A longitudinal point prevalence survey of antimicrobial use and resistance in tertiary care hospitals in Kerman: results from the national Iranian multicenter point prevalence survey of antimicrobials in 2021

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Abstract

Background The Global Point Prevalence Survey (PPS) of antimicrobial consumption and resistance has been widely undertaken to combat the global threat of antimicrobial resistance (AMR). This study was conducted in alignment with the Global-PPS in three tertiary care hospitals in Kerman, Iran, to evaluate antimicrobial consumption patterns.

Methods The study was conducted from January 2020 to January 2021 in Afzalipour, Shafa, and Shahid Bahonar Hospitals. Data were collected using the standardized Global-PPS method at three different points throughout the year to minimize bias. Information on antimicrobial prescriptions, primary diagnosis, prophylaxis, therapy indications, and treatment type were documented. Antimicrobial prevalence was calculated using the total number of admitted patients as the denominator and those on antimicrobial regimens as the numerator.

Results The point prevalence of antimicrobial consumption in adult wards was 65.6% in Afzalipour Hospital, 42.3% in Shafa Hospital, and 78.7% in Bahonar Hospital. Non-penicillin beta-lactams, macrolides, lincosamides, and streptogramins were the most frequently prescribed antibiotic classes. Approximately 80% of prescriptions had explicit reasons documented, and targeted antibiotic therapy rates varied between 7.7% and 44.8% across hospitals.

Conclusions Antimicrobial consumption in Kerman's tertiary care hospitals exceeded national and global levels, indicating an urgent need for interventions to promote rational antibiotic use. Infection control committees must implement rigorous monitoring measures to reduce antimicrobial resistance. Ongoing surveillance and targeted interventions are essential to curb the rising rates of antimicrobial resistance in the region.

Keywords Global point prevalence survey, Antimicrobial consumption, Antimicrobial resistance

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Introduction

Antimicrobial resistance (AMR) is an increasing global threat to human health, with an estimated 99,000 annual deaths from healthcare-associated infections (HAI) in the United States [1, 2]. According to the World Health Organization (WHO), due to the excessive consumption of antibiotics, AMR will become so widespread that by 2050, mortalities will occur from even the mildest infectious pathogens [3].

Moreover, the economic burden for pneumonia and sepsis was approximately $8 billion in 2006 for the United States alone, a considerable portion of which was attributed to AMR [1]. Iran is among the top 20 countries in antibiotic consumption worldwide, having experienced the rates of antibiotic consumption in 2000 almost tripled in 2016 [2].

There are several potential approaches for adjustment of antibiotic consumption and reducing antibiotic resistance. Moreover, in recent years, an increased effort to optimize the frequency of antibiotic consumption and reduce AMR has been demonstrated [3]. One of the mentioned efforts is the undergoing of the Global Point Prevalence Survey of Antimicrobial Consumption and Resistance (Global PPS) project, intending to collect and survey data regarding the frequency of antimicrobial use in different parts of the world and introduce measures to control AMR trends with the help of WHO [4, 5].

The primary goal of this study was to evaluate antibiotic usage in three tertiary hospitals in Kerman, Iran, using Global PPS standards. This research aimed to better understand local antimicrobial practices by evaluating antimicrobial usage statistics. The results will contribute to continuing worldwide efforts, in partnership with the WHO, to optimize antibiotic usage and reduce the rising danger of antimicrobial resistance.

Methods

Study design and data collection

The present descriptive cross-sectional study was conducted in three tertiary care centers of Kerman University of Medical Sciences, consisting of Afzalipour, Shafa, and Shahid Bahonar Hospitals, from January 2020 to January 2021. Data were collected using the standardized Global PPS method at three different points of the year with a four-month window period between data collection days to avoid bias. A specific non-holiday day was chosen for data collection, and information regarding the prescription of antimicrobials at 8:00 a.m. of the PPS day for patients in all wards of the hospitals was collected. These data included the antimicrobial agent used, primary diagnosis or reason for prophylaxis, indications for therapy (e.g., community-acquired or healthcare-associated infections), treatment type (i.e., targeted or

Table 1 Prevalence of antimicrobial consumption by ward type of the tertiary hospitals of Kerman, Iran

Type of wards	Afzalipour hospital	Shafa hospital	Bahonar hospital
Adult medical wards	62.6%	25.4%	100%
Surgical wards	87.5%	77.8%	71.4%
Adult intensive care unit	73.7%	45.5%	91.3%
Hematology oncology ward	53.3%	-	-
Pneumology ward	68.4%	-	-
Transplant related wards	100%	-	-
Total	**65.6%**	**42.3%**	**78.7%**

Table 2 Prevalence of patients prescribed one anti-microbial at least on day of survey in the tertiary hospitals of Kerman, Iran

Anti-microbial type	Afzalipour hospital	Shafa hospital	Bahonar hospital
Antibiotics for systemic use	67.6%	41.5%	87.7%
Systemic Antifungal	8.2%	1.6%	2.7%
Anti-tuberculosis	0.7%	0%	4%
Anti-viral	11.4%	0%	0%
Intestinal anti-infective	0.4%	0.8%	0%
Nitro imidazole derivatives	0.7%	0.8%	0%
Anti-malaria	0%	0%	0%

empirical), and ward setting (adults, children, newborns, surgical, intensive care).

Ethical consideration

Documenting any personal information that would lead to the exposure of either the patient or their clinician was withheld, and the study was approved by the local institutional review board (IR.KMU.REC.1401.072).

Statistical analysis

Frequency, percentage, median, mean, standard deviation, and prevalence rates were used to describe the data. Prism Ver.10.2.1 software was used for statistical analysis. The point prevalence of antimicrobial use was calculated by utilizing the total number of patients admitted at the time as the ratio's denominator and the number of those under antimicrobial regimens as the numerator. The collected data were then put into context by comparing them with the data from previous studies using the online Global PPS tool (by the University of Antwerp).

Results

Adult antimicrobial consumption

The point prevalence of antimicrobial consumption in adult patients was 65.6% in Afzalipour Hospital (AH), 42.3% in Shafa Hospital (SH), and 78.7% in Bahonar Hospital (BH) (Table 1). Antimicrobials were prescribed for systemic use in the majority of cases across all hospitals, with the highest rates in BH (78.7%) and the lowest in SH (42.3%) (Table 2).

The most commonly prescribed antibiotic classes in all three hospitals were non-penicillin beta-lactams, accounting for 41% of prescriptions in AH and BH and 46% in SH, followed by macrolides, lincosamides, and streptogramins (Fig. 1). At AH, third-generation cephalosporins were the most frequently prescribed antibiotics (24.2%), with glycopeptides (13.8%), carbapenems (11%), and imidazole derivatives (11%) also being common. At SH, first-generation cephalosporins (21.5%) were the most prescribed, followed by glycopeptides (13.9%), carbapenems (12.7%), fluoroquinolones (11.4%), third-generation cephalosporins (10.1%), and lincosamides (10.1%). In BH, third-generation cephalosporins (19.6%), glycopeptides (15.5%), first-generation cephalosporins (11.9%), and lincosamides (10.5%) were frequently prescribed.

Pediatric and neonatal antimicrobial consumption

In AH, the overall point prevalence of antimicrobial consumption among pediatric patients was higher than in adults, reaching 80.2% (71% in the pediatric medical ward, 100% in the the pediatric intensive care unit (PICU), and 83.7% in the neonatal intensive care unit (NICU)). Among pediatric patients, third-generation cephalosporins were the most prescribed antibiotics (38.5%), followed by glycopeptide antibiotics (20.5%), lincosamides (15.4%), and carbapenems (10.3%). In PICU, third-generation cephalosporins, carbapenems, glycopeptide antibiotics, and polymyxins each accounted for 14.3% of prescriptions. In the NICU, glycopeptides (26.6%), third-generation cephalosporins (18.1%), aminoglycosides (17%), and broad-spectrum penicillins (16%) were the most frequently used antibiotics (Table 3).

Empirical therapy and infections treated

A significant proportion of antimicrobial prescriptions were empirical. At AH, 43.6% of patients were treated for community-acquired infections (CAI), with 96.1% receiving empirical therapy, while 56.4% were treated for HAI, of which 88.8% were empirical. Overall, 93.5% of prescriptions at AH were empirical, with higher rates observed in adults (95.5%) compared to pediatric patients (84.7%) and newborns (94.7%).

In SH, empirical therapy was used in all patients treated for CAI (49.2%) and in 63.6% of patients with HAI (50.8%). In BH, the majority of patients were treated for
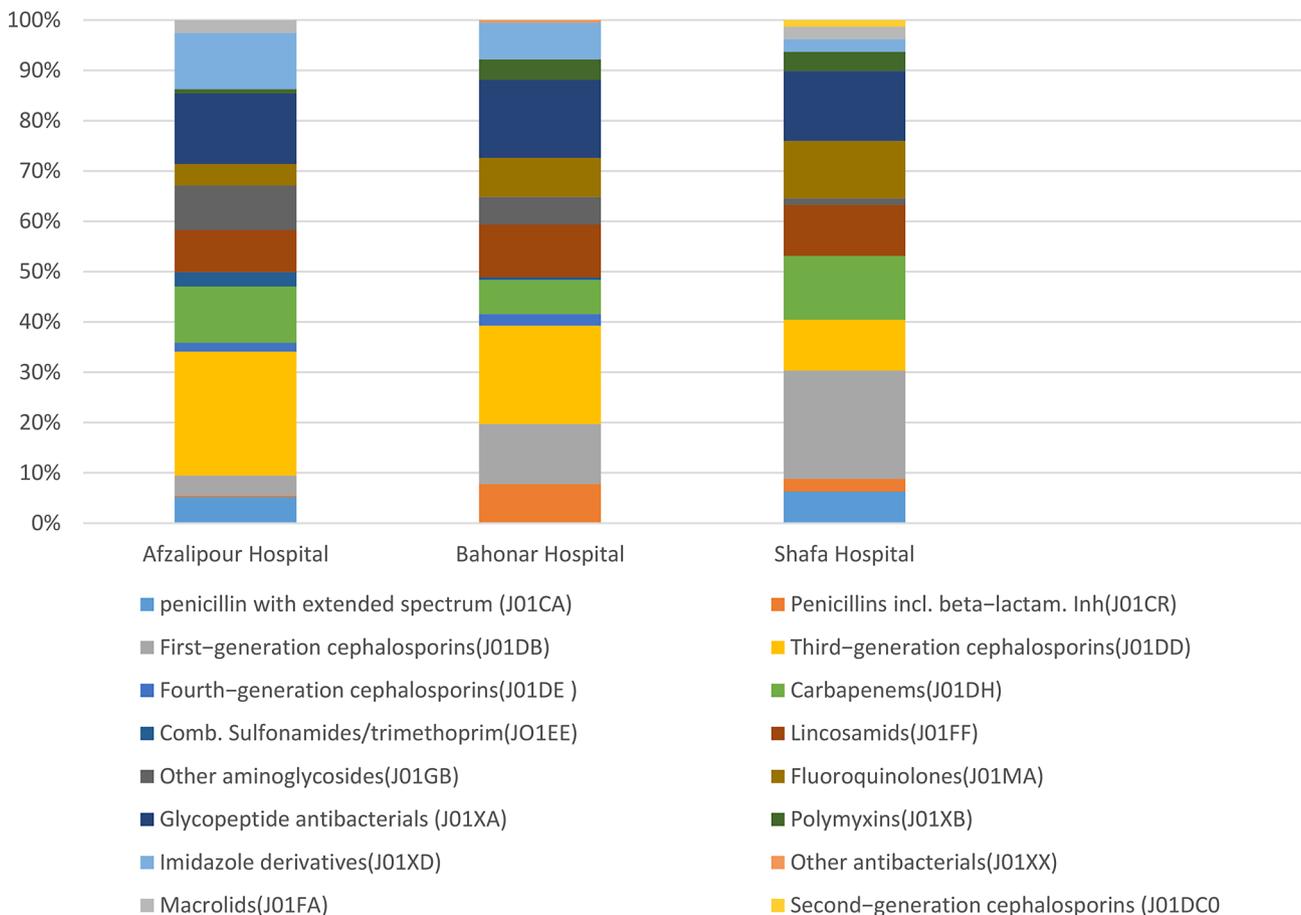

Fig. 1 Proportional antibiotic use in the tertiary hospitals of Kerman, Iran

Table 3 Proportional antibiotic use in different pediatric and neonatal wards of the tertiary hospitals of Kerman, Iran

ACT 4 category	Antibiotic name	Pediatric medical wards	Neo-natal wards	Pedi-atric ICU
J01CA	Penicillins with extended spectrum	-	16%	-
J01CR	Penicillins incl. beta − lac-tam. inh	-	-	7.1%
J01DD	Third − generation cephalosporins	38.5%	18.1%	14.3%
J01DE	Fourth − generation cephalosporins	-	-	7.1%
J01DH	Carbapenems	10.3%	10.6%	14.3%
J01FA	Macrolides	5.1%	-	-
J01FF	Lincosamides	15.4	-	7.1%
J01GB	Other aminoglycosides	7.7%	17%	-
J01MA	Fluoroquinolones	-	-	-
J01XA	Glycopeptide antibacterials	20.5%	26.6%	14.3%
J01XB	Polymyxins	-	-	14.3%
J01XD	Imidazole derivatives	2.6%	10.6%	7.1%
J01XX	Other antibacterials	-	-	14.3%

HAI (93.3%), of which 69.1% received empirical therapy, while 94.9% of those with CAI (6.7%) were also treated empirically (Table 4).

Pneumonia was the leading diagnosis requiring antimicrobial therapy across the hospitals. At AH, pneumonia (26%) and COVID-19 (13.3%) were the most common conditions treated with antibiotics, followed by gastrointestinal surgeries and hepatobiliary diseases (7.2%). In SH, pneumonia, sepsis, and skin and soft tissue infections each accounted for 20.5% of cases, while bronchitis (9.1%) and bacteremia (6.8%) were also notable causes. In BH, pneumonia (29.2%) remained the most common, followed by central nervous system infections (11.5%), sepsis (11.5%), bacteremia (10.4%), skin and soft tissue infections (10.4%), and upper urinary tract infections (7.3%).

Antibiotic management and monitoring

Documentation of reasons for antimicrobial use and plans for review or termination varied between hospitals. At AH, the reason for antibiotic use was documented in 83.9% of medical ward cases, 91.7% in surgical wards, and 58.6% in the ICU. However, the date for stopping or reviewing antibiotics was mentioned in only 18.1% of

medical ward cases, 37.5% in surgical wards, and 10.3% in ICU cases. In pediatric wards, reasons for antibiotic use were documented in 61.5% of cases, compared to 95.4% in the ICU (PICU and NICU). However, the date for stopping or reviewing antibiotics was documented in none of the pediatric ward cases and only 0.9% of ICU cases.

At SH, reasons for antibiotic use were documented in 91.7% of medical wards, 100% of surgical wards, and 95.8% of ICU cases. However, the date for stopping or reviewing antibiotics was mentioned in just 4.2% of medical ward cases, 6.5% of surgical ward cases, and 0% of ICU cases. In BH, reasons for antibiotic use were documented in 100% of medical wards, 83.8% of surgical wards, and 83.7% of ICU cases. However, the date for stopping or reviewing antibiotics was noted in 0% of medical ward cases, 19.8% of surgical ward cases, and 3.1% of ICU cases.

Discussion

As concerns regarding the increasing trends of AMR are rising as a global threat, the excessive consumption of antibiotics needs to be further monitored and controlled to avoid an impending crisis leading to millions of deaths due to the mildest infections [3, 5, 6]. Therefore, we investigated the point prevalence of antimicrobial consumption following the methods provided by the Global-PPS.

The findings of the present study showed that the point prevalence of antimicrobial consumption in tertiary hospitals of Kerman, Iran, largely exceeded both national and global records, with only one of the three evaluated centers having a point prevalence in line with these records. Notably, the rate in the other two centers surpassed even the highest international records (27.9–57.5%), highlighting the importance of interventions to practice targeted and careful consumption of antimicrobial treatments [7–24]. Such interventions have previously yielded convincing results, showcasing the prospect of managing antimicrobial consumption effectively and preventing the development of resistance [25].

In pediatric wards (General, PICU, or NICU), antimicrobial consumption rates were alarmingly high, exceeding national and global rates [8, 26]. While AH serves as the regional pediatric referral center, admitting patients with severe infections, the elevated use of third-generation cephalosporins and glycopeptides is highly

Table 4 Proportion of antibiotics prescribed for CAI or HAI in targeted or empirical way in three different tertiary hospitals of Kerman, Iran

Hospital name	Empirical CAI	Targeted CAI	Total CAI	Empirical HAI	Targeted HAI	Total HAI
Afzalipour Hospital	96.1% (N: 146)	3.9% (N: 6)	43.6%(N:152)	88.8% (N: 175)	11.2% (N: 22)	56.4%(N:197)
Shafa Hospital	100% (N:32)	0% (N:0)	49.2% (N:32)	63.6% (N:21)	36.4% (N:12)	50.8% (N: 33)
Bahonar Hospital	90% (N:9)	10% (N:1)	6.7% (N:10)	69.1% (N:96)	30.9% (N;43)	93.3% (N:139)

CAI (community acquired infection), HAI (hospital acquired infection), N (number of patients)

concerning. Although third-generation cephalosporins are frequently used for children globally, the consumption rates in our study significantly exceed those reported across Europe [7–24]. With resistance rates for cephalosporins reaching as high as 54% in Iran, the need for immediate action is palpable [5].

Our study confirmed pneumonia and sepsis as the leading indications for antibiotic therapy across the three hospitals, consistent with previous Iranian surveys. However, antibiotic prescribing varied by ward type, reinforcing the need for more tailored and ward-specific interventions to optimize antimicrobial use and reduce the risk of AMR development [5, 26, 27].

Although over 80% of prescriptions had documented reasons for antibiotic use, the lack of clear documentation for the review and stopping dates of antibiotics is a significant issue. In this study in some cases, particularly in pediatric wards, this rate approached 0%, far lower than in national surveys. Proper documentation is essential to avoid prolonged and inappropriate antibiotic use, which contributes directly to AMR [5, 8, 26, 27].

Our study also showed varying rates of targeted antibiotic therapy across the hospitals, ranging from 7.7 to 44.8%. While these rates align with those reported in prior surveys from Iran and Europe, they remain insufficient to prevent the emergence of resistant strains. Improving these rates through targeted interventions and better diagnostic tools is crucial to combating AMR effectively [4, 28].

The findings of our study underscore the vital role of point prevalence surveys in shaping antibiotic stewardship policies. Expanding the monitoring and promoting guideline-based antibiotic prescribing practices is critical. We strongly advocate for the continued use of longitudinal studies in our region to monitor trends in antimicrobial consumption and resistance, with strict stewardship measures to reduce unnecessary antibiotic use. By leveraging the insights gained from Global-PPS and infection control committees, we are hopeful that effective strategies can be implemented to reverse current AMR trends and avert a looming global health crisis.

Conclusions
The point prevalence of antimicrobial consumption in the hospitals of Kerman, Iran, is alarmingly high. These findings underscore the urgent need for infection control committees to implement and enforce strict measures aimed at actively monitoring and promoting the rational use of antibiotics. By doing so, the rate of antimicrobial resistance can be reduced, and the growing threat it poses to public health can be mitigated. Establishing ongoing surveillance and targeted interventions will be crucial in fostering more responsible antibiotic use and preventing further escalation of resistance.

Declarations

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