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Analysis of antimicrobial consumption and cost in a teaching hospital

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Summary
Background: The aim of this study is to compare the periods before and after the intervention applied using the ATC/DDD method in order to ascertain the rational use of antibiotics in a newly established hospital.
Method: The appropriateness of the hospital's antibiotic use, consumption rates and the costs were calculated and compared with other hospitals. Based on these data, an intervention has been planned in order to raise the quality of antibiotic use. The periods before and after the intervention were compared. Between 16 May 2011 and 23 May 2012, data were collected from all hospital units by the infectious diseases specialists and a point prevalence survey was conducted. Anatomical therapeutic chemical classification and the defined daily dose (DDD) methodology were used to calculate the antibiotic consumption.
Results: On two specific days in 2011 and 2012, 194 out of 307 patients (63.2%) and 224 out of 412 patients (54.4%) received antibiotic treatment, respectively. In 2011 and 2012, the percentage of appropriate antibiotic use was 51% and 64.3%, respectively. Both in 2011 and 2012, inappropriate antibiotic use was found to be significantly higher in surgical clinics in comparison to the internal diseases clinics and the ICU. This was caused by the high rates of inappropriate perioperative antimicrobial prophylaxis observed in surgical clinics. During both years, approximately one-third of the antibiotics were prescribed for the purposes of perioperative prophylaxis, while 88.5% and 43.7% of these, respectively, were inappropriate and unnecessary. Cephalosporins, fluoroquinolones, combinations of penicillins

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(including β-lactamase inhibitors) and carbapenems were the most frequently prescribed antibiotics during the study periods. The mean total antibiotic consumption was 93.6 DDD/100 bed-days and 63.1 DDD/100 bed-days, respectively. The cost of total antibacterial consumption was € 7901.33 for all the patients (€ 40.72 per infected patient) and € 6500.26 (€ 29.01 per infected patient), respectively.
Conclusion: Each hospital should follow and assess their antibiotic use expressed in DDD in order to compare their antibiotic use with national and international hospitals (WHO, 2009 [14]).

Introduction

The overuse of antimicrobial agents is a global problem. Several studies have demonstrated an overall increase in the rate of antimicrobial drug consumption over time. This widespread use of antimicrobial agents has been associated with increased healthcare costs and the emergence of bacterial resistance to these drugs [1—3]. Antibiotics are among the drugs associated with the highest costs worldwide and account for 20—30% of total drug expenditures [4,5]. The total expenditure on antimicrobials in Turkey in 2010 equaled 13.9% of all drug costs and ranked first in drug expenditures [5]. However, the majority of this consumption is considered to be unnecessary or inappropriate. Inappropriate antibiotic use is regarded as a common problem in Turkey [6].

Through rational antimicrobial use, healthcare costs can be reduced, and the quality of antimicrobial treatment can be improved. According to reports, 20—50% of antimicrobial use in hospitals is questionable or inappropriate [1,3]. These data highlight the importance of surveillance of antimicrobial use. To improve the quality of antimicrobial treatment and to reduce the related costs, several recent initiatives have encouraged hospitals to undertake surveillance of antimicrobial consumption patterns to evaluate the current situation [3,7].

Our aim was to compare antibiotic consumption rates, related costs and the appropriateness of antibiotic use between our hospital and national and international hospitals. In particular, the Anatomical Therapeutic Chemical/Defined Daily Dose (ATC/DDD) method was used to ascertain rational antibiotic use in a newly established hospital. We further aimed to compare the periods before and after an intervention planned to improve the quality of antibiotic use.

Methods

Hospital setting

Diyarbakir Teaching and Research Hospital is a 672 bed tertiary center with six intensive care units (ICUs), 10 medical units and eight surgical units. This center first admitted patients in 2010, and it serves as a referral hospital for Turkey's southeast region.

For the purposes of this study, data were collected from the medical (cardiology, gastroenterology, nephrology, internal medicine, infectious diseases, chest diseases, medical oncology, neurology, dermatology and psychiatry) and surgical (general surgery, cardiovascular surgery, neurosurgery, orthopedics, otorhinolaryngology, plastic surgery, thoracic surgery and urology) departments and the ICUs (anesthesiology and reanimation, neurosurgery, thoracic surgery, chest diseases, general surgery and neurology).

A cross-sectional study was planned to compare the periods before and after an intervention. More specifically, the point prevalence method was used in this study. Three separate teams, each consisting of an infectious diseases specialist and an infection control nurse, underwent training, and all clinics were surveyed by these teams from May 16, 2011, through May 23, 2012. All patients receiving antimicrobial treatment were included in the study, regardless of the indication. Patient files, nursing observation flow sheets and physicians' orders from each clinic were individually inspected for each patient. When necessary, the clinics' physicians and nurses were also consulted. The demographic characteristics, diagnoses, drugs, antimicrobial drug doses and dose ranges, microbiological and biochemical test results and radiological imaging findings of each patient receiving antimicrobial treatment were recorded on a pre-designed, standard form. Furthermore, to determine the duration of antimicrobial treatment in the patients who were treated for prophylactic purposes, antibiotic use on the previous day was also assessed. Any missing data were completed through the revision of the patient files in the days following the study.

The criteria of the Centers for Disease Control (CDC) and the methodology of the National Healthcare Safety Network (NHSN) were employed for the diagnosis of hospital-acquired infections (HAIs) [8]. Fever of unknown origin (FUO) was diagnosed according to the criteria described by Petersdorf and Beeson [9]. Every physician evaluated the appropriateness of antibiotic use in the clinics that s/he inspected according to the criteria specified in the Sanford Guide to Antimicrobial Therapy [10].

The appropriateness of surgical prophylactic antibiotherapy was evaluated in light of the international guidelines for the antibiotic of choice, its dose and dose interval, the time and duration of its administration and any additional doses due to the duration of surgery [11—13].

The guidelines recommend the administration of a nontoxic and low-cost, narrow-spectrum antibiotic within 30—60 min before incision. In this context, the World Health Organization (WHO) regards cefazolin and cefuroxime as the only suitable antimicrobial agents. If the rates of methicillin-resistant *Staphylococcus epidermidis* or *Staphylococcus aureus* infections are known or thought to be high, if the patient has a life-threatening beta-lactam allergy, or if a large-scale surgery involving a metal prosthesis is planned, vancomycin is recommended as the antibiotic of choice. In all other procedures, first- or second-generation cephalosporins (cefazolin or cefuroxime) are recommended as the first-line antibiotic. Moreover, if blood loss during surgery exceeds 1500 ml or if the duration of surgery is longer than 240 min, additional doses of antibiotics are recommended [11—13].

The administered antibiotic treatments were classified into three groups: appropriate, inappropriate and unnecessary. Treatment was determined to be 'inappropriate' if the antimicrobial agent was microbiologically or pharmacologically incorrect. Treatment was judged 'unnecessary' when there was no clinical or laboratory evidence of infection or when antibiotics were used for prophylaxis without proper indications.

Microbiologically inappropriate use was defined as the use of antibiotics without a justifiable indication; the choice of an antibiotic that does not include the infection-causing agent in its spectrum, an unnecessarily wide-spectrum drug or a reserve drug that was administered despite the availability of an alternative with a narrower spectrum; or the use of a drug as part of an unnecessary combination treatment. Pharmacologically inappropriate use was defined as the administration of antibiotics at inappropriate doses and for inappropriate durations or the use of a more toxic antibiotic (having greater side effects) when a less-toxic alternative was available.

The WHO recommends the use of the ATC/DDD index (2010), which was created in collaboration with the Centre for Drug Statistics Methodology for the calculation of the intensity of antibiotic use in hospitals. The ATC/DDD index provides ATC codes and DDD values for each substance and/or ATC levels. The WHO recommends the application of the ATC classification system and the DDD measurement unit in drug utilization studies. The ATC classification system separates drugs into groups that are classified at five different levels. The 1st level divides the drugs into 14 main groups. The 2nd level indicates the pharmacological and therapeutic subgroups. The 3rd and 4th levels include the chemical, pharmacological and therapeutic subgroups, and the 5th level is the chemical substance. In cases in which the pharmacological subgroups are considered to be more appropriate than the therapeutic or chemical subgroups, the 2nd, 3rd and 4th levels are often used to identify the pharmacological subgroups [14].

The DDD method standardizes the calculation of antibiotic consumption intensity in hospitals, allowing comparisons with other hospitals. This assessment helps to improve the quality of antimicrobial use. The DDD assigned by the WHO is the assumed average maintenance dose per day of a drug used for its main indication. Definitions of DDD are updated on a yearly basis. DDD is calculated by dividing the total amount of the antibiotic used daily for every procedure by the DDD coefficient of that antibiotic in the ATC/DDD system. The recommended standard unit for measuring antibiotic consumption in hospitals is defined as the DDD per 100 bed-days, which is also referred to as the Antimicrobial Consumption Index (ACI) [14]. The ACI of a hospital is calculated by dividing the total (inpatient) DDD by the number of bed-days and multiplying this value by 100. The result is expressed as DDD/100 bed-days. Quantifying their antibiotic use using the ACI allows hospitals to compare their antibiotic consumption with that of other hospitals, regardless of differences in the formulary composition, antibiotic potency and hospital census [4,14].

In our study, the DDDs of the administered antimicrobial agents are listed according to the ATC/DDD Index 2010 Group 'J01' (antibiotics for systemic use) [14]. The costs of the administered antimicrobials were calculated based on the daily retail prices in Turkish Liras (TL). The total cost was calculated in Euros based on the exchange rate in Turkey. The exchange rate for Euros in 2011 was 1€ = 2.15 TL, whereas the rate was 1€ = 2.32 TL in 2012.

Intervention

To achieve an effective intervention and maintain good coordination with our physicians, the Infection Control Committee held a series of meetings with an appointed attending physician from each clinic. During these meetings, the following decisions were made: (1) International therapeutic and surgical prophylaxis guidelines shall be adopted by our hospital and will be used to promote appropriate antibiotic use. (2) To administer antibiotics at the right time point, the anesthesia technician, instead of the ward nurse, shall be responsible for the initial prophylactic antibiotic dose.

All of these decisions were announced to all physicians, and regular observations were performed for 1 year. The daily clinic visits of an ICN were accompanied by visits by a responsible Infectious Diseases Control Specialist (IDCS) twice per week, and the observation results were shared with the physicians at every clinic. The frequency of the inspections and feedback was increased in the clinics in which compliance with the guidelines was observed to be low. Additionally, the responsible IDCS who visited the ICUs daily evaluated ongoing antibacterial treatments discontinued unnecessary treatments and replaced inappropriate antibiotics with appropriate agents. This protocol was implemented in coordination with the physician responsible for the ICU and several doctors working in the ICU. Additionally, monthly seminars were held to educate the clinicians about the appropriate use of antibiotics.

Following the 1-year intervention period, the point prevalence study was repeated, and the newly obtained data for 2012 were compared with the pre-intervention data from 2011. For the years 2011 and 2012, the ACI and DDD values and the costs of antibiotic consumption were individually calculated for the medical units, surgical units and ICUs, as previously described. Furthermore, the ACI and DDD values for the unnecessarily and inappropriately used antibiotics were calculated, and a cost analysis was performed.

All data were coded and entered into a Microsoft Excel file, which was analyzed using the SPSS 15.0 software package. In the statistical analysis of the data obtained before and after the intervention, ACI values were assessed using the Mann-Whitney *U*-test. Additionally, the Student's *t*-test was employed for cost analysis, and the Chi-square test was used for the evaluation of antibiotic consumption. A value of $p < 0.05$ was accepted as statistically significant.

Results

In 2011 and 2012, a total of 719 patients (307 and 412 patients, respectively) were hospitalized, and 194 of 307 (63.2%) and 224 of 412 (54.4%), respectively, received antibiotic treatment. In the 2 years, the antibiotic consumption rates in the wards were similar. In particular, in 2011 and 2012, the antibiotic consumption rates were respectively 54.1% and 47.7% in the surgical units, 64.8% and 54% in the internal medicine units and 85% and 81.8% in the ICUs ($p = 0.397$). On the study days, none of the patients in the psychiatry, dermatology or urology clinics received any antibiotics. In 2011, the mean age (±SD) of the patients was 49.9 ± 27.2 years, and men accounted for 53.1% of the patients. Similarly, in 2012, the mean age (±SD) of the patients was 47.6 ± 17.4 years, and men accounted for 50.4% of the patients. The nosocomial infection (NI) rates were 13.9% and 11.2% in 2011 and 2012 respectively. The rates of antimicrobial use by the individual clinics in 2011 and 2012 and the related indications are presented in Table 1.

Tables 2 and 3 detail the indications for antimicrobial treatment in 2011 and 2012, respectively, according to the clinical service (medical, surgical or intensive care). Appropriate antibiotics were used in 51% and 63.4% of cases, respectively. Inappropriate antibiotics use was more prevalent in the surgical units than in the medical units or ICUs ($p = 0.004$ in 2011 and $p = 0.009$ in 2012). The route of administration of antimicrobial prophylaxis was appropriate in all of the procedures, whereas the duration was optimal in only 10.3% and 59.4% of the patients in 2011 and 2012, respectively. The mean total antibiotic consumption rate was 93.6 DDD/100 bed-days in 2011 and 63.1 DDD/100 bed-days in 2012, and the absolute change was 30.2 DDD/100 bed-days ($p = 0.008$) (Table 4).

During the study period, the most frequently used antibiotics were cephalosporin, fluoroquinolones, combinations of penicillin (including β-lactamase inhibitors) and carbapenems (Table 5). However, the most prominent reduction was observed in the consumption of glycopeptides and fluoroquinolones (absolute change: −6.3; $p = 0.162$) (Table 6). The most frequently misused antibiotics in both years were cephalosporin, fluoroquinolones, penicillin (including β-lactamase

Table 1 Rates of antibiotic use by hospital unit: 2011 and 2012.

	Medical units		Surgical units		Intensive care units		Total		p
	2011	2012	2011	2012	2011	2012	2011	2012	
ET	95.7	98.1	48.5	50	55.9	77.8	72.7	77.2	0.397
MEBT	4.3	1.9	12.1	11	35.3	22.2	12.4	8.5	
PT	–	–	39.4	39	8.8	–	14.9	14.3	

ET: empirical treatment; MEB: microbiological evidence-based treatment; PT: prophylactic treatment.

Table 2 2011 and 2012: evaluating antibiotic indications by hospital units.

	Medical units			Surgical units			Intensive care units		
	2011/2012(%)			2011/2012(%)			2011/2012(%)		
	A	U	I	A	U	I	A	U	I
ET	54.4/63.4	20/15.4	25.6/21.2	43.8/56.1	21.8/17.1	34.4/26.8	73.7/75	10.5/10.7	15.8/14.3
MEB	75/100	–/–	25/–	75/77.8	12.5/11.1	12.5/11.1	83.4/87.5	8.3/–	8.3/12.5
PT	–/–	–/–	–/–	11.5/25	19.2/15.6	69.3/59.4	–/–	–/–	100/–
Total	55.3/64.2	20.2/15.1	24.5/20.7	34.8/46.3	19.7/15.9	45.5/37.8	70.6/77.8	8.8/8.3	20.6/13.9

A: appropriate; U: unnecessary; I: inappropriate; ET: empirical treatment; MEB: microbiological evidence-based treatment; PT: prophylactic treatment.

Table 3 Evaluating of treatments according to indications of total usage in 2011 and 2012.

	2011(%)			2012(%)			p
	A	U	I	A	U	I	
ET	54.6	19.1	26.3	63.6	15	21.4	
MEB	79.2	12.5	8.3	84.2	5.3	10.5	0.023
PT	10.3	17.2	72.5	56.3	6.2	37.5	
Total	51	18	31	64.3	12.9	22.8	

A: appropriate; U: unnecessary; I: inappropriate; ET: empirical treatment; MEB: microbiological evidence-based treatment; PT: prophylactic treatment.

Table 4 Total antibiotic consumption by class: 2011 and 2012.

Antiinfectives group	ATC code	ACI[a]		Absolute change (%)	Percentage of total use	
		2011	2012	2011–2012	2011	2012
Combination of penicillins						
Including β-lactamase	JO1CR	14.4	10.1	−4 (−28.3)	15.39	16
Cephalosporins, first-generation	JO1DB	6.1	6	−0.1 (−1.63)	6.52	9.5
Cephalosporins, third-generation	JO1DD	12.7	7.7	−5 (−39.3)	13.56	12.3
Carbapenems	JO1DH	12	9.2	−2.8 (−23.3)	12.82	14.58
Aminoglycosides	JO1GB	1.2	1.2	0 (0)	1.29	1.9
Fluoroquinolones	JO1MA	16.4	10.5	−5.9 (−35.9)	17.52	16.64
Glycopeptides	JO1XA	14	7.7	−6.3 (−45)	14.96	12.3
Lınezolıds	JO1XX	8.3	5.3	−3 (−36.1)	8.86	8.39
Polymyxins	JO1XB	4	2.5	−1.5 (−37.5)	4.28	3.97
Tigecycline	JO1AA	4.5	2.9	−1.6 (−35.5)	4.8	4.6
Total		93.6	63.1	−30.2	100	100

[a] ACI: antimicrobial consumption index (DDD per 100 bed-days).

Table 5 DDD and ACI[a] by class and clinical unit: 2011 and 2012.

Antiinfectives group	Medical units				Surgical units				Intensive care units			
	2011		2012		2011		2012		2011		2012	
	DDDs	ACI	DDDs	ACI	DDDs	ACI	DDDs	ACI	DDDs	ACI	DDDs	ACI
Combination of penicillins												
Including β-lactamase	19	13.4	22	11.2	24	19.6	18	10.4	1.5	3.7	2	4.5
Cephalosporins	34	23.4	25	12.7	19	15.5	25	14.5	5	12.5	7	15.9
Carbapenems	11	7.5	10	5.1	18	14.7	18	10.4	8	20	10	22.7
Aminoglycosides	1.3	0.9	2	1	1.3	1	2	1.1	1.3	3.2	1.3	3
Fluoroquinolones	16	11	17.6	8.9	23.6	19.3	16.8	9.7	10.8	27	9.2	20.9
Glycopeptides	18	12.4	11	5.6	15	12.2	12	6.9	10	25	9	20.4
Lınezolıds	7.5	5.1	10	5.1	12	9.8	9	5.2	6	15	3	6.8
Polymyxins	2.5	1.7	2.5	1.2	5	4	5	2.9	5	12.5	3	6.8
Tigecycline	2	1.3	2	1	8	6.5	4	2.3	4	10	6	13.6
Total	113.3	76.7	102.1	51.8	127.9	102.6	109.8	63	51.6	128.9	50.5	114.6

[a] ACI: antimicrobial consumption index (DDD per 100 bed-days).

Table 6 Inappropriate/unnecessary antibiotics by class: 2011 and 2012.

Antiinfectives group	ATC code	ACI[a]		Absolute change (%)	Percentage of total use	
		2011	2012	2011–2012	2011	2012
Combination of penicillins						
Including β-lactamase	JO1CR	5.8	2.9	−2.9 (−50)	23.48	21.32
Cephalosporins, first-generation	JO1DB	2	1	−1 (−50)	8.09	7.35
Cephalosporins, third-generation	JO1DD	4.2	2.1	−1 (−50)	17	15.44
Carbapenems	JO1DH	3.4	2.1	−1.3 (−38.2)	13.76	15.44
Aminoglycosides	JO1GB	0.6	0.3	−1 (−50)	2.43	2.3
Fluoroquinolones	JO1MA	6.5	3.8	−2.7 (−41.5)	26.32	27.94
Glycopeptides	JO1XA	1.3	0.7	−0.6 (−46.1)	5.27	5.15
Lınezolıds	JO1XX	0.9	0.7	−0.2 (−22.2)	3.65	5.15
Total		24.7	13.6	−9.7	100	100

[a] ACI: antimicrobial consumption index (DDD per 100 bed-days).

inhibitors) and carbapenems (Table 6). When our hospital's unnecessary antibiotic consumption levels in 2011 and 2012 were compared, we observed reductions in two classes: penicillin (specifically, β-lactam inhibitor combinations) and fluoroquinolones. The absolute reductions observed were 2.9% and 2.7%, respectively ($p = 0.247$). When the consumption rates of individual services were compared, we found the highest levels in surgery and the ICUs, followed by the surgical and medical units.

In the 2011 and 2012 study periods, the daily cost of all of the administered antibacterial agents was € 7901.3 (€ 40.7 per infected patient) and € 6500.3 (€ 29 per infected patient), respectively ($p < 0.001$). Compared with 2011, the total cost of antibiotics in the medical units, surgical units and ICUs in 2012 decreased by 32.5%, 38.6% and 11.1%, respectively. The daily cost of all analyzed antibiotics was respectively € 2733.7 (€ 29.1 per infected patient) and € 2378.3 (€ 22.4 per infected patient) in the medical units, € 2940.7 (€ 44.6 per infected patient) and € 2218.7 (€ 27.1 per infected patient) in the surgical units and € 2226.9 (€ 65.5 per infected patient) and € 1903.2 (€ 52.9 per infected) in the ICUs. In 2011 and 2012, the daily cost of unnecessary antibiotic use alone was € 1204.7 (€ 6.2 per infected patient) and € 1127.5 (€ 5 per infected patient), respectively ($p < 0.001$).

Discussion

To the best of our knowledge, this is the first study to compare pre- and post-interventional periods using the ATC/DDD method to improve antibiotic use in a newly established teaching and research hospital in Turkey.

The point prevalence survey (PPS) is a practical surveillance tool that can be used to monitor antibiotic use across hospital units and practitioners. Local data can then be compared with data from national and international hospitals to identify the outliers and to plan corrective action [4,15]. When our hospital's antibiotic consumption in 2011 was compared with that of national and international hospitals, our hospital's consumption was determined to be excessive and inappropriate. Additionally, the rate of inappropriate surgical prophylaxis was higher than in other hospitals [4,15—18]. This finding led us to plan an intervention to promote the appropriate use of therapeutic antibiotics and antibiotics for perioperative prophylaxis.

The ATC/DDD system is already widely used internationally, and its use is constantly increasing. The DDD has been used to compare hospitals and countries, and the ACI has been used to compare both inpatient and outpatient antibiotic use in the international setting [14]. The antibiotic consumption rate of our hospital was found to be higher than that of most other national (36—53%) [4,16] and European (14—32%) [17] hospitals. In a multicenter study conducted in Europe, the PPS indicated ACI values between 31.2 and 72.2 [18], whereas the PPS in a multicenter study performed in Turkey [15] revealed ACI values between 42.1 and 100.7. The ACI values of our hospital in 2011 were much higher than the values reported in Europe but were close to the upper limits reported in Turkey.

This finding might be explained by the tendency of inexperienced staff to prescribe unnecessary antibiotics with longer courses of treatment. When the staff was asked to justify such practices, challenging working conditions were often cited. Data obtained from our initial PPS allowed us to design an educational intervention. In addition to monthly seminars that broadly focused on hand hygiene and other measures to prevent HAIs, antibiotic overuse was also addressed, with targeted reviews of prescribing habits and systematic feedback provided to physicians [19,20]. Following these interventions, the PPS conducted in 2012 found that the ACI values for all classes of antibiotics decreased by 32.6% (from 93.6% to 63.1%). Unnecessary antibiotic use also declined from 24.7% to 13.6%, with a decrease of 44.9%, and the rate of NI fell by 19.4%, from 13.9% to 11.2%. Although this initiative achieved several goals, further interventions will be necessary to improve guideline compliance and to ensure continued reductions in antibiotic use.

Studies have reported that 10.7—30% of prescribed antibiotics are unnecessary [1,21]. When inappropriate use of antibiotics is also taken into consideration, this value rises to 28—63% [4,21—23]. In Turkey, 30—53% of the hospitalized patients are prescribed antibiotics, and 30—68% of these prescriptions are reported to be inappropriate. At our hospital, the rates of unnecessary antibiotic use were 18% and 14.3% in 2011 and 2012, respectively. When inappropriate use of antibiotics was added, these rates increased to 49% and 40.2%, respectively. These values are consistent with reports in the literature [4,21—23].

A multicenter study performed by Bailly et al. indicated that 58.3% of all perioperative antimicrobial prophylaxes are inappropriate [24]. In 2011 and 2012, inappropriate antibiotic use was significantly higher in surgical clinics than in internal medicine clinics and ICUs. This discrepancy was largely due to the high level of inappropriate antibiotics that were administered to prevent perioperative infections. Our hospital is not exceptional in this regard. It is estimated that one-third of all antibiotics consumed globally are prescribed for this reason. Other reports identified perioperative prophylaxis as the reason for the high levels of inappropriate antibiotics consumed by inpatients. Published reports also emphasized that the majority of irrational antibiotic prescriptions in surgery departments are due to inappropriate prophylaxis [25—27].

During both study periods, approximately one-third of the indications for antibiotic use in our surgical clinics were perioperative prophylaxis (39.4% in 2011 and 39% in 2012), and 88.5% to 43.7% of the antibiotic prescriptions for this indication in 2011 and 2012 respectively, were inappropriate and unnecessary. In another multicenter study conducted in Turkey, Hosoglu et al. observed that 88% of surgeons prescribed more than one dose of antibiotics and that 32% chose the wrong antibiotic agent [28]. The most important cause of such inappropriate perioperative prophylaxis was a long duration of antibiotic treatment [29,30]. In our country, there are no established national guidelines for surgical prophylaxis, although certain hospitals conform to their local guidelines.

To improve compliance with international guidelines for perioperative antimicrobial prophylaxis in our hospital, we tried to create synergy through educational seminars, observations, feedback and frequent meetings. Consequently, inappropriate durations of perioperative antimicrobial prophylaxis fell from 89.7% (26 of 29 patients administered perioperative antimicrobial prophylaxis) in 2011 to 40.6% (13 of 32 patients administered perioperative antimicrobial prophylaxis) in 2012.

The antibiotic consumption rates in Turkey are higher than in many European countries, including Sweden, Denmark, Germany and Hungary [31]. In the ARPAC Project, the majority of the antibiotics used in all hospitals were found to be penicillin beta-lactams, followed by non-penicillin beta-lactams and quinolones [32]. In our study, the most frequently used antibiotics were cephalosporin, followed by fluoroquinolones, penicillins (including beta-lactam inhibitors) and carbapenems. These groups of antibiotics were also the most frequently misused at our hospital. In another study conducted in a university hospital in Turkey, the most commonly used classes of antibiotics were found to be cephalosporins, penicillins (including beta-lactam inhibitors) and carbapenems [6]. Our study yielded similar results. In the previous study, daily antibiotic costs per infected patient ranged from €25.4 to 29.9. Our intervention also successfully reduced the per-person costs to this range, as a reduction of 28.8% (from €40.7 prior to the intervention to € 29 at the conclusion of our study) was achieved.

Conclusion

When daily monitoring of antibiotic use is not practical, hospitals should routinely conduct PPSs to ensure the appropriateness of antibiotic prescriptions strategies. Additionally, these hospitals should use the DDD and ACI calculations to standardize and compare their antibiotic use with that of both national and international hospitals.

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