Journal of Pharmacoeconomics and Pharmaceutical Management

Journal homepage: http://jppm.tums.ac.ir

Evaluating the Pattern of Use and Direct Cost of Injectable Antibiotics Before and After Health Transformation Plan at Namazi Hospital in Shiraz

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Citation Behdadian. Sh, Sakhajoo. N, Soleymani. F, Vazin. A, Mahmoudi. L , Abdizadeh. F, Karimzadeh. I. Evaluating the pattern of use and direct cost of injectable antibiotics before and after Health Transformation Plan at Namazi hospital in Shiraz. Journal of Pharmacoeconomics and Pharmaceutical Management. 2024; 10(3):39-53.

Article Type Research Paper

Article info:

Received: 06.11.2024
Revised: 15.12.2024
Accepted: 25.12.2024

ABSTRACT

Background: The inappropriate use of antimicrobials in outpatient and inpatient settings has led to the spread of microbial resistance, reduced clinical effectiveness of antimicrobial drugs, and significant direct and indirect costs. Various programs have been implemented to improve antimicrobial usage patterns. The study examined how the Health Transformation Plan (HTP) affected prescribing injectable antibiotics and costs at a referral teaching hospital.

Methods: A retrospective observational study was conducted covering the periods 2011 to 2014 (pre-HTP period) and 2014 -2017 (post-HTP period) at Namazi Hospital in Shiraz, Iran. Forty-four injectable antimicrobial drugs were categorized into antifungals, antibacterials, and antivirals based on their Anatomical, Therapeutic, and Chemical codes. Changes in prescribing practices were assessed annually based on total consumption rate, per capita consumption, total cost, and per capita cost. Required data were extracted from the hospital pharmacy database.

Results: Following the implementation of HTP, there were increases in total consumption (13.31%), numerical per capita consumption (1.39%), total cost (142.63%), and per capita cost (146%) of injectable antimicrobial drugs. The increases in per capita consumption, total cost, and per capita cost were statistically significant (P <0.05).

Conclusion: In conclusion, changes in antimicrobial consumption patterns following the implementation of HTP may be partially attributed to increased demand facilitated by easier and faster access to requested antibiotics by pharmacists and physicians in hospitals.

Keywords: Antibacterials, Antifungal, Antiviral, Cost, Medication use.

Introduction

Antibiotics are extensively utilized globally and are one the most commonly used classes of drugs worldwide. In developed countries such as those in Europe and the United States, studies indicate that 23% to 38 % of hospitalized patients receive systemic antibiotics [1, 2]. Similarly, in Iran, as a developing country, systemic antibiotic consumption has been notably high. From 2000 to 2016, Iran's antibiotic consumption rate was nearly three times higher than the average of Organization for Economic Co-operation and Development countries [4]. A systematic review and meta-analysis of 54 studies in Iran revealed that antibiotic prescribing accounted for 45% of outpatient prescriptions and substantial proportions of inpatient prescriptions across various wards [5].

Antibiotic resistance poses a significant global threat, leading to increased mortality, morbidity, healthcare costs, treatment duration, drug toxicity/adverse reactions, and hospitalizations [6]. In 2019, antibiotic resistance directly and indirectly contributed to an estimated 1.27 and 4.95 million deaths worldwide, respectively [7]. Inappropriate antibiotic prescribing, including unnecessary usage, incorrect antibiotic selection, and improper dosing, is a major driver of antibiotic resistance [8,9]. Studies indicate that up to half of antibiotics prescribed in hospitals in the United States are either unnecessary or inappropriate [10]. High rates of bacteria resistance, particularly gram-negative bacteria, have also been reported in Iran [11].

Rationalizing drug use is a priority for healthcare policymakers globally, particularly in resource-constrained settings. Accordingly, the World Health Organization (WHO) advocated for administrative, educational, and regulatory strategies to promote rational drug use, emphasizing appropriate medication selection, dosage, and treatment duration [12]. These measures have many beneficial impacts from both clinical and economic perspectives. In the case of antimicrobial agents, implementing antibiotic stewardship programs has shown promising results in numerous health care settings worldwide [13].

In Iran, the Health Transformation Plan (HTP) was initiated on May 15, 2014, with the main objectives to improve financial protection, enhance equity in healthcare access, and elevate service quality. Implemented in three phases, phase I involved reducing out-of-pocket payments, supporting physician retention in deprived areas, promoting natural vaginal delivery, updating specialist residency programs, improving outpatient visits and hospital hoteling services, and providing financial protection to patients with incurable illness. Phase II involved developing primary healthcare and family physician programs, and phase III involved modifying medical tariffs, establishing control systems for informal payments, and reforming the payment system [14]. Several studies have examined the achievements and challenges of the HTP in Iran. This study aims to investigate the potential effects of the HTP on the prescribing patterns and costs of injectable antibiotics at a referral teaching hospital in southwestern Iran.

Methods

Study Type, Place, and Time

This retrospective, observational study was conducted at Shiraz Namazi Hospital, a tertiary, referral teaching hospital with 1,000 beds, affiliated with Shiraz University of Medical Sciences. The study duration spanned six years, divided into pre-HTP (2011 to 2014) and post-HTP (2014 to 2017) phases. Approval for the study was obtained from the Ethical Committee of Shiraz University of Medical Sciences (Ethical ID: IR.SUMS.REC.1397.207). The studied clinical and paraclinical wards are shown in table 1.

Identification and Classification of Antimicrobials

A list of 44 parenteral injectable antibiotics was compiled based on data from the hospital's health information system (HIS). These antibiotics, including different potencies, were considered as individual agents. The list was approved by the hospital's infectious disease service and categorized according to the WHO Anatomical Therapeutic Chemical (ATC) classification system [15] into antibacterials, antifungals, and antivirals (Table 2). The parenteral antimicrobials were further classified into common (used in all 6 years of study) and non-common (used in some rather than all years of study) injectable antimicrobials (Table 3).

Data Extraction & Studied Indexes

Behdadian. Sh, Sakhajoo. N, Soleymani. F, Vazin. A, Mahmoudi. L , Abdizadeh. F, Karimzadeh. I. Evaluating the pattern of use and direct cost of injectable antibiotics before and after Health Transformation Plan at Namazi hospital in Shiraz. Journal of Pharmacoeconomics and Pharmaceutical Management. 2024; 10(3):39-53.

Data were extracted from the hospital HIS, including the number of patients, type of ward, total consumption rate, consumption per capita rate, total cost rate, cost per capita rate, and prescribed daily dose (PDD). Consumption per capita and cost per capita were calculated by dividing the number and cost of a specific injectable medication annually by the total number and cost of all medications administered during the same year, respectively. Costs were converted from Rials into United States Dollars (USD) based on rates announced by the Central Bank of Iran [16]. Conversion to USD was according to the average rate of the corresponding year (the sum of months divided by 12). To minimize the possible effect of cost variation on results, the price stability (cost at the first year of study [2011]) was either taken or not taken into account for related calculations and comparisons, including total direct cost and cost per capita rate. The PDD was calculated as the average daily amount of each prescribed antibiotic during one year, expressed in grams. [17].

Statistical analyses

Categorical variables were described as percentages or frequencies, while continuous variables were expressed as mean ± standard deviation (SD). The normal distribution of continuous variables was assessed using the Kolmogorov-Smirnov test. Paired t-tests and Wilcoxon signed-rank tests were used to compare normally and non-normally distributed continuous variables before and after the HTP, respectively. Statistical significance was set as P-values less than 0.05. Data analyses were performed by using the IBM SPSS Statistics Version 20 software.

Result

During the years 2011-2012, 2012-2013, 2013-2014, 2014-2015, 2015-2016, and 2016-2017, Namazi Hospital admitted 56,593, 49,807, 54,580, 51,703, 50,918, and 56,152 patients, respectively.

Table 4 presents studied indices, including total consumption rate, consumption per capita rate, total cost rate (with and without price stability), and cost per capita rate (with and without price stability) of injectable antimicrobials over the six-year study period. The comparison of these indices between the pre-and post-HTP periods is demonstrated in Table 5. It is observed that all four variables —total consumption rate, consumption per capita rate, total cost rate, and cost per capita rate of injectable antimicrobials —increased after the initiation of the HTP. Except for the total consumption rate ($P = 0.064$), all other three indices showed statistically significant increases compared to the pre-HTP phase ($P < 0.001$). Notably, the change in cost per capita rate was the highest.

Based on ATC codes, among 44 injectable antimicrobials prescribed in the hospital during pre- and/or post-HTP phases, 37 were classified as antibacterials (J01), 4 as antifungals (J02), and 3 as antivirals (J05). When considering the major therapeutic classes of studied antimicrobials, including antibacterials, antivirals, and antifungals, all studied indices exhibited higher values in the post-HTP period compared to the pre-HTP phase. Changes in consumption per capita rate ($P < 0.001$), total cost rate ($P < 0.001$), and cost per capita rate ($P < 0.001$) of antibacterials reached the level of statistical significance (Table 6).

Figures 1 to 4 illustrate the total consumption rate, consumption per capita rate, total cost rate, and cost per capita of different categories of injectable antibacterials based on the ATC classification system over the six-year study period. Notably, the consumption rate of penicillins, sulfonamides, fluoroquinolones, and other antibiotics (e.g., polymyxins, glycopeptides, lincomycin, and imidazole derivatives) increased during the post-HTP phase compared to the pre-HTP period. Conversely, the consumption rate of aminoglycosides declined post-HTP.

Among the 26 common injectable antimicrobials prescribed before and after the HTP, both the total consumption rate (P value = 0.620) and consumption per capita rate (P value = 0.400) showed comparable values between the pre- and post-HTP phases. In contrast, there were significant differences in the total cost rate and cost per capita rate of common injectable antibiotics before and after HTP ($P < 0.001$ for both indices). Notably, the direct cost of 23 and 3 common injectable antimicrobials increased and decreased during the study, respectively. These three common antimicrobials were acyclovir 250mg, ampicillin/sulbactam 1.5g, and imipenem 500mg.

Regarding 18 non-common injectable antimicrobials, all studied indices, including the total consumption rate (P value = 0.004), consumption per capita rate (P value = 0.004), total cost rate (P value = 0.002), and cost per capita rate (P value = 0.002), increased significantly in the post-HTP compared to the pre-HTP phase. Except for ampicillin 250mg and cefepime 1 g, the direct cost of the other 16 non-common injectable antimicrobials increased during the post-HTP compared to pre-HTP period.

Comparing the total PDD between pre- and post-HTP phases revealed a 19.94% increase that was statistically significant (P value = 0.012). The PDD of 24 and 7 injectable antimicrobials increased and decreased, respectively (Table 7).

Among the 59 clinical and paraclinical wards of the hospital, the total consumption rate of injectable antimicrobials decreased and increased in 17 and 38 wards after HTP, respectively. Except for three wards (adult neurology, pediatric surgical ICU, and CCU), all other wards reported an increase in the total cost rate of injectable antimicrobials in the post-HTP phase, with this median increase reaching statistical significance (P = 0.002). Notably, several new wards were established post-HTP, including pediatric emergency, fast track, hematology-oncology 3, high-risk mothers, ICU-2, cardiac angiography, and adult emergency units 2, 3, and 5. The most commonly prescribed injectable antimicrobials in these new wards after the HTP phase have been listed in Table 8.

Table 9 highlights the three most commonly prescribed and costly injectable antimicrobials over the six-years study period. Vancomycin, clindamycin, and ceftriaxone emerged as the most frequently prescribed, while imipenem-cilastatin 500mg and voriconazole 200mg were consistently among the most costly injectable antimicrobials throughout the study duration.

Discussion

The HTP stands as one of Iran's most recent and remarkable health system reforms, marked by various achievements and challenges. While some objectives have been successfully met, others remain unattained.[14]. Two observational studies conducted in in-patient settings in Tehran (Dr. Shariati Hospital) and Zabol (Amiralmomenin Ali Hospital) have examined the changing patterns of various indices related to injectable antibiotics, including total consumption rate, consumption per capita rate, total cost rate, and cost per capita rate, spanning from 2010 to 2016 (Unpublished data). However, to our knowledge, no published study has specifically addressed the potential impact of HTP on the pattern of injectable antibiotics use in in-patient settings in Iran.

Injectable antibiotics typically fall under the category of essential medications based on the vital/essential/non-essential (VEN) analysis in hospitals [18]. Furthermore, according to ABC analysis, they predominantly belong to class A or B, constituting approximately 75-80% and 15-20% of the total hospital drug budget, respectively [16]. In our investigation, we observed a significant increase in most studied variables, including total consumption rate, consumption per capita rate, total cost rate, cost per capita rate, and PDD of injectable antimicrobials compared to pre-HTP phase, in a referral teaching hospital in Iran.

Our findings are consistent with two other studies in Iran that reported similar changing patterns post-HTP. For instance, at Dr. Shariati Hospital in Tehran, the total consumption rate, total cost rate, and cost per capita rate in the year 2015-16 (post-HTP) increased by 17.36%, 134.24%, and 72.45%, respectively, compared to their mean values in 2011-2014 (pre-HTP). Similarly, at Amiralmomenin Ali Hospital in Zabol, there was an 18.04%, 66.04%, and 38.51% rise in the mean total consumption rate, total cost rate, and cost per capita rate in 2015-2016 (post-HTP), respectively, compared to the corresponding mean values in 2011-2014 (pre-HTP) (Unpublished data). The increased financial resources enabling hospitals to afford more antibiotics, particularly high-cost agents like voriconazole, can partially justify the rise in all studied indices in our survey. This phenomenon can be described as an "induced demand phenomenon [19]".

In addition to financial affordability, the Drug and Therapeutic Committee (DTC) of the hospital gained more freedom and flexibility to add new antibiotics to the pharmacopeia post-HTP, informing other healthcare professionals accordingly. Consequently, medications such as caspofungin 50mg, ciprofloxacin 200mg, colistin 1 million units, levofloxacin 500mg, teicoplanin 200 & 400mg were incorporated into the hospital pharmacopeia during the post-HTP phase. This pharmacopeia expansion provided physicians more antibiotic options for prescribing. Furthermore, the addition of at least 7 new wards to the hospital during the post-HTP phase may have also contributed to this increasing trend.

The significant increase in the PDD of studied injectable antimicrobials during the HTP period compared to the pre-HTP phase is mostly anticipated, given the concurrent rise in both total consumption rate and consumption per capita rates. However, it is noteworthy that PDD is influenced by various factors such as inappropriate antibiotic use. Calculating the PDD to the defined daily dose (DDD) ratio for each antibiotic can guide in determining whether the overuse/inappropriate of a certain antibiotic exist or not. This was beyond the scope of the present survey. However, improving the pattern of use by implementing antibiotic stewardship programs has been demonstrated to decrease PDD in at least two teaching hospitals in Iran [20] [21].

Although the studied indices of injectable antibiotics demonstrated an increasing trend during the post-HTP phase compared to the pre-HTP period, this pattern was not continuous for the total consumption and consumption per capita rates. Notably, a decrease in these values was observed in the last year of the post-HTP phase (2015-2016). One possible explanation for this finding could be the impact of different regulatory measures with either direct or indirect contributions from the pharmaceutical care team. The main aim of these interventions was rationalizing the utilization pattern of strategic or last-resort antibiotics (e.g., liposomal amphotericin B, caspofungin, colistin, linezolid, and voriconazole) in certain or all wards of Namazi hospital in the years 2014, 2015, 2017, and 2018. The results of these programs have been published and discussed elsewhere [22] [20]. Moreover, economic issues such as increasing financial burden or even bankruptcy of insurance companies, health budget deficits secondary to international sanctions and possible mismanagement could also contribute to this phenomenon during HTP [23]. Additionally, the national shortage of certain antimicrobials such as amphotericin B and colistin in 2015-2016 should be also taken into account to explain these findings more realistically.

Concerning the major therapeutic class of studied antimicrobials, all studied indices of antibacterials, antivirals, and antifungals were higher in the post-HTP period compared to the pre-HTP phase, with some reaching statistical significance. The most significant increase in both total consumption rate and consumption per capita rates was observed with antifungals. This finding is partially attributed to the addition of caspofungin and liposomal amphotericin B to the hospital pharmacopeia by the DTC during the post-HTP phase. The decrease in the consumption per capita and cost per capita rates of aminoglycosides during the post-HTP phase compared to the pre-HTP period can be relatively due to the introduction and availability of alternative antibacterials with a better safety profile (less nephrotoxicity and ototoxicity) [24], such as injectable levofloxacin and ciprofloxacin.

For two years in both pre- and post-HTP phases of the study, vancomycin, clindamycin, and ceftriaxone were the most commonly prescribed injectable antimicrobials. Consistent with these results, a prospective cross-sectional study in hospitalized children in a tertiary referral hospital in Kerman, Iran, demonstrated that ceftriaxone, clindamycin, and vancomycin were the most frequently prescribed antibiotics [25]. Similarly, Nabovati et al. in a systematic review and meta-analysis study on 54 studies until January 2020, reported that ceftriaxone, cefazolin, vancomycin, and clindamycin were the most commonly prescribed antibiotics in 15 inpatient healthcare settings in Iran [5]. Outside Iran, a comparison of results from Emerging Infections Program prevalence surveys between 2011 and 2015 in 10 states of the US revealed that the most commonly prescribed antimicrobials were parenteral vancomycin, cefazolin, ceftriaxone, piperacillin-tazobactam, and levofloxacin [26]. It is important to note that the choice of antimicrobials in hospitals depends on various factors such as the type of hospital (general versus specialty/subspecialty, teaching versus non-teaching), living conditions of admitted patients (urban versus rural), age categories of admitted patients (pediatrics versus adults), availability/cost of antibiotics, and, more importantly, the local sensitivity/resistance pattern of microbial species [27] [28].

The present study has several limitations. First, there were several confounders including the addition of seven new wards to the hospital, national shortage of certain antibiotics in the post-HTP phase, and also implementing antibiotic stewardship programs during certain time period of the post-HTP phase. Apart from HTP per se, these can also affect the trend of antibiotic use in the present survey. Second, the pattern of antibiotic susceptibility/resistance of pathogens in pre- and post-HTP phases were not determined and compared. Third, the study was performed in only one hospital and the possibility of center-bias cannot be ruled out. Therefore, our results should be interpreted with caution and generalizing these findings to other in-patient health-care settings in Iran appears to be irrational.

Conclusion

While the introduction of HTP has led to notable improvements in healthcare accessibility and affordability, particularly in terms of antibiotic provision, it also presents challenges, including the potential for overutilization and inappropriate prescribing practices. The increased financial resources allocated to hospital pharmacies post-HTP have likely contributed to the observed rise in antimicrobial utilization. Furthermore, the addition of new antibiotics to hospital formularies and the expansion of healthcare facilities have extended prescribing options for physicians. Moving forward, it is imperative to implement strategies aimed at optimizing antibiotic use, including the development of antibiotic stewardship programs and the adherence to evidence-based guidelines. Additionally, further clinical researches are warranted to explore other aspects of antibiotic prescribing practices and to assess the effectiveness of interventions aimed at promoting rational antimicrobial use after HTP.

Tables

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Table1. List of studied clinical and paraclinical wards

Clinical wards	Paraclinical wards
Emergency 2,3,5	Intensive transplant unit
General ICU	Cardiac angiography
Central ICU	Cardiopulmonary cerebral resuscitation
ICU1,2	
Surgery ICU	
Neurosurgery ICU1,2	
Emergency ICU	
Endoscopic ICU	
Neonate surgery ICU	
Pediatric surgery ICU	
kidney transplant	
Pediatric ICU1,2	
Neonate ICU	
Brain death ICU	
CCU3	
Post-operative, recovery	
Pediatric neurosurgery	
Acute 1 & 2 (emergency)	
Neonate emergency	
Pediatric emergency	
Epileptic patients care	
Hematology and oncology1,2,3	
Surgery1,3	
Pediatric surgery	
Operation room	
Plastic surgery	
Cardiac surgery	
Fast Track	
Nephrology	
Neurology1,2	
Internal 1,3	

Pediatric internal 1,2,3	
Neurosurgery	
Orthopedic	
Liver transplant	
Bone marrow transplant	
Pediatric endocrinology	
Gastroenterology	
Pediatric gastroenterology	
Urology	
CCU1,2	

Antibacterial	Antifungal	Antiviral
Amikacin 100 mg/2 ml	Amphotericin-B 50 mg	Acyclovir 250 mg
Ampicillin 250 mg	Caspofungin 50 mg/10 ml	Acyclovir 500 mg
Ampicillin 500 mg	Fluconazole 200 mg/100 ml	Ganciclovir 500 mg
Ampicillin 1000 mg	Voriconazole 200 mg	
Ampicillin/Sulbactam 1.5 grams		
Ampicillin/Sulbactam 3 grams		
Cefazolin 1 gram		
Cefepime 1 gram		
Cefotaxime 500 mg		
Cefotaxime 1 gram		
Ceftazidime 1 gram		
Ceftazidime 2 grams		
Ceftizoxime 500 mg		
Ceftizoxime 1 gram		
Ceftriaxone 1 gram		
Cefuroxime 750 mg		
Cefuroxime 1.5 grams		
Ciprofloxacin 200 mg/20 ml		
Cloxacillin 500 mg		
Colistin 1,000,000 units		
Co-trimoxazole 480 mg/5 ml		
Clindamycin 300 mg/2 ml		
Gentamicin 80mg/2ml		
Imipenem 500 mg		
Levofloxacin 500 mg/2 ml		
Linezolid 600 mg		
Meropenem 500 mg		
Metronidazole 500 mg		
Penicillin G sodium 5,000,000 units		
Penicillin G procaine 800,000 units		
Penicillin 600,000/300,000/300,000 units		
Penicillin G benzathine1,200,000 units		
Piperacillin/Tazobactam 2.25 grams		

Piperacillin/Tazobactam 4.5 grams		
Teicoplanin 200 mg		
Teicoplanin 400 mg		
Vancomycin 500 mg		

Table 2. List of studied injectable antimicrobials divided by main therapeutic classes

Table 3. List of studied injectable antimicrobials divided by common and non-common agents in pre and post phases of health transformation plan

Common injectable antimicrobials	Non-common injectable antimicrobials
Acyclovir 250 mg	Acyclovir 500 mg
Amikacin 100 mg/2 ml	Ampicillin 250 mg
Ampicillin 500 mg	Caspofungin 50 mg/10 ml
Ampicillin 1000 mg	Cefepime 1 gram
Ampicillin/Sulbactam 1.5 grams	Cefuroxime 750 mg
Ampicillin/Sulbactam 3 grams	Cefuroxime 1.5 grams
Amphotericin-B 50 mg	Ciprofloxacin 200 mg/20 ml
Cefazolin 1 gram	Colistin 1,000,000 units
Cefotaxime 500 mg	Fluconazole 200 mg/100 ml
Cefotaxime 1 gram	Levofloxacin 500 mg/2 ml
Ceftazidime 1 gram	Linezolid 600 mg
Ceftazidime 2 grams	Penicillin G sodium 5,000,000 units
Ceftizoxime 500 mg	Penicillin G procaine 800,000 units
Ceftizoxime 1 gram	Penicillin 600,000/300,000/300,000 units
Ceftriaxone 1 gram	Penicillin G benzathine1,200,000 units
Cloxacillin 500 mg	Teicoplanin 200 mg
Co-trimoxazole 480 mg/5 ml	Teicoplanin 400 mg
Clindamycin 300 mg/2 ml	Voriconazole 200 mg
Ganciclovir 500 mg	
Gentamicin 80 mg/2ml	
Imipenem 500 mg	
Meropenem 500 mg	
Metronidazole 500 mg	
Piperacillin/Tazobactam 2.25 grams	
Piperacillin/Tazobactam 4.5 grams	
Vancomycin 500 mg	

Table 4. Total consumption rate, consumption per capita rate, total cost rate, and cost per capita rate of 44 injectable antimicrobials during 6 years of the study

Index /Year	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017
Total consumption rate, number	506,444	541,964	522,817	610,339	624,052	545,995
Consumption per capita rate, number	8,949	10,881	9,579	11,805	12,256	9,723
Total cost rate (without price stability), USD	191,222.406	219,884.662	114,132.157	174,258.914	201,667.163	207,379,717
Total cost rate (with price stability), USD	189,720.086	199,840.87	79,376.1876	85,035.69	77,029.48	60,384.036
Cost per capita rate (without price stability), USD	3.378	4.414	2.091	3.370	3.960	3.906
Cost per capita rate (with price stability), USD	3.352	4.012	1.154	1.644	1.512	1.075

Table 5. Comparison of studied indexes between pre- and post-health transformation plan phases

Variable	Percentage of changes during the health transformation plan	P.value
Total consumption rate	+13.31%	0.064
Consumption per capita rate	+1.39%	< 0.001
Total cost rate	+ 142.63%	< 0.001
Cost per capita rate	+ 146%	< 0.001

Table 6. Comparison of studied indexes divided by major therapeutic classes of antimicrobials between pre- and post-health transformation plan phases

Class of antimicrobials	Variable	Percentage of changes during the health transformation plan	P.value
Antibacterials	Total consumption rate	+ 12.55%	0.13
	Consumption per capita rate	+ 1.39%	< 0.001
	Total cost rate	+ 70.39%	< 0.001
	Cost per capita rate	+ 72.76%	< 0.001
Antivirals	Total consumption rate	+ 4.94%	1
	Consumption per capita rate	+ 6.43%	0.59
	Total cost rate	+ 114.14%	0.285
	Cost per capita rate	+ 117.17%	0.285
Antifungals	Total consumption rate	+159.65%	0.068
	Consumption per capita rate	+ 26.163%	0.068
	Total cost rate	+ 62.70%	0.068
	Cost per capita rate	+ 64.71%	0.068

Table 7. Comparison of prescribed daily dose of studied injectable antimicrobials between pre- and post-health

transformation plan phases

Drug Name	Prescribed daily dose (grams)		Difference Before and After health transformation plan phases	Wilcoxon Output	
	Pre-health transformation plan phase	Post-health transformation plan phase		Z	p-value
Acyclovir	1837/25	2504/37	667/12	-2.49	0.012
Amikacin	3291	2249	-1042		
Ampicillin	12085/78	12893	807/25		
Ampicillin/sulbactam	14988/5	29029/75	14041/3		
Caspofungin	0	2725	2725		
Cefazolin	39645/33	32577/66	-7067/67		
Cefepime	417025	3	-468/25		
Cefotaxime	3785/12	7948/75	4163/62		
Ceftazidime	8774	9353/25	579/25	-2.49	0.012
Ceftizoxime	4889/75	6640	1750/25		
Ceftriaxone	105433/75	100343	-5091/75		
Cefuroxime	0	0	0		
Ciprofloxacin	0	25168	25168		
Cloxacillin	15240/25	15517	276/75		
Colistin	0	14968/33	14968/3		
Amphotericin-B	13871/42	25902/85	12031/4		
Clindamycin	19780/65	37850	-1930/65		
Co-trimoxazole	4617/34	7364/87	2768/32		
Fluconazole	0	1127	1127		
Ganciclovir	3722	5517	1795		
Gentamicin	15218/66	10709/66	-4509		
Imipenem/Cilastatin	44039/75	34103	-9936/75		
Levofloxacin	0	556	556		
Linezolid	9/5	2696/5	2687		
Meropenem	11447/5	22709/75	11262/3		
Metronidazole	51082/66	61447	10394/3		
Penicillin G	0	1244/7	1244/7		
Piprecillin-Tazobactam	5326/46	55544/2	227/96		
Teicoplanin	0	8135/5	8135/5		
Vancomycin	67194/75	72091/25	4896/5		
Voriconazole	18/8	1662	1643/5		

Table 8. The most common injectable antimicrobials prescribed in 7 wards developed after the health transformation plan

Hospital ward	The most commonly prescribed antibiotics	Consumption rate during three years
Pediatric Emergencies	Clindamycin	946
Fast Track	Ceftriaxone	2,161
Hematology and Oncology 3	Vancomycin	3,732
High-risk mothers	Cefazolin	618
ICU2	Vancomycin	1,481
Cardiac angiography	Ceftriaxone	90
Adult Emergency units 2, 3, 5	Ceftriaxone	5

Table 9. The most commonly prescribed and most costly injectable antimicrobials during 6 years of the study

Year	The most costly injectable antimicrobials		The most commonly prescribed injectable antimicrobials	
	Injectable Antibiotics	Average Price ($)	Injectable Antibiotics	Total Usage in a Year
2011-2012	Voriconazole 200 mg	14.208	Vancomycin 500 mg	80,641
	Ganciclovir 500 mg	6.733	Clindamycin 300 mg/2ml	73,899
	Imipenem/Cilastatin 500 mg	1.863	Ceftriaxone 1 g	66,161
2012-2013	Ganciclovir 500 mg	7.030	Vancomycin 500 mg	95,099
	Imipenem/Cilastatin 500 mg	1.908	Clindamycin 300 mg/2ml	82,116
	Acyclovir 500 mg	0.876	Ceftriaxone 1 g	73,722
2013-2014	Linezolid 600 mg	9.217	Vancomycin 500 mg	93,039
	Ganciclovir 500 mg	4.514	Amphotericin-B 50 mg	82,669
	Imipenem/Cilastatin 500 mg	0.807	Ceftriaxone 1 g	70,985
2014-2015	Voriconazole 200 mg	10.263	Vancomycin 500 mg	101,851
	Linezolid 600 mg	5.780	Clindamycin 300 mg/2ml	86,661
	Ganciclovir 500 mg	4.491	Ceftriaxone 1 g	71,795
2015-2016	Voriconazole 200 mg	9.590	Vancomycin 500 mg	96,970
	Linezolid 600 mg	5.804	Clindamycin 300 mg/2ml	84,195
	Amphotericin-B 50 mg	4.347	Ceftriaxone 1 g	75,394
2016-2017	Caspofungin 50 mg	18.453	Vancomycin 500 mg	89,544
	Voriconazole 200 mg	8.650	Metronidazole 500 mg	58,614
	Linezolid 600 mg	4.818	Clindamycin 300 mg/2ml	56,244

Figures

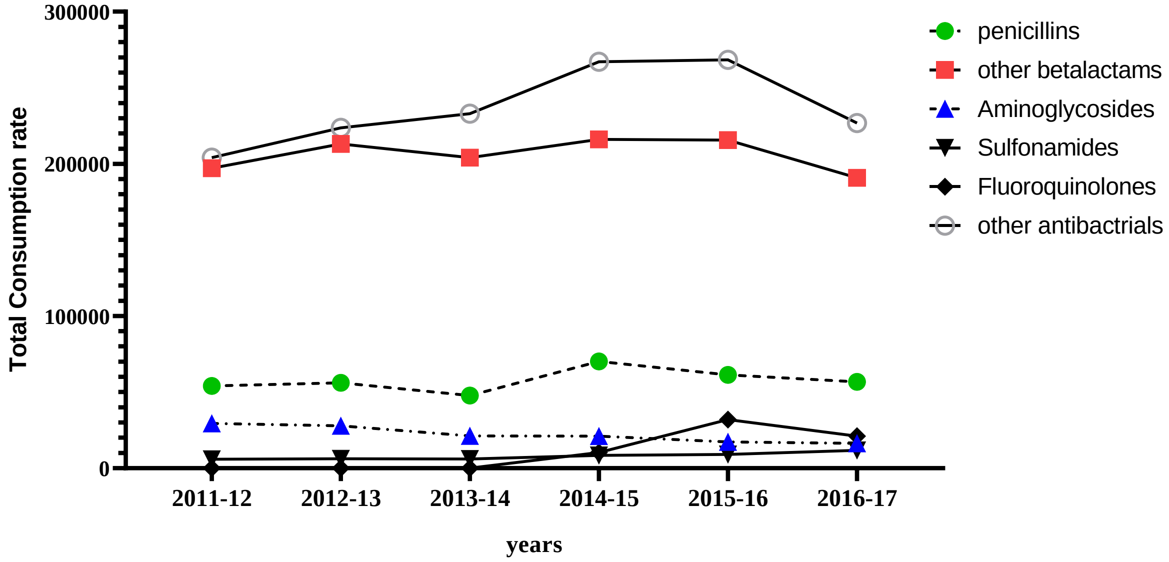

Figure 1. The total consumption rate of different categories of injectable anti-bacterials based on the ATC classification system during 6 years of the study

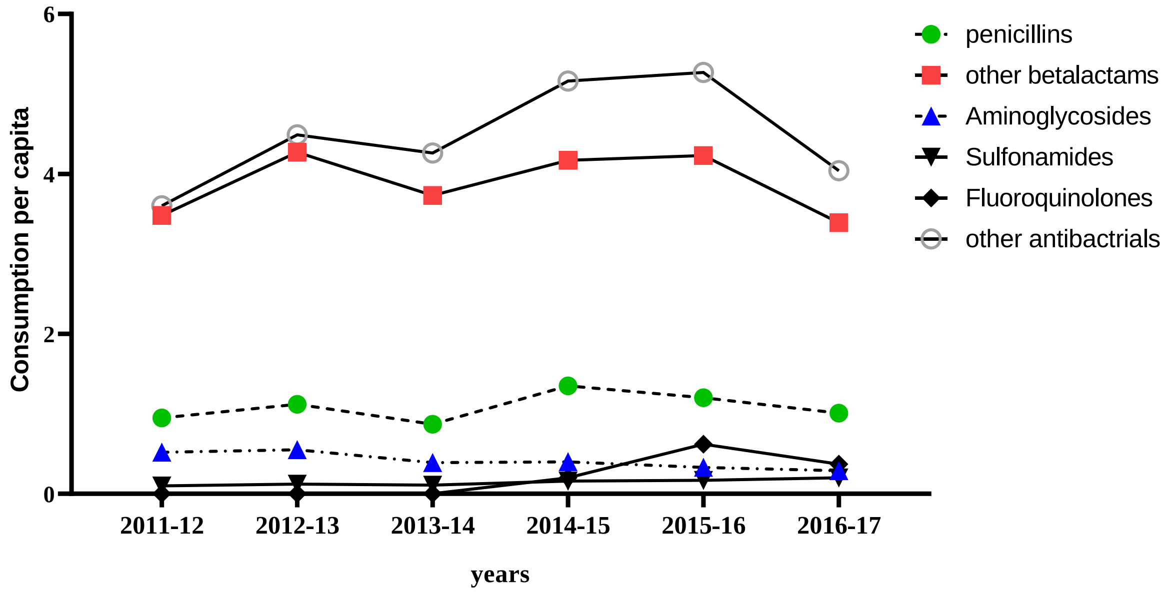

Figure 2. The consumption per capita rate of different categories of injectable anti-bacterials based on the ATC classification system during 6 years of the study

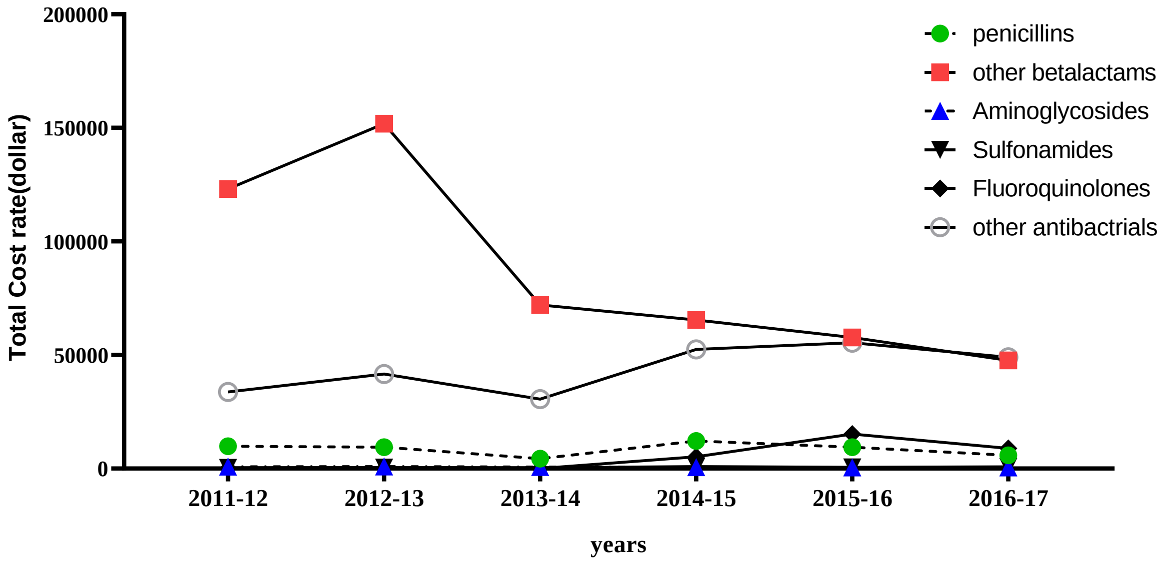

Figure 3. The total cost rate of different categories of injectable anti-bacterials based on the ATC classification system during 6 years of the study

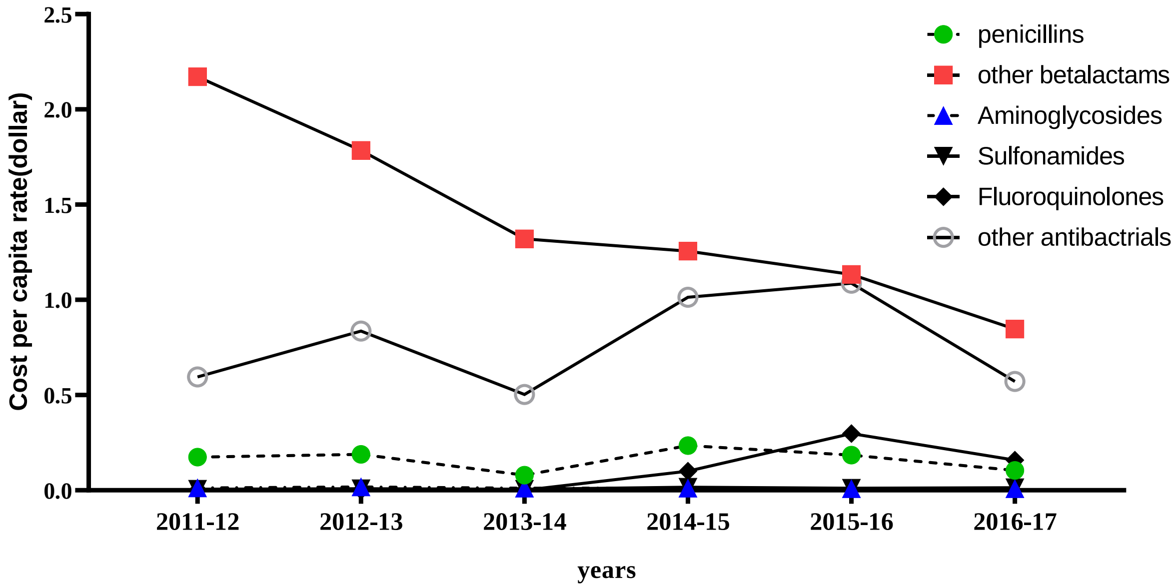

Figure 4. The cost per capita of different categories of injectable anti-bacterials based on the ATC classification system during 6 years of the study

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