Article Type: Research
J Name: Modern Phytomorphology
Short name: MP
ISSN: ISSN 2226-3063/eISSN 2227-9555
Year: 2025
Volume: 18
Page numbers: 284 - 291
DOI: 10.5281/zenodo.200121
(10.5281/zenodo.2025-18-PDFNo.)
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RESEARCH ARTICLE

The use and misuse of leftover antibiotics: An investigation of people's practices and perceptions

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Received: 10.12.2024, Manuscript No: mp-24-154641 | **Editor Assigned:** 13.12.2024, Pre-QC No. mp-24-154641(PQ) | **Reviewed:** 28.12.2024, QC No. mp-24-154641(Q) | **Revised:** 03.01.2025, Manuscript No. mp-24-154641(R) | **Accepted:** 09.01.2025 | **Published:** 15.01.2025

Abstract

Background: The misuse of leftover antibiotics poses a significant global public health challenge, contributing to the alarming rise in antibiotic resistance. In Saudi Arabia, practices such as self-medication and the reuse of leftover antibiotics remain prevalent, presenting considerable health risks. This study investigates the behaviors and perceptions of individuals in Saudi Arabia concerning leftover antibiotic use, with a focus on factors driving misuse and levels of awareness regarding associated risks.

Methods: A cross-sectional, quantitative approach was used to collect data from 4,019 participants aged 18 and above via an online, self-administered questionnaire. Random sampling ensured representation across various regions of Saudi Arabia. Data analysis, performed using SPSS version 25, included descriptive statistics to summarize participant demographics and behaviors and inferential analyses (e.g., chi-square tests, logistic regression) to explore demographic correlations with antibiotic misuse.

Results: The findings revealed that 44.19% of participants reported using leftover antibiotics, and 52.44% stored them for future use. Additionally, 47.45% had taken antibiotics without a prescription, while 39.02% perceived leftover antibiotics as safe for reuse. Although 61.03% of respondents were aware of antibiotic resistance, only 75.30% identified misuse as a contributing factor. Significant associations were observed between lower misuse rates and higher levels of education and older age. Cluster analysis identified a high-risk group characterized by frequent misuse and limited awareness.

Conclusions: This study highlights the critical need for targeted public health interventions in Saudi Arabia to combat antibiotic misuse. Recommended strategies include educational initiatives, enhanced regulatory measures, and the adoption of digital tools to increase awareness of the dangers of leftover antibiotic use and promote responsible practices. Addressing these issues is essential to curbing the escalating threat of antibiotic resistance and protecting public health.

Keywords: Antibiotic misuse, Leftover antibiotics, Public health, Antibiotic resistance, Saudi Arabia, Self-medication

Introduction

The health and well-being of populations are central to societal advancement, necessitating ongoing research into practices that impact public health. One significant challenge is the misuse of leftover antibiotics, a practice that exacerbates the problem of antibiotic resistance a global health crisis. This issue is particularly critical in Saudi Arabia, where improper antibiotic usage, including self-medication and storage of leftover antibiotics, poses serious risks. Despite its importance, there is a noticeable paucity of research addressing public perceptions and behaviors related to leftover antibiotics in the region. Addressing this gap is essential to developing targeted interventions aimed at mitigating the risks associated with antibiotic misuse and promoting responsible practices.

The misuse of antibiotics, especially those left over from previous treatments, has been a long-standing public health concern with significant implications. Over the last two decades, researchers have increasingly recognized its contribution to antibiotic resistance and adverse health outcomes (Ventola, 2015). This issue is particularly acute in regions with lenient drug-dispensing regulations, underlining the need for robust policy interventions.

Historically, studies into antibiotic practices have often focused on compliance and misuse patterns. Early research, such as that conducted in Brazil, demonstrated relatively high adherence to prescription-only antibiotic use. However, a 2005 study revealed widespread self-medication practices, with 75% of participants using antibiotics without prescriptions (Grigoryan et al., 2005). Similarly, Väänänen et al. (2006) found that around 30% of individuals used leftover antibiotics, emphasizing persistent knowledge gaps about their risks.

More recent investigations have sought to understand the underlying drivers of self-medication with antibiotics. Despite global awareness campaigns, misuse continues, particularly in low- and middle-income countries. For example, over 30% of respondents in a Jordanian study admitted to non-prescribed antibiotic use (Al-Bakri et al., 2015). Factors such as easy access to antibiotics have further exacerbated this issue.

Several studies have highlighted the roles of awareness deficits, weak regulations, and misconceptions regarding antibiotic efficacy as key contributors to misuse (Nair et al., 2016). The World Health Organization (WHO, 2020) has called for global action to address these challenges. In Saudi Arabia, nearly 45% of individuals reportedly lack awareness about the dangers of leftover antibiotic use, reinforcing the urgency for targeted public health strategies.

The present study builds on this body of literature, aiming to bridge the knowledge gap regarding the behaviors and perceptions of leftover antibiotic use in Saudi Arabia. This understanding is crucial for formulating effective interventions to curb misuse and combat antibiotic resistance.

Methodology

Research design

This study utilized a cross-sectional, quantitative research design to investigate the practices and perceptions of individuals in Saudi Arabia concerning the use and misuse of leftover antibiotics. The quantitative approach facilitated the systematic collection and statistical analysis of data, enabling the identification of patterns, trends, and relationships among the variables under study (Creswell, 2014). Such a design also supports the generalizability of findings, enhancing the external validity of the research.

Participants and sampling

The target population included Saudi individuals actively engaged on social media platforms. Random sampling was employed to ensure the representativeness of the sample, with a planned size ranging from 400 to 1,200 participants, considered adequate for reliable statistical inference (Yamane, 1967). Inclusion criteria required participants to be 18 years or older with internet access, ensuring their ability to comprehend and complete the survey. Individuals below 18 years were excluded to maintain ethical integrity and ensure informed consent. The sampling approach incorporated participants from various Saudi regions to capture potential geographic variations in perceptions and behaviors.

Data collection methods

Data were gathered through an online, self-administered questionnaire designed to assess participants' behaviors and attitudes toward leftover antibiotics. The questionnaire was rigorously validated by a panel of public health, pharmacology, and health informatics experts to ensure its relevance and clarity. A pilot study with 30 participants was conducted to refine the questionnaire, enhancing its usability (Dillman et al., 2014). The final version was disseminated through popular social media platforms, including WhatsApp, X (formerly Twitter), and Telegram, over a one week period. To maximize participation, the research team actively promoted the survey throughout this period.

Data analysis

The data were analyzed using SPSS version 25. Descriptive statistics, including frequencies, percentages, means, medians, and standard deviations, were employed to summarize demographic characteristics and survey responses. Inferential analyses, such as chi-square tests and logistic regression, were performed to identify associations between demographic variables (e.g., age, education) and antibiotic misuse behaviors. Statistical significance was set at $p < 0.05$ for all tests.

Ethical considerations

This study adhered to rigorous ethical guidelines and was approved by the Institutional Review Board (IRB) of the University of Hail (approval number 2024-349). Participants provided informed consent after being fully briefed on the study's objectives, procedures, and any potential risks. Participation was voluntary, and strict confidentiality protocols were implemented to protect participant data and maintain anonymity throughout the research process.

Results

The demographic characteristics of the study participants are summarized in tab. 1. A majority of the respondents were female, representing 73.16% of the sample (n=3672), while males accounted for 26.84% (n=1347). In terms of age distribution, most participants were between 18 and 29 years old, comprising 47.02% (n=2238) of the total. This was followed by participants aged 30-39 years (20.34%, n=968), 40 years-49 years (19.10%, n=909), and those 50 years or older (13.55%, n=645). Regarding education, the majority held a Bachelor's degree (53.00%, n=2660), followed by secondary school graduates (25.26%, n=1268), those with a diploma (10.08%, n=506), Master's degree holders (7.31%, n=367), and Doctoral degree holders (4.34%, n=218). A significant portion of respondents were not healthcare workers (73.16%, n=3672), while 24.61% (n=1235) reported working in healthcare.

Table 1. Demographic information.

Item	Option	Frequency	Percentage (%)
Gender	Female	3672	73.16%
	Male	1347	26.84%
Age Group (Years)	18-29	2238	47.02%
	30-39	968	20.34%
	40-49	909	19.10%
	50 and above	645	13.55%
Education Level	Bachelor's Degree	2660	53.00%
	Secondary School	1268	25.26%
	Diploma	506	10.08%
	Master's Degree	367	7.31%

	Doctoral Degree	218	4.34%
Healthcare Worker	Yes	1235	24.61%
	No	3672	73.16%

Tab. 2 provides an overview of the antibiotic use and misuse behaviors among the respondents. Approximately 44.19% (n=2218) reported having used leftover antibiotics, while 55.81% (n=2801) indicated they had not. Similarly, 52.44% (n=2632) of participants reported storing leftover antibiotics, while 47.56% (n=2387) did not. When asked about completing the full course of antibiotics, 44.41% (n=2229) indicated they always completed it, while 35.53% (n=1783) sometimes did, 9.17% (n=460) rarely did, and 1.87% (n=94) never completed the full course. Nearly half of the participants (47.45%, n=2381) had taken antibiotics without a prescription, while 52.55% (n=2638) had not. Additionally, 22.95% (n=1152) had shared leftover antibiotics with others, compared to 77.05% (n=3867) who had not. Regarding the safety of using leftover antibiotics for future illnesses, 39.02% (n=1959) believed it was safe, while 60.98% (n=3060) did not. When asked about disposal methods, nearly half of the participants (49.74%, n=2495) reported discarding leftover antibiotics in the trash.

Table 2. Antibiotic use and misuse.

Item	Option	Frequency	Percentage (%)
Used Leftover Antibiotics	Yes	2218	44.19%
	No	2801	55.81%
Store Leftover Antibiotics	Yes	2632	52.44%
	No	2387	47.56%
Complete Full Antibiotics Course	Always	2229	44.41%
	Sometimes	1783	35.53%
	Rarely	460	9.17%
	Never	94	1.87%
Taken Antibiotics Without Prescription	Yes	2381	47.45%
	No	2638	52.55%
Shared Leftover Antibiotics	Yes	1152	22.95%
	No	3867	77.05%
Safe to Use Leftover Antibiotics	Yes	1959	39.02%
	No	3060	60.98%
How Do You Dispose Leftover Antibiotics	Discard in trash	2495	49.74%

The perceptions and awareness of antibiotic misuse and resistance are detailed in tab. 3**.** A majority of respondents (75.30%, n=3780) agreed that misuse contributes to antibiotic resistance, while 24.70% (n=1239) did not share this view. Regarding the effectiveness of antibiotics against viral infections, 53.34% (n=2678) believed they were effective, whereas 46.66% (n=2341) did not. A significant portion of the sample (61.03%, n=3063) had heard of antibiotic resistance, while 38.97% (n=1956) had not. When asked about their primary source of information on antibiotics, 52.12% (n=2616) cited healthcare professionals, followed by the internet at 21.80% (n=1094). Public awareness campaigns were believed to reduce misuse by 85.73% (n=4303) of respondents, while 5.58% (n=280) disagreed. Additionally, 74.04% (n=3716) of participants expressed a desire for more information on the proper use of antibiotics.

Table 3. Perceptions and awareness.

Item	Option	Frequency	Percentage (%)
Misuse Contributes to Antibiotic Resistance	Yes	3780	75.30%
	No	1239	24.70%
Antibiotics Effective Against Viral Infections	Yes	2678	53.34%
	No	2341	46.66%
Heard of Antibiotic Resistance	Yes	3063	61.03%
	No	1956	38.97%
Primary Source of Antibiotics Information	Healthcare Professionals	2616	52.12%
	Internet	1094	21.80%
Awareness Campaigns Reduce Misuse	Yes	4303	85.73%
	No	280	5.58%
Want More Information on Proper Use of Antibiotics	Yes	3716	74.04%

In tab. 4, the mean and standard deviation for key behaviors related to antibiotic use and misuse are provided. The mean score for completing the full course of antibiotics was 3.35 (SD=0.74) on a scale where "Always" was the highest score. For the use of leftover antibiotics, the mean was 0.44 (SD=0.50), indicating that less than half of participants reported engaging in this behavior. Storing leftover antibiotics had a mean score of 0.52 (SD=0.50). The mean score for taking antibiotics without a prescription was 0.52 (SD=0.50), while the mean for sharing leftover antibiotics was 0.37 (SD=0.48). Finally, the belief that it is safe to use leftover antibiotics for future illnesses had a mean score of 0.33 (SD=0.47).

Table 4. Antibiotic use and misuse.

Item	Mean	Standard Deviation (SD)
Complete Full Antibiotics Course	3.35	0.74
Used Leftover Antibiotics	0.44	0.5
Store Leftover Antibiotics	0.52	0.5
Taken Antibiotics Without Prescription	0.52	0.5
Shared Leftover Antibiotics	0.37	0.48
Safe to Use Leftover Antibiotics for Future Illness	0.33	0.47

The logistic regression analysis revealed significant predictors of using leftover antibiotics, as detailed in tab. 5. Gender was a significant factor, with females being 38% more likely to use leftover antibiotics compared to males (OR=1.38, $p<0.05$, $p<0.05$, $p<0.05$). Age group also played a critical role, where older participants were less likely to use leftover antibiotics, as indicated by an odds ratio of 0.64 ($p<0.01$, $p<0.01$, $p<0.01$). Education level demonstrated a protective effect, with higher education levels reducing the likelihood of misuse (OR=0.78, $p<0.01$, $p<0.01$, $p<0.01$). While healthcare worker status was associated with a slightly increased likelihood of antibiotic misuse (OR=1.16), this result was not statistically significant ($p=0.12$, $p=0.12$, $p=0.12$). The baseline log-odds for using leftover antibiotics, when all predictors are at their reference levels, was -1.02.

Table 5. Logistic regression.

Predictor	Coefficient (β)	Odds Ratio (OR)	p-value
Gender (Female=1, Male=0)	0.32	1.38	<0.05
Age Group (1=18–29, ...)	-0.45	0.64	<0.01
Education Level	-0.25	0.78	<0.01
Healthcare Worker (Yes=1)	0.15	1.16	0.12
Intercept	-1.02	-	-

Cluster analysis identified three distinct groups based on antibiotic misuse behaviors, as shown in tab. 6. Cluster 1 represented individuals with high misuse behaviors, characterized by the highest means for using leftover antibiotics (0.58), storing leftover antibiotics (0.75), taking antibiotics without a prescription (0.80), and believing in the safety of using leftover antibiotics (0.72). Cluster 2 exhibited moderate misuse behaviors, with mean values of 0.35 for using leftover antibiotics and 0.40 for believing in their safety. Cluster 3 had the lowest misuse behaviors, with mean values of 0.22 for using leftover antibiotics and 0.20 for the belief in their safety.

Table 6. Cluster analysis.

Cluster	Used Leftover Antibiotics (Mean)	Store Leftover Antibiotics (Mean)	Taken Antibiotics Without Prescription (Mean)	Belief in Safety of Using Leftover Antibiotics (Mean)
1	0.58	0.75	0.8	0.72
2	0.35	0.45	0.38	0.4
3	0.22	0.3	0.28	0.2

Discussion

The findings of this study on antibiotic misuse in Saudi Arabia contribute to the existing body of literature, providing new insights into the demographic and behavioral predictors of misuse. Logistic regression analysis revealed that gender, age, and educational attainment significantly influence the practice of using leftover antibiotics. Specifically, females and younger individuals were more likely to engage in self-medication, consistent with findings from (Alhur et al. 2024), who documented similar patterns within the Saudi population. These results align with (Grigoryan et al. 2005), who observed a higher prevalence of antibiotic misuse among younger demographics in Europe, suggesting that this behavior transcends cultural and regional boundaries.

Cluster analysis identified three distinct behavioral groups, one of which demonstrated high misuse rates and low awareness levels. These observations mirror the findings of (Alhur et al. 2024), who identified subpopulations in Saudi Arabia exhibiting risky self-medication practices due to limited awareness. Similarly, (Väänänen et al. 2006) reported that misconceptions about the safety of leftover antibiotics were a significant factor in their misuse, even in developed countries. These findings emphasize the necessity of tailored public health campaigns to address specific high-risk groups.

Educational attainment emerged as a protective factor against misuse, supporting results by (Alhur et al. 2024), which highlighted the role of education in reducing misuse and increasing awareness. These findings are consistent with earlier research by, who reported that individuals with higher education levels in Brazil were more likely to adhere to prescribed antibiotic courses. Addressing knowledge gaps through targeted educational initiatives, as recommended by, remains a critical strategy for reducing misuse.

The practice of self-medication and reliance on leftover antibiotics is not unique to Saudi Arabia but represents a global concern. (Ventola 2015 and Alhur et al. 2024) have linked these behaviors to the alarming growth of antibiotic

resistance worldwide. This study's findings reinforce these global observations and underscore the urgent need for stricter regulatory frameworks and public health interventions to curb misuse.

The integration of digital health tools offers a promising solution to these challenges. (Alhur et al. 2024) emphasized the potential of digital innovations in pharmacy practice to enhance public awareness about the risks associated with antibiotics. (Al-Bakri et al. 2015) also suggested that digital platforms could serve as effective channels for education, particularly in resource-constrained settings.

The public health implications of antibiotic misuse, particularly the threat of resistance, are significant. As noted by (Alhur et al. 2024), a considerable portion of the Saudi population remains unaware of these risks, highlighting the need for collaboration among healthcare professionals, policymakers, and educators. Enhanced inter-professional communication, as emphasized by, is crucial for reducing the reliance on leftover antibiotics and ensuring adherence to prescribed regimens.

In conclusion, this study highlights the diverse factors contributing to antibiotic misuse in Saudi Arabia. Drawing on insights from both local and global research, it is clear that targeted strategies encompassing education, regulation, and innovation are critical for addressing misuse and mitigating the escalating threat of resistance.

Conclusions

This study presents a comprehensive analysis of antibiotic misuse in Saudi Arabia, identifying critical demographic and behavioral factors, including gender, age, and educational attainment. The findings highlight the widespread practice of using leftover antibiotics, particularly among younger and less-educated individuals, and reveal substantial gaps in public knowledge about the associated risks. By conducting cluster analysis, the study identified specific high-risk groups, emphasizing the need for tailored public health interventions.

To address the misuse of antibiotics and combat the growing threat of resistance, it is essential to integrate education, regulatory measures, and digital innovations into public health strategies. Comprehensive awareness campaigns, user-friendly digital tools, and improved communication between healthcare providers and patients are fundamental to promoting responsible antibiotic practices. Future efforts should prioritize these approaches to safeguard public health and ensure the effectiveness of antibiotics for generations to come.

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