in outpatient visits and hospital admissions during the pandemic period may have contributed to the decline in the overall volume of antibiotic consumption observed in 2020 and 2021. However, despite the reduction in total consumption volume, the inpatient antibiotic consumption rate increased in 2021, possibly reflecting the admission of patients with more severe illnesses who required prolonged hospitalisation and antibiotic therapy during the pandemic. Reduction in outpatient visits and hospital admissions during the COVID-19 pandemic could be the reason for the decline in the volume of antibiotic consumption in 2020 and 2021. However, we observed a significant increase in the antibiotic consumption rate in 2021 among inpatients. An increase in the antibiotic consumption rate, despite the reduction in the overall volume of antibiotic consumption, was also reported in primary and secondary healthcare settings in England during the COVID-19 pandemic [9]. During the COVID-19 pandemic, patients who needed hospitalisation were more likely to have severe diseases compared to previous years, which could explain the increased antibiotic consumption rate [26]. These findings indicate a shift in the characteristics of hospitalised patients during the pandemic toward more severe conditions, leading to a longer duration of antibiotic therapy rather than a higher number of patients treated with antibiotics in the pre-pandemic period [8]. In contrast to the progressive change observed in outpatient antibiotic consumption rates, the inconsistencies observed in inpatient antibiotic consumption rates also support our claim about changes in hospitalised patients' characteristics. However, findings from other studies on the impact of COVID-19 on hospital antibiotic consumption rates were inconsistent [26–30]. Another observation in our study was a reduction in the volume of antibiotic consumption in 2022 compared to the pre-COVID-19 period (2018 and 2019). We have also found a significant decline in the antibiotic consumption rate in 2022 compared to 2021. The economic crisis in Sri Lanka in 2022, resulting in reduced availability of medication, could be the contributing factor to the lower antibiotic consumption observed in 2022 [31].

We found that oral antibiotics accounted for more than 80% of the total antibiotic consumption. A similar trend was seen in hospitals in Hungary and Ghana, while a Chinese study reported that consumption of oral and parenteral antibiotics was almost equal in tertiary hospitals [19, 32, 33]. In our study, almost all the antibiotics consumed at the OPD were oral, while the consumption of oral and parenteral antibiotics was almost equal in inpatient units. A study conducted in Kazakhstan [34] also reported a similar trend in inpatient antibiotic consumption. The mean outpatient (186.1 ± 32.3 DDD/100 patients) and inpatient (292.0 ± 38.4 DDD/100 admissions) antibiotic consumption rates in our study indicate the greater consumption of antibiotics by hospitalised patients. Furthermore, the inpatient units consumed nearly all of the parenteral antibiotics. These observations are not unexpected, as hospitalised patients have more severe illnesses, which often require parenteral antibiotic therapy and/or longer durations of treatment. They reflect the characteristics of patients treated at OPD and inpatient units.

In the present study, the Access group of antibiotics was the most commonly consumed, and their consumption was well above the WHO's minimum target of 60% throughout the study period [11]. A study conducted in a secondary healthcare facility in Ghana reported a similar finding [19], whereas in other LMICs, namely India, Nepal, Pakistan, and Sierra Leone, consumption of the Watch group antibiotics was greater than in the Access group in hospital settings [35–39]. However, the Ghana study showed an increasing trend in the consumption of the Watch group's antibiotics, and the Access-to-Watch ratio declined from 2.4 to 1.2 over a period of six years, while the ratio remained > 2 throughout the five-year period in our study. National surveys in Sri Lanka have also shown a greater consumption of the Access group of antibiotics compared to the Watch group in the public sector [13, 14]. In Sri Lanka, the Medical Supplies Division of the Ministry of Health is responsible for the procurement and distribution of medicines to all public sector healthcare facilities, guided by the National Essential Medicines List, which informs selection and supply practices [40]. This study explains the greater consumption of access group antibiotics in the public sector. The Teaching Hospital, Jaffna, as a public sector institution, exhibited antibiotic consumption patterns comparable to those observed in other public sector healthcare facilities nationwide. However, there was an increase in the consumption rate of antibiotics that was observed in the Watch group in 2021. A similar trend was reported in the antibiotic consumption rate in healthcare settings in other countries as well, where the consumption of the Watch and Reserve groups was increased during the COVID-19 pandemic [8, 9, 41].

Eleven to twelve antibiotics accounted for 90% (DU90%) of antibiotic consumption, and the majority of DU90% segment antibiotics were Access group antibiotics (64%) in our study. The number of antibiotics contributed to the DU90% segment reported in the literature varied between 7 and 13, and, like our finding, the majority of DU90% antibiotics belonged to the Access group [25, 42–44]. When considering the cumulative change in the consumption of DU90% segment antibiotics in our study, the majority of antibiotics with a net increase were in the Access group, indicating a trend favouring the use of Access antibiotics.

The most commonly consumed antibiotic subgroup (ATC level 3) at the Teaching Hospital, Jaffna, was penicillin, followed by other beta-lactam antibiotics, macrolides, tetracyclines, and quinolones. A similar pattern was reported in the public sector healthcare facilities in Sri Lanka [13, 14]. In our study, the pattern of antibiotic consumption by subgroups was almost consistent throughout the five-year period. Like the present study, the penicillin group remained the most commonly consumed subgroup in most of the other studies that reported the pattern of antibiotic consumption over a period of time [25, 42–44].

Amoxicillin/clavulanic acid was the most commonly consumed antibiotic product in the present study, which was the most commonly consumed antibiotic in a secondary healthcare facility in Ghana as well [19]. However, findings of many other studies differed. Many studies reported amoxicillin as the most commonly consumed antibiotic [13, 14, 25, 42–44]. In contrast, studies conducted in India, Nepal, and Sierra Leone found that second-and third-generation cephalosporins were the most commonly consumed antibiotics in hospital settings [35–37]. A lack of a surveillance systems integrating antimicrobial consumption with antimicrobial resistance patterns could have contributed to the consumption of antibiotics with a broader spectrum of activity to cover all the potential resistant organisms [3, 14, 16, 19].

Limitations

There are some limitations in this study. Because of the lack of records on duration of therapy and hospital stay, we used the number of admissions/outpatient visits as the denominator to express inpatient antibiotic utilisation, whereas many other studies have used different outcome measures, such as DDD per patient day. This limited the comparison of our findings with those of other studies. As the Teaching Hospital, Jaffna is a public hospital; the findings may not reflect antibiotic utilisation trends in private sector hospitals in Jaffna, which also contribute substantially to patient care. In addition, patient-level data were not available to assess the appropriateness of antibiotic use. Furthermore, analysis was carried out for a short period, particularly the pre-COVID-19 years, which limits the ability to detect the evolving long-term trend.

Conclusions

The analysis of the supply data was able to determine the pattern of antibiotic consumption over a period of time. At Teaching Hospital, Jaffna, overall consumption remained largely stable over a five-year period, although notable variations were observed in response to external factors such as the COVID-19 pandemic and the economic crisis. These findings demonstrate the utility of hospital supply data in assessing antibiotic consumption in terms of both quantity and pattern. Routine analysis of such readily available data offers a practical approach to understanding consumption patterns, identifying gaps, and informing targeted strategies to optimise antimicrobial use in low- and middle-income countries.

Abbreviations

AMR	antimicrobial resistance
LMICs	low- and middle-income countries
WHO	World Health organization
AMC	antimicrobial consumption
AwaRe	Access, Watch and Reserve
NAP	National Strategic Plan
ATC	Anatomic Therapeutic Chemical classification
OPD	outpatient department
DDD	defined daily dose
WHO CC	WHO Collaborating Centre
DU90%	Drug Utilisation-90%

Supplementary Information

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Supplementary Material 1

Supplementary Material 2

Supplementary Material 3

Supplementary Material 4

Supplementary Material 5

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Author contributions

Study was conceptualized by Thiyahiny Sunil Navaratinaraja and Yalini Guruparan. Pavithra Meenadchisundaram, Saranya Amarasingam and Somasundaram Nithiyananda were responsible for data collection and data acquisition. All five authors involved in data analysis. TSN and YG were responsible for manuscript preparation. All authors reviewed and approved the manuscript.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki. Ethical permission was granted by the Ethics Review Committee, Faculty of Medicine, University of Jaffna, Sri Lanka (J/ERC/22/134/NDR/0273). Permission was obtained from the hospital authorities to collect the secondary data from the pharmacy records.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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References

1. Tang KWK, Millar BC, Moore JE. Antimicrobial Resistance (AMR). Br J Biomed Sci. 2023;80:11387. https://doi.org/10.3389/bjbs.2023.11387.

2. Roberts SC, Zembower TR. Global increases in antibiotic consumption: a concerning trend for WHO targets. Lancet Infect Dis. 2021;21(1):10–1. https://doi.org/10.1016/s1473-3099(20)30456-4.
3. World Health Organization. WHO report on surveillance of antibiotic consumption: 2016–2018 early implementation. Geneva: World Health Organization. 2018 [Accessed 2024 Dec 16]. https://iris.who.int/handle/10665/277359.
4. World Health Organization. Global action plan on antimicrobial resistance. Geneva: World Health Organization. 2015. [Accessed 2024 Dec 16]. https://iris.who.int/handle/10665/193736.
5. Van Boeckel TP, Gandra S, Ashok A, Caudron Q, Grenfell BT, Levin SA, et al. Global antibiotic consumption 2000 to 2010: an analysis of national pharmaceutical sales data. Lancet Infect Dis. 2014;14(8):742–50. https://doi.org/10.1016/S1473-3099(14)70780-7.
6. Browne AJ, Chipeta MG, Haines-Woodhouse G, Kumaran EPA, Hamadani BHK, Zaraa S, et al. Global antibiotic consumption and usage in humans, 2000-18: a spatial modelling study. Lancet Planet Health. 2021;5(12):e893–904. https://doi.org/10.1016/S2542-5196(21)00280-1.
7. Klein EY, Impalli I, Poleon S, Denoel P, Cipriano M, Van Boeckel TP, et al. Global trends in antibiotic consumption during 2016–2023 and future projections through 2030. Proc Natl Acad Sci USA. 20243;121(49):e2411919121. https://doi.org/10.1073/pnas.2411919121.
8. Castro-Lopes A, Correia S, Leal C, Resende I, Soares P, Azevedo A, et al. Increase of antimicrobial consumption in a tertiary care hospital during the first phase of the COVID-19 pandemic. Antibiotics. 2021;10(7):778. https://doi.org/10.3390/antibiotics10070778.
9. Andrews A, Budd EL, Hendrick A, Ashiru-Oredope D, Beech E, Hopkins S, et al. Surveillance of antibacterial usage during the COVID-19 pandemic in England, 2020. Antibiotics. 2021;10(7):841. https://doi.org/10.3390/antibiotics10070841.
10. Bassetti S, Tschudin-Sutter S, Egli A, Osthoff M. Optimizing antibiotic therapies to reduce the risk of bacterial resistance. Eur J Intern Med. 2022;99:7–12. https://doi.org/10.1016/j.ejim.2022.01.029.
11. Zanichelli V, Sharland M, Cappello B, Moja L, Getahun H, Pessoa-Silva C, et al. The WHO AWaRe (Access, Watch, Reserve) antibiotic book and prevention of antimicrobial resistance. Bull World Health Organ. 2023;101(4):290–6. https://doi.org/10.2471/BLT.22.288614.
12. Sharland M, Zanichelli V, Ombajo LA, Bazira J, Cappello B, Chitatanga R, et al. The WHO essential medicines list AWaRe book: from a list to a quality improvement system. Clin Microbiol Infect. 2022;28(12):1533–5. https://doi.org/10.1016/j.cmi.2022.08.009.
13. Fernandopulle BM, Yasarathna KW, Gunasekara AD, Wijesinghe KG, Beneragama BV, Panapitiya L, et al. Antibiotic consumption in the state sector of Sri Lanka over 25 Years: 1994–2018 using the GAP methodology. Pharm J Sri Lanka. 2020;10(1). https://doi.org/10.4038/pjsl.v10i1.57.
14. Sri Ranganathan S, Wanigatunge C, Senadheera GP, Beneragama BV. A national survey of antibacterial consumption in Sri Lanka. PLoS ONE. 2021;16(9):e0257424. https://doi.org/10.1371/journal.pone.0257424.
15. National Strategic Plan for Combating Antimicrobial Resistance in Sri Lanka. 2023–2028. [Accessed 2024 Dec 16]. https://www.who.int/publications/m/item/sri-lanka-national-strategic-plan-for-combating-antimicrobial-resistance-2023-2028.
16. Ariyawansa S, Gunawardana KN, Hapudeniya MM, Manelgamage NJ, Karunarathne CR, Madalagama RP, et al. One Health surveillance of antimicrobial use and resistance: challenges and successes of implementing surveillance programs in Sri Lanka. Antibiotics. 2023;12(3):446. https://doi.org/10.3390/antibiotics12030446.
17. GLASS guide for national surveillance systems for monitoring antimicrobial consumption in hospitals. Geneva: World Health Organization. 2020. [Accessed 2024 Dec 16]. https://www.who.int/publications/i/item/9789240000421.
18. World Health Organization. GLASS methodology for surveillance of national antimicrobial consumption. Geneva: World Health Organization. 2020. [Accessed 2024 Dec 16]. https://www.who.int/publications/i/item/9789240012639.
19. Labi AK, Kartey BS, Hedidor GK, Nuertey BD, Kodjoe E, Vanderpuije LN, et al. Antibiotic consumption trends in Ghana: analysis of six-years pharmacy issue data from a secondary healthcare facility. JAC-Antimicrobial Resist. 2023;5(2):dlad025. https://doi.org/10.1093/jacamr/dlab087.
20. Rajapaksa L, De Silva P, Abeykoon A, Somatunga L, Sathasivam S, Perera S et al. Sri Lanka health system review. New Delhi: World Health Organization Regional Office for South-East Asia; 2021,Vol 10(1). ISBN 978-92-9022-853-0. [Accessed 2024 Dec 16]. https://www.researchgate.net/publication/354751678_Sri_Lanka_Health_System_Review.
21. Amaha ND, Weldemariam DG, Berhe YH. Antibiotic consumption study in two hospitals in Asmara from 2014 to 2018 using WHO's defined daily dose (DDD) methodology. PLoS ONE. 2020;15(7):e0233275. https://doi.org/10.1371/journal.pone.0233275.
22. WHO Collaborating Centre for Drug Statistics Methodology, Guidelines for ATC classification and DDD assignment. 27th ed. 2024. [Accessed 2024 Dec 16]. https://atcddd.fhi.no/filearchive/publications/1_2024_guidelines__final_web.pdf.
23. AWaRe classification. Geneva: World Health Organization. 2021. [Accessed 2024 Dec 16]. https://www.who.int/publications/i/item/2021-aware-classification.
24. Bergman U, Popa C, Tomson Y, Wettermark B, Einarson TR, Aberg H, et al. Drug utilization 90%--a simple method for assessing the quality of drug prescribing. Eur J Clin Pharmacol. 1998;54(2):113–8. https://doi.org/10.1007/s002280050431.
25. Gutema G, Ali S, Suleman S. Trends of community-based systemic antibiotic consumption: Comparative analyses of data from Ethiopia and Norway calls for public health policy actions. PLoS ONE. 2021;16(5):e0251400. https://doi.org/10.1371/journal.pone.0251400.
26. Fukushige M, Ngo NH, Lukmanto D, Fukuda S, Ohneda O. Effect of the COVID-19 pandemic on antibiotic consumption: a systematic review comparing 2019 and 2020 data. Front Public Health. 2022;10:946077. https://doi.org/10.3389/fpubh.2022.946077.
27. Grau S, Echeverria-Esnal D, Gómez-Zorrilla S, Navarrete-Rouco ME, Masclans JR, Espona M, Gracia-Arnillas MP, Duran X, Comas M, Horcajada JP, Ferrández O. Evolution of antimicrobial consumption during the first wave of COVID-19 pandemic. Antibiotics. 2021;10(2):132. https://doi.org/10.3390/antibiotics10020132.
28. Perrella A, Fortinguerra F, Pierantozzi A, Capoluongo N, Carannante N, Lo Vecchio A, Bernardi FF, Trotta F, Cangini A. Hospital Antibiotic Use during COVID-19 Pandemic in Italy. Antibiotics. 2023;12(1):168. https://doi.org/10.3390/antibiotics12010168.
29. Nagassar RP, Jalim N, Mitchell A, et al. Antimicrobial Consumption from 2017 to 2021 in East Trinidad and Tobago: A Study in the English-Speaking Caribbean. Antibiotics. 2023;12(3):466. https://doi.org/10.3390/antibiotics12030466.
30. Vlahović-Palčevski V, Rubinić I, Payerl Pal M. Impact of the COVID-19 pandemic on hospital antimicrobial consumption in Croatia. J Antimicrob Chemother. 2022;77(10):2713–7. https://doi.org/10.1093/jac/dkac247.
31. Walker R, Abeygunawardana K. Sri Lanka Development Update: Sri Lanka Development Update: Protecting the Poor and Vulnerable in a Time of Crisis. Office of the Publisher, The World Bank, Washington DC, USA; 2022. [Accessed 2024 Dec 16]. http://documents.worldbank.org/curated/en/099052823154036369/P179559078517c0bd0bcc20748bed66c540.
32. Wushouer H, Zhou Y, Zhang X, et al. Secular trend analysis of antibiotic utilisation in China's hospitals 2011–2018, a retrospective analysis of procurement data. Antimicrob Resist Infect Control. 2020;9(1):53. https://doi.org/10.1186/s13756-020-00709-6.
33. Ruzsa R, Benkő R, Hambalek H, et al. Hospital Antibiotic Consumption before and during the COVID-19 Pandemic in Hungary. Antibiot (Basel). 2024;13(1):102. https://doi.org/10.3390/antibiotics13010102.
34. Zhussupova G, Skvirskaya G, Reshetnikov V, et al. The evaluation of antibiotic consumption at the inpatient level in Kazakhstan from 2011 to 2018. Antibiotics. 2020;9(2):57. https://doi.org/10.3390/antibiotics9020057.
35. Baral P, Hann K, Pokhrel B, et al. Annual consumption of parenteral antibiotics in a tertiary hospital of Nepal, 2017–2019: A cross-sectional study. Public Health Action. 2021;11(1):52–7. https://doi.org/10.5588/pha.21.0043.
36. Sinha I, Kanth K, Krishnamoorthy Y, Gopichandran V. Access-Watch ratio based on access, watch, and reserve classification of antibiotics in public health facilities of Tamil Nadu. Indian J Public Health. 2022;66(3):352–4. https://doi.org/10.4103/ijph.ijph_274_22.
37. Lakoh S, Williams CEE, Sevalie S, et al. Antibiotic use and consumption among medical patients of two hospitals in Sierra Leone: a descriptive report. BMC Infect Dis. 2023;23(1):737. https://doi.org/10.1186/s12879-023-08517-0.
38. Jabeen N, Ullah W, Khalid J, Samad Z. Estimating antibiotics consumption in a tertiary care hospital in Islamabad using a WHO's defined daily dose methodology. Antimicrob Resist Infect Control. 2023;12(1):132. https://doi.org/10.1186/s13756-023-01311-2.
39. Bhardwaj A, Agarwal R, Agarwal L, Mangesh M, Bhardwaj A. Impact of coronavirus disease pandemic on antimicrobials consumption and antimicrobial

resistance during the first and second wave in a tertiary care hospital, in India. Int J Basic Clin Pharmacol. 2023;12(6):828–35. https://doi.org/10.18203/2319-2003.ijbcp20233194.
40. Medicines in Health Care Delivery, Sri Lanka, Situational Analysis., 16–27 March 2015. Report prepared using the WHO/SEARO workbook tool for undertaking a situational analysis of medicines in health care delivery in low- and middle-income countries 2016. [Accessed 2024 Dec 16]. https://cdn.who.int/media/docs/default-source/searo/hsd/edm/csa-bhutan-situational-analysis-2015.pdf?sfvrsn=40de3b0_2.
41. Hussein RR, Rabie ASI, Bin Shaman M, et al. Antibiotic consumption in hospitals during COVID-19 pandemic: A comparative study. J Infect Dev Ctries. 2022;16(11):1679–86. https://doi.org/10.3855/jidc.17148.
42. Horvat O, Mijatović V, Milijasević B, et al. Are There Striking Differences in Outpatient Use of Antibiotics Between South Backa District, Serbia, and Some Scandinavian Countries? Front Public Health. 2018;6:91. https://doi.org/10.3389/fpubh.2018.00091.
43. Abbasian H, Hajimolaali M, Yektadoost A, Zartab S. Antibiotic Utilization in Iran 2000–2016: Pattern Analysis and Benchmarking with Organization for Economic Co-operation and Development Countries. J Res Pharm Pract. 2019;8(3):162–7. https://doi.org/10.4103/jrpp.JRPP_19_42.
44. Abejew AA, Wubetu GY, Fenta TG. A six years trend analysis of systemic antibiotic consumption in Northwest Ethiopia. PLoS ONE. 2024;19(1):e0290391. https://doi.org/10.1371/journal.pone.0290391.g001.

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