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RESEARCH ARTICLE
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Assessment of Storage Behavior of Antibiotics and Influence Factors Among Household Members in Boyolali, Indonesia: A Cross-sectional Study

Hidayah Karuniawati[1,*], Roshiedah Abdul Rahman[1], Md. Sanower Hossain[2], Arifah Sri Wahyuni[1], Dinda Zanur'aini Aulia Hakim[1] and Ikhwan Yuda Kusuma[3]

[1]*Department of Pharmacology and Clinical Pharmacy, Faculty of Pharmacy, Universitas Muhammadiyah Surakarta, 57162, Indonesia*
[2]*Centre for Sustainability of Ecosystem and Earth Resources (Pusat ALAM) Universiti Malaysia Pahang, Kuantan26300, Pahang, Malaysia*
[3]*Institute of Clinical Pharmacy, University of Szeged, Szeged, Hungary*

Abstract:

Introduction: Storing antibiotics at home is common in many developing countries, often leading to irrational use and increasing the risk of antibiotic resistance. This study assessed antibiotic storage practices, reasons for storage and use, knowledge levels, and household influencing factors.

Methods: A cross-sectional online survey with a validated questionnaire was conducted from November 2021 to January 2022 in the Boyolali Regency, Central Java, Indonesia. The inclusion criteria were as follows: resident of Boyolali, 18-65 years old, used antibiotics and could fill out a questionnaire. The exclusion criteria were respondents who had no internet access. Descriptive, bivariate, and multivariate analyses were performed, with statistical significance set at $p < 0.05$.

Results: Of the 407 respondents, most were aged 18–25 years (71.7%), female (71.7%), single (75.2%), and had a senior high school education (61.4%). Antibiotics, primarily amoxicillin and tetracycline, were the second most commonly stored drugs (19%) after analgesics/antipyretics. Common reasons for storage included preparation for sudden illness (40.4%), leftover prescriptions (38.6%), and ongoing treatments (13.2%). Self-medication was reported by 45.2% of participants. Although 68.3% had moderate knowledge, inappropriate storage and use remained prevalent. Key factors significantly associated with antibiotic storage practices included the last time the antibiotic was used less than three months (p=0.001), having a family member in the healthcare field (p=0.01), and low and moderate antibiotic knowledge scores (p=0.002).

Discussion: The findings underscore the ongoing public health challenge of inappropriate antibiotic storage and self-medication, even among individuals with moderate knowledge. These behaviors contribute to the misuse of antibiotics and potentially drive antimicrobial resistance, aligning with concerns raised in prior research from other low- and middle-income settings. The study reinforces the role of household factors, such as recent antibiotic use and family healthcare background, in influencing storage practices. However, limitations include reliance on self-reported data and the use of an online survey, which may not capture perspectives from less internet-accessible populations.

Conclusion: Despite moderate awareness, inappropriate antibiotic use and storage are widespread, underscoring persistent behavioral gaps. These findings highlight the need for targeted public health campaigns and community-level interventions to promote responsible antibiotic practices and mitigate antimicrobial resistance risks.

Keywords: Antibiotics, Antibiotic leftover, Knowledge, Antibiotic storage practices, Self-medication.

*Address correspondence to this author at the Department of Pharmacology and Clinical Pharmacy, Faculty of Pharmacy, Universitas Muhammadiyah Surakarta, 57162, Indonesia; E-mail: hk170@ums.ac.id

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1. INTRODUCTION

The misuse and overuse of antibiotics are among the leading drivers of antimicrobial resistance (AMR), a growing global public health threat that compromises the effective treatment of infectious diseases [1]. Various problems, including the lack of understanding of the proper and rational use of drugs, excessive use of over-the-counter drugs, and inadequate knowledge of proper drug storage and disposal, are frequently encountered in the community and cause drug resistance, particularly antibiotics resistance [2], [3], [4]. Globally, studies have shown that self-medication with antibiotics and storage of leftover prescriptions are common, especially in low- and middle-income countries (LMICs), contributing to increasing rates of AMR [5].

Based on the results reported by the Indonesian Ministry of Health, 103,860 households out of 249,959 households in Indonesia store medicines for self-medication, of which as many as 27.8% of households store antibiotics [6]. Antibiotics are drugs used to treat and prevent bacterial infections [7]. The sources of stored antibiotics are the leftover drugs of the previous doctor's prescription (27.8%), antibiotics purchased without a prescription (69.3%), and those received from other individuals (1.8%). A recent study in Ethiopia reported similar findings, with the majority of individuals acquiring antibiotics without prescriptions (43.1%) mainly from pharmacies and informal vendors [8]. Another research reported that the most common sources of antibiotics for self-medication were pharmacies (46.8%), shops or stalls (26.0%), leftovers (16.9%), and friends or relatives (10.3%) [4].

Although Indonesian law prohibits the sale of antibiotics without a doctor's prescription, weak regulatory enforcement allows some individuals to continue obtaining antibiotics for conditions that do not warrant their use. This behavior is particularly dangerous as it increases the likelihood of incomplete or inappropriate antibiotic courses, creating ideal conditions for developing bacterial resistance. Storing antibiotics outside the prescribed treatment period- including for future use or saving leftovers is prohibited, as these drugs may be misused, degraded, or expire, leading to irrational use [6].

A study conducted by Wang *et al*. (2018) found that students who stored antibiotics at home were five times (95% CI 3.53-7.05) more likely to self-medicate when ill and 2.6 times (95% CI 2.34-2.89) more likely to use antibiotics for prophylaxis [3]. Similar trends have been observed in other LMICs, highlighting a global challenge in public antibiotic stewardship [9], [10]. Using antibiotics without proper diagnosis increases the risk of ineffective treatment and contributes to rising antimicrobial resistance. This resistance is not limited to hospitals. Community-acquired resistance strains are emerging, complicating treatment in outpatient settings and increasing public health risks [3], [4].

In studies from two major cities in Indonesia, Semarang, and Surabaya, resistance to tetracycline was found in 24.9% of *Staphylococcus aureus* isolates from 3,995 individuals, indicating a significant burden of community-based resistance, unrelated to hospital exposure [11]. The growing resistance rates in the community have been linked to prolonged illness, increased healthcare costs, and higher mortality rates due to treatment failure [12], [13], [14].

In preliminary research conducted in the Boyolali Regency, Central Java, 30% of 40 surveyed households stored antibiotics, primarily for future illness, leftover prescriptions, or current use [15]. The findings suggested that most antibiotic-related practices were inappropriate. Respondents showed limited knowledge about the indications and functions of antibiotics and lacked awareness of the importance of completing the full course of treatment despite receiving advice to do so.

While several national-level studies have explored household antibiotic storage and use, few have examined this issue locally in rural or semi-rural regions such as Boyolali. This presents a critical gap in understanding how contextual, educational, and socioeconomic factors influence antibiotic practices in such settings. Therefore, this study investigates antibiotic storage practices, reasons for storage and use, knowledge levels, and household influencing factors. The results are expected to inform local health education initiatives and contribute to national antibiotic stewardship efforts.

2. METHODS

2.1. Study Design

This study is a cross-sectional study with a questionnaire survey in the form of a Google form to determine the practice of antibiotic storage and the factors that influence the storage of antibiotics in the community in Boyolali Regency, Central Java, Indonesia. A cross-sectional design was selected for its efficiency in capturing data on antibiotic storage behaviours and associated factors at a single time point, enabling the identification of prevalent practices and potential associations within a large population. This approach is widely used in public health research due to its practicality and cost-effectiveness compared to longitudinal or qualitative designs [16]. This research has complied with the code of ethics from the Medical and Health Research Ethics Committee, Faculty of Medicine, University of Muhammadiyah Surakarta, Indonesia, with No: 3743/B.1/KEPK_FKUMS/X/2021. The nature of the study was explained in writing to the respondents, who were then asked to sign an informed consent form by clicking “agree to participate” to confirm their participation. This study was conducted between November 2021 to January 2022.

2.2. Sample Size and Data Collection

The sample size for this study was determined using Raosoft's sample size calculator. The minimum number of estimated samples for a population of 1 million (Boyolali Regency, Indonesia, according to the Department of

Statistics, Indonesia) with a 95% confidence interval and a 5% margin of error was 384 [17], [18]. Ultimately, 407 participants were recruited. Participants were selected using a convenience sampling method, where the survey link was distributed via community networks, local WhatsApp groups, and public health centres. While this approach ensured broad reach, it may introduce selection bias, particularly toward individuals with internet access or higher health awareness. The inclusion criteria were: (i) resident of Boyolali Regency, Central Java, (ii) age 18-65 years, (iii) previously used antibiotics, (iv) able to fill out a questionnaire via a Google form, and (v) willing to participate in the study. The exclusion criteria were respondents who had no internet access.

2.3. Study Instrument

The questionnaire consists of demographic data, knowledge of antibiotics, and antibiotic storage practices. This study used a validated questionnaire developed by Karuniawati *et al.* [19]. This questionnaire consists of 20 questions, including the identification of antibiotics as many as three items at points 1, 2, and 3; the function of antibiotics as many as four items at points 4, 5, 6, and 7; antibiotics access as many as four items at points 8, 9, 10 and 11; antibiotic misuse effect, as four items at points 12, 13, 14 and 15; side effects of antibiotics, as two items at points 16 and 17; and antibiotic use, as many as three items at points 18, 19 and 20 [19]. Items no. 3, 5, 7, 8, 9, 10, 11, 18, 19, and 20 are unfavourable items, so if the respondent answers “no, ” the answer is correct and scores 1. A correct answer was assigned a score of 1, while an incorrect or unknown response received a score of 0. The score total is 20. The level of knowledge was based on the mean value and categorized into low knowledge <7.5 (X<mean-1SD), medium 7.5-16 (mean-1SD≤X<mean+1SD), and high >16 (mean+1SD≤X) [20]. Before full deployment, a pilot test was conducted with 30 participants to assess clarity, timing, and reliability. Feedback was used to refine the wording and layout. Cronbach's alpha for the knowledge section was 0.78, indicating acceptable internal consistency. The antibiotic storage practices section consisted of 10 open-ended questions, including the availability, types, reasons, storage locations, source of antibiotics, and self-medication behaviour.

2.4. Data Analysis

The collected data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 25 (International Business Machines Corporation, New York, NY, USA). Descriptive statistics are used to analyze respondents' demographic data. A bivariate test (Chi-square) determined the relationship between demographic characteristics and antibiotic knowledge as independent variables and antibiotic storage practices as dependent variables. Variable results of the bivariate analysis with a $p< 0.25$ were followed by a multivariate analysis test with a logistic regression analysis [28]. A statistically significant difference between groups was determined at the 95% confidence level ($p< 0.05$).

3. RESULTS AND DISCUSSION

3.1. Socio-demographic Information of Respondents

A total of 407 respondents were involved in this study, with socio-demographic details shown in Table **1**. The majority were aged 18-25 years (71.7%), women (71.7%), unmarried (75.2%), and had completed senior high school (61.4%). Most respondents had no formal education in health-related fields (85.0%) and were unemployed (58.5%), which likely limited their access to accurate health information. Only 5.2% worked in the health sector, while 18.9% had family members employed in healthcare. These demographic trends are consistent with previous studies conducted in similar low-resource settings conducted in similar low-resource settings [15], [17], [21], [22].

3.2. Drugs and Antibiotic Storage Practices

Table **2** summarizes the types of medications stored at home. Antipyretic analgesics were the most commonly stored drugs (37.6%), followed by antibiotics (19.0%) and antacids (11.2%). This suggests a pattern of symptom-focused self-care, with antibiotics positioned as second-line but still commonly held.

Table 1. Socio-demographic characteristics of respondents.

No	Variable	(N=407)	%
1.	Age (year)		
	18-25	292	71.7
	26-35	38	9.3
	36-45	40	9.8
	46-55	19	4.7
	56-65	18	4.4
2.	Gender		
	Women	292	71.7
	Man	115	28.3
3.	Marital Status		
	Single	306	75.2
	Married	100	24.6
	Widow/Widower	1	0.2

(Table 1) contd.....

No	Variable	(N=407)	%
4.	Educational Background		
	No school	3	0.7
	Elementary school	1	0.2
	Junior High School	10	2.5
	Senior High School	250	61.4
	Diploma	36	8.8
	Undergraduate	99	24.3
	Postgraduate	8	2.0
5.	Employment Status		
	Unemployed	238	58.5
	Retired	7	1.7
	Housewife	29	7.1
	Employed	133	32.7
6.	Monthly Income (IDR)		
	Have no income	234	57.5
	<Rp 2.000.000	75	18.4
	≥Rp.2.000.000	98	24.1
7.	Education is related to health		
	No	346	85.0
	Yes	61	15.0
8.	Health-related work		
	No	386	94.8
	Yes	21	5.2
9.	The family has a job in the health sector		
	No	330	81.1
	Yes	77	18.9
10.	Last time used antibiotics		
	Currently	14	3.4
	<3 months ago	95	23.3
	3-6 months ago	64	15.7
	7-12 months ago	29	7.1
	>12 months ago	36	8.8
	Forget	169	41.5

Our findings are supported by the study conducted in Ethiopia, where the authors reported that the respondents stored analgesics (29%), followed by antibiotics (25%) [23]. However, Ocan (2014) found that antibiotics were the highest stored medicine (40.1%), followed by analgesics (19.6%) and antimalarials (15.6%) for self-medication [24]. Another study in Basrah, Iraq, also showed that antibiotics were the most common drug stored and used at home (26%) [25]. There are many other medicines stored for further use. For example, Huang (2019) found that flu medicine (86.1%) was the most common medicine stored in households in China. Another study showed that gastrointestinal drugs (27.0%), pain medications (22.9%), vitamins (20.6%), antibiotics (19.0%), painkillers (16.5%), and anti-inflammatory drugs (15.4%) were also stored for further uses [26].

Table **3** details the types of antibiotics stored. We found 13 different antibiotics stored in households for future use in case of illness recurrence. Among these antibiotics, amoxicillin was the most common (51.3%), followed by tetracycline (18.7%), FG Troches® consisting of Fradiomysin sulfate and Gramicidin-S HCL (10%), in line with previous studies in Indonesia [4], [15], [17]. However, according to Cortez's 2017 study on the storage and knowledge of antibiotics in communities in northwest Angola, the most commonly stored antimicrobials were penicillin and its derivatives, antimalarials, and metronidazole [22]. These findings suggest persistent patterns of storing broad-spectrum antibiotics, which may contribute to resistance when used without indication.

Table **4** illustrates antibiotic storage behavior. Over 40% of the respondents stored antibiotics for future illness, while 38.6% retained leftover antibiotics from incomplete treatment. This highlights a major contributor to irrational antibiotic use: the failure to complete prescribed regimens. Most respondents stored antibiotics in non-secure locations such as boxes (53.8%), drawers or cupboards (17.7%), refrigerators (8.8%), bedrooms (6.4%), kitchens (3.2%), and others (2.7%). Another study reported a similar finding, which found that in the storage place of household drugs and related factors in Northern Ethiopia, most of the drugs are stored in drawers (36%) and cupboards (35%) [23]. Improper storage can compromise drug efficacy and encourage casual access, increasing the risk of misuse.

Table 2. Types of medicines stored at home.

No	Types of Medicines Stored at Home	N	%
1	Analgesic and Antipyretic	296	37.6
2	Antibiotic	150	19.0
3	Antacid	88	11.2
4	Supplements & Vitamins	42	5.3
5	Herbal Medicines	39	4.9
6	Antitussive/Expectorant	39	4.9
7	External Medicines	35	4.4
8	Antihistamines	34	4.3
9	Antidiarrhea	25	3.2
10	Corticosteroids	11	1.4
11	Antiasthma	5	0.6
12	Antihypertensive	4	0.5
13	Anti-Nausea/Vomiting	3	0.4
14	Antifungal	3	0.4
15	Antidiabetic	3	0.4
16	Lowering Uric Acid	2	0.3
17	Antivertigo	2	0.3
18	Anthelmintic	2	0.3
19	Cholesterol Lowering Medicines	2	0.3
20	Laxative	2	0.3
21	Antiplatelet	1	0.1

Table 3. Types of antibiotic storage.

Types of Antibiotics Stored	N=150	%
Amoxicillin	77	51.3
Tetracycline	28	18.7
Fg troches®	15	10.0
Amoxicillin clavulanate	8	5.3
Penicillin	6	4.0
Cefadroxil	5	3.3
Ciprofloxacin	4	2.7
Cefixime	2	1.3
Ampicillin	1	0.7
Benzoyl peroxide	1	0.7
Clindamycin	1	0.7
Chloramphenicol	1	0.7
Gentamicin	1	0.7

Table 4. Antibiotics storage and use behavior.

Reasons to Keep Antibiotics	N=114	%
Just in case one day will get sick	46	40.4
centerovers from the previous prescription	44	38.6
On treatment with antibiotics	15	13.2
For farm animals/pets	8	7.0
Others	1	0.9
Antibiotic resources	N=117	%
The rest of the doctor's previous prescription	48	41.0
Buy antibiotics from pharmacies without a prescription	34	29.1
Antibiotics from a doctor's prescription that are still in use	17	14.5
Buying at a store or grocery store	9	7.7

(Table 4) contd.....

Reasons to Keep Antibiotics	N=114	%
Given by a relative or someone else	4	3.4
Getting from the midwife	2	1.7
Getting from the nurse	2	1.7
Others	1	0.9
Diseases treated with self-medication of antibiotics	N=184	%
Sore throat	33	17.9
Fever	33	17.9
Cough	27	14.7
Toothache	25	13.6
Flu	20	10.9
Headache	12	6.5
Wound	12	6.5
Skin infection	10	5.4
Diarrhea	5	2.7
Ear infection	4	2.2
Shortness of breath	1	0.5
Dysuria	1	0.5
Others	1	0.5

Most stored antibiotics were either leftover from previous prescriptions (41%), purchased from pharmacies without a doctor's prescription (29.1%), or obtained through ongoing prescriptions that were not yet completed (14.5%). A study conducted in China reported that 48.1% of respondents stored antibiotics at home for their children. Among these, 63.1% reported the antibiotics were leftovers from previous prescriptions, while 35.3% purchased them directly from pharmacies [27]. Many individuals reported storing leftover medications because they felt reluctant to discard them and preferred to save them for future illnesses.

In this study, 184 respondents (over 45.2%) reported self-medication with antibiotics for minor illnesses, such as sore throat, fever, cough, toothache, and flu, conditions that typically do not require antibiotic treatment. This trend is consistent with findings from other studies. For example, Cortez (2017) documented common reasons for antibiotic use, including cough and respiratory infections (37.84%), flu and muscle aches (31.08%), wounds (29.73%), fever (18.92%), bladder pain, urinary tract (17.57%), diarrhea and typhoid fever (13.51%) [22].

This widespread misuse is concerning as it contributes to antibiotic resistance and the ineffective treatment of viral infections [1], [11]. The results highlight a significant public gap in when antibiotics are necessary. Public health initiatives are needed to educate the public on the risks of self-medication and promote responsible antibiotic practices.

Table 5 presents the distribution of antibiotic knowledge. Only 16.2% of respondents demonstrated low knowledge, 68.3% had moderate knowledge, and 15.5% had high knowledge. The most common gaps included understanding antibiotic function, routes of access, and awareness of side effects. These findings are consistent with previous reports of limited public understanding of antibiotics in LMICs [28], [29]. Critically, knowledge gaps were strongly associated with incorrect storage and usage behavior, indicating that knowledge alone may not suffice to change practice.

Table 6 shows the results of the bivariate and multivariate analyses. Gender, health-related education, occupation in the health sector, having a healthcare professional in the family, recent antibiotic use, and knowledge levels were significantly associated with storage practices ($p < 0.05$). Specifically, respondents with low-to-moderate knowledge were 5-6 times more likely to store antibiotics compared to those with high knowledge, reinforcing the need for targeted education [30], [31]. However, knowledge is not enough to change a person's behavior. Knowledge can shape beliefs and attitudes toward certain behaviors. Therefore, community practice is a very important factor [17].

Table 5. Responses to the questionnaire on knowledge of antibiotics (N = 407).

Domain	Statements	Respondents' answer (%)			
		Expected Ideal Response	Yes	No	Don't know
Identification of an antibiotic	Q1. Amoxicillin is an antibiotic	Yes	352 (86.5)	17 (4.2)	38 (9.3)
	Q2. Supertetra® is antibiotic	Yes	243 (59.7)	46 (11.3)	118 (29)
	Q3. Paracetamol is antibiotic	No	116 (28.5)	263 (64.6)	28 (6.9)
Knowledge of the role of antibiotics	Q4. Antibiotics are used to kill bacteria.	Yes	347 (85.3)	37 (9.1)	23 (5.7)
	Q5. Antibiotics can be used to treat infections caused by viruses.	No	209 (51.4)	146 (35.9)	52 (12.8)
	Q6. Colds and flu can be cured without antibiotics.	Yes	270 (66.3)	93 (22.9)	44 (10.8)
	Q7. Antibiotics can reduce fever.	No	187 (45.9)	164 (40.3)	56 (13.8)

(Table 5) contd.....

Domain	Statements	Respondents' answer (%)			
		Expected Ideal Response	Yes	No	Don't know
Knowledge of antibiotic access	Q8. Antibiotics can be bought online.	No	211 (51.8)	146 (35.9)	50 (12.3)
	Q9. Antibiotics from other people may be taken.	No	83 (20.4)	270 (66.3)	54 (13.3)
	Q10. Amoxicillin can be purchased at a pharmacy without a doctor's prescription.	No	174 (42.8)	174 (42.8)	59 (14.5)
	Q11. Antibiotics can be purchased at the grocery store.	No	63 (15.5)	299 (73.5)	45 (11.1)
Knowledge of the effects of antibiotic misuse	Q12. Inappropriate use of antibiotics will cause antibiotic resistance.	Yes	286 (70.3)	37 (9.1)	84 (20.6)
	Q13. Inappropriate use of antibiotics will cause these antibiotics cannot be used later.	Yes	261 (64.1)	43 (10.6)	103 (25.3)
	Q14. Inappropriate use of antibiotics can cause more severe illness.	Yes	266 (65.4)	40 (9.8)	101 (24.8)
	Q15. Inappropriate use of antibiotics increases costs.	Yes	262 (64.4)	62 (15.2)	83 (20.4)
Knowledge of the side effects of antibiotics	Q16. Antibiotics can cause allergic reactions such as redness of the skin.	Yes	251 (61.7)	43 (10.6)	113 (27.8)
	Q17. Antibiotics can kill good bacteria in the intestines.	Yes	135 (33.2)	115 (28.3)	157 (38.6)
Knowledge of antibiotic use	Q18. Antibiotics need to be stored in case of illness in the future.	No	158 (38.8)	206 (50.6)	43 (10.6)
	Q19. Antibiotic centerovers can be used again if sick.	No	113 (27.8)	238 (58.5)	56 (13.8)
	Q20. Antibiotics can be stopped if the illness has improved.	No	165 (40.5)	217 (53.3)	25 (6.1)

Table 6. Relationship of demographic factors and knowledge of antibiotics to antibiotic storage practices (N=407).

		Store		Not Store		Bivariate	Multivariate	
		n	%	n	%	*p*-Value	*p*-Value	OR (95%CI)
Age (year)	18-25	86	75.4	206	70.3	0.795	-	-
	26-35	8	7.0	30	10.2			
	36-45	11	9.6	29	9.9			
	46-55	4	3.5	15	5.1			
	56-65	5	4.4	13	4.4			
Gender	Women	74	25.3	218	74.7	0.056	0.212	0.71 (0.41-1.22)
	Man	40	34.8	75	65.2			Ref
Marital Status	Single	90	29.4	216	70.6	0.476	-	-
	Married	24	24.0	76	76.0			
	Widow/Widower	0	0.0	1	100			
Educational Background	No	1	33.3	2	66.7	0.506	-	-
	Elementary School	0	0.0	1	100			
	Junior High School	5	50.0	5	50.0			
	Senior High School	73	29.2	177	70.8			
	Diploma	7	19.4	29	80.6			
	Undergraduate	27	27.3	72	72.7			
	Postgraduate	1	12.5	7	87.5			
Employment Status	Unemployed	70	29.4	168	70.6	0.593	-	-
	Retired	2	28.6	5	71.4			
	Housewife	5	17.2	24	82.8			
	Employed	37	27.8	96	72.2			
Monthly income (IDR)	No	65	27.8	169	72.2	0.907	-	-
	< Rp 2.000.000	20	26.7	55	73.3			
	≥ Rp 2.000.000	29	29.6	69	70.4			
Education is related to health	No	102	29.5	244	70.5	0.116	0.918	0.96 (0.41-1.22)
	Yes	12	19.7	49	80.3			Ref
Health-related work	No	111	28.8	275	71.2	0.150	0.355	1.99 (0.46-8.55)
	Yes	3	14.3	18	85.7			Ref
The family has a job in the health sector	No	84	25.5	246	74.5	0.01	0.452	0.45 (0.25-0.83)
	Yes	30	39.0	47	61.0			Ref

(Table 6) contd.....

		Store		Not Store		Bivariate	Multivariate	
		n	%	n	%	*p*-Value	*p*-Value	OR (95%CI)
Last time used antibiotics	<3 months ago	39	41.1	56	58.9	<0.001	0.001	2.57 (1.44-4.56)
	3-6 months ago	15	23.4	46	76.6		0.465	1.31 (0.64-2.68)
	7-12 months ago	7	24.1	22	75.9		0.389	1.52 (0.59-3.97)
	>12 months ago	6	16.7	30	83.3		0.899	0.94 (0.35-2.51)
	Forget	33	19.5	136	80.5			Ref
Antibiotic knowledge	Low	24	36.4	42	63.6	<0.001	0.003	6.37 (1.91-21.24)
	Moderate	86	30.9	192	69.1		0.002	5.34 (1.81-15.73)
	High	4	6.3	59	93.7			Ref

These findings suggest that both demographic characteristics and antibiotic knowledge influence storage behavior. Notably, a significant association was found between antibiotic knowledge and storage practices, consistent with prior research [17]. Interestingly, unique storage patterns were related to the presence of family members working in healthcare, which could have inadvertently promoted non-standard behaviors and biased home antibiotic management. Such power could come from informal medical advice or family-perceived authority, strengthening misunderstandings about suitable antibiotic usage. Moreover, the study sample mostly comprised young, single women with secondary-level education, which might restrict the generalizability of these results. This demographic concentration emphasizes the necessity of more extensive, inclusive sampling in future studies to capture a larger spectrum of behaviours and sociocultural factors.

4. LIMITATIONS AND FUTURE RECOMMENDATIONS

This study has several limitations. The possibility of recall inaccuracies and social desirability bias has increased due to the use of self-reported data. The survey instrument was designed using validated tools and reviewed by subject experts to ensure revelatory clarity and contextual relevance in addressing these concerns. The anonymity and confidentiality of participants were assured to foster candid participation. Although the study was geographically constrained, efforts were made to incorporate respondents from varied socio-demographic backgrounds to enhance insight coverage.

Nevertheless, the findings may not be entirely generalizable to broader populations due to the limited sample size. Future research should be conducted to cover more demographically and geographically diverse participants from different parts of the country or world so that behavioral trends can be better captured over time. Additionally, intervention-based studies examining the efficacy of educational and behavioral strategies in curbing inappropriate antibiotic use are warranted to inform public health policy more effectively.

CONCLUSION

This study highlights that antibiotics were the second most commonly stored medications in households, with leftover antibiotics often retained for further use, reflecting incomplete adherence to prescribed treatment. This practice potentially increases the risk of antibiotic resistance, a critical global health threat for the 21st century. Self-medication practices, such as purchasing antibiotics without a prescription, were also prevalent, suggesting limited public understanding of appropriate antibiotic use. Furthermore, knowledge gaps regarding antibiotic function, access, and side effects were consistently observed among respondents, reinforcing the need for focused community education. Factors such as having a family member in the health sector, recent antibiotic use, and knowledge levels significantly influenced storage behavior.

These findings underscore the urgency for integrating antibiotic education into public health strategies, particularly in settings where informal access to medications is common. Pharmacists and primary healthcare providers can play a pivotal role in delivering structured, community-based education sessions to improve antibiotic literacy and promote appropriate storage and use practices.

We recommend that the Indonesian Ministry of Health and local governments implement policy-driven interventions focused on antibiotic stewardship at the community level. These may include mandatory pharmacist-led counseling during antibiotic dispensing, public awareness campaigns, and tighter regulation of over-the-counter sales. Engaging communities directly through outreach and education can lead to sustainable changes in behavior, ultimately contributing to a reduction in antibiotic resistance rates nationwide.

AUTHORS' CONTRIBUTIONS

The authors confirm their contribution to the paper: study conception and design: HK, MSH, ASW; data collection: RAR, DZAH; analysis and interpretation of results: HK, MSH, ASW, RAR, DZAH, IYK; draft manuscript: HK, MSH, ASW, RAR, DZAH, IYK. All authors reviewed the results and approved the final version of the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The present study was approved by the Medical and Health Research Ethics Committee, Faculty of Medicine, University of Muhammadiyah Surakarta, Indonesia, with Reference No: 3743/B.1/KEPK_FKUMS/X/2021.

HUMAN AND ANIMAL RIGHTS

No animals were used in this research. All human research procedures followed were in accordance with the ethical standards of the committee responsible for human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2013.

CONSENT FOR PUBLICATION

Informed consent was obtained from all patients participating in the study.

STANDARDS OF REPORTING

Standards of reporting follow the STROBE guidelines.

AVAILABILITY OF DATA AND MATERIALS

The data supporting the findings of the article is available within the article.

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None.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest, financial or otherwise.

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REFERENCES

[1] Ho CS, Wong CTH, Aung TT, *et al.* Antimicrobial resistance: A concise update. Lancet Microbe 2025; 6(1): 100947. http://dx.doi.org/10.1016/j.lanmic.2024.07.010 PMID: 39305919

[2] Rather IA, Kim BC, Bajpai VK, Park YH. Self-medication and antibiotic resistance: Crisis, current challenges, and prevention. Saudi J Biol Sci 2017; 24(4): 808-12. http://dx.doi.org/10.1016/j.sjbs.2017.01.004 PMID: 28490950

[3] Wang X, Lin L, Xuan Z, Li L, Zhou X. Keeping antibiotics at home promotes self-medication with antibiotics among Chinese university students. Int J Environ Res Public Health 2018; 15(4): 687. http://dx.doi.org/10.3390/ijerph15040687 PMID: 29621165

[4] Karuniawati H, Suryawati S, Hassali M, Taufik T, Ismail W, Hossain M. Self-medication practice of antibiotics and associated factors in the community in Indonesia. 7th International Conference on Public Health 2021 (ICOPH 2021) Kotte Road, Pitakotte, 10100, Sri Lanka, 4th-5th August-2021, PP.31

[5] Mendoza AMB, Maliñana SAA, Maravillas SID, Moniva KC, Jazul JP. Relationship of self-medication and antimicrobial resistance (AMR) in low- and middle-income countries (LMICs): A scoping review. J Public Health Emerg 2025; 9(0): 6. http://dx.doi.org/10.21037/jphe-23-184

[6] Basic Health Research (Riskesdas). 2018. Available from: https://pusdatin.kemkes.go.id/resources/download/general/Hasil%20Riskesdas%202013.pdf

[7] Antibiotic resistance. 2023. Available from: https://www.who.int/news-room/fact-sheets/detail/antibiotic-resistance

[8] Ayana H, Sileshi T, Bule MH, Chaka EE. Non-prescription antibiotics use and associated factors among drug retail outlets in ambo, ethiopia: A Cross-sectional study. Patient Prefer Adherence 2021; 15: 2739-47. http://dx.doi.org/10.2147/PPA.S337364 PMID: 34916784

[9] Sharma A, Singh A, Dar MA, *et al.* Menace of antimicrobial resistance in LMICs: Current surveillance practices and control measures to tackle hostility. J Infect Public Health 2022; 15(2): 172-81. http://dx.doi.org/10.1016/j.jiph.2021.12.008 PMID: 34972026

[10] Klein EY, Impalli I, Poleon S, *et al.* Global trends in antibiotic consumption during 2016–2023 and future projections through 2030. Proc Natl Acad Sci USA 2024; 121(49): e2411919121. http://dx.doi.org/10.1073/pnas.2411919121 PMID: 39556760

[11] Lestari ES, Severin JA, Filius PMG, *et al.* Antimicrobial resistance among commensal isolates of *Escherichia coli and Staphylococcus aureus* in the Indonesian population inside and outside hospitals. Eur J Clin Microbiol Infect Dis 2007; 27(1): 45-51. http://dx.doi.org/10.1007/s10096-007-0396-z PMID: 17934766

[12] Bisht R, Katiyar A, Singh R, Mittal P. Antibiotic resistance: A Global issue of concern. Asian J Pharm Clin Res 2009; 2(2): 6.

[13] Antibiotics Resistance Threats in the United States. U.S Department of Health and Human Services Centers for Disease Control and Prevention 2019.

[14] Bestari MP, Karuniawati H. Evaluation of the rationality and effectiveness of antibiotic use in pediatric pneumonia patients at the inpatient installation of central Java Hospital. Pharmacon: Jurnal Farmasi Indonesia 2019; 14(2): 62-71. http://dx.doi.org/10.23917/pharmacon.v14i2.6524

[15] Karuniawati H, Hassali MAA, Suryawati S, Ismail WI, Taufik T, Wiladatika A. Public practices towards antibiotics: A qualitative study. Clin Epidemiol Glob Health 2020; 8(4): 1277-81. http://dx.doi.org/10.1016/j.cegh.2020.04.027

[16] Wang X, Cheng Z. Cross-sectional studies. Chest 2020; 158(1): S65-71. http://dx.doi.org/10.1016/j.chest.2020.03.012 PMID: 32658654

[17] Karuniawati H, Hassali MAA, Suryawati S, Ismail WI, Taufik T, Hossain MS. Assessment of knowledge, attitude, and practice of antibiotic use among the population of boyolali, indonesia: A cross-sectional study. Int J Environ Res Public Health 2021; 18(16): 8258. http://dx.doi.org/10.3390/ijerph18168258 PMID: 34444015

[18] Sample Size Calculator by Raosoft, Inc. 2018. Available from: http://www.raosoft.com/samplesize.html

[19] Ismail WI, Suryawati MAA, Hassali S, Karuniawati S. Development and validation of knowledge, attitude, and practice towards antibiotics questionnaire (KAPAQ) for General Community. Res J Pharm Technol 2022; 15(1): 1277-81. http://dx.doi.org/10.1016/j.cegh.2020.04.027

[20] Riwidikdo H. Statistics for Health Research with R and SPSS Program Applications. Yogyakarta: Pustaka Rihama 2010.

[21] Savira M, Ramadhani FA, Nadhirah U, *et al.* Drug storage and disposal practices in the family. J Commun Pharm 2020; 7(2): 38-47. http://dx.doi.org/10.20473/jfk.v7i2.21804

[22] Cortez J, Rosário E, Pires JE, *et al.* Antimicrobial storage and antibiotic knowledge in the community: A cross-sectional pilot study in north-western Angola. Int J Infect Dis 2017; 60: 83-7. http://dx.doi.org/10.1016/j.ijid.2017.05.011 PMID: 28546075

[23] Wondimu A, Molla F, Demeke B, *et al.* Household storage of medicines and associated factors in Tigray Region, Northern Ethiopia. PLoS One 2015; 10(8): e0135650. http://dx.doi.org/10.1371/journal.pone.0135650 PMID: 26275057

[24] Ocan M, Bbosa GS, Waako P, Ogwal-Okeng J, Obua C. Factors predicting home storage of medicines in Northern Uganda. BMC Public Health 2014; 14(1): 650. http://dx.doi.org/10.1186/1471-2458-14-650 PMID: 24964746

[25] Jassim AM. In-home drug storage and self-medication with antimicrobial drugs in Basrah, Iraq. Oman Med J 2010; 25(2): 79-87. http://dx.doi.org/10.5001/omj.2010.25 PMID: 22125705

[26] Huang Y, Wang L, Zhong C, Huang S. Factors influencing the attention to home storage of medicines in China. BMC Public

Health 2019; 19(1): 833.
http://dx.doi.org/10.1186/s12889-019-7167-5 PMID: 31248407

[27] Sun C, Hu YJ, Wang X, Lu J, Lin L, Zhou X. Influence of leftover antibiotics on self-medication with antibiotics for children: A cross-sectional study from three Chinese provinces. BMJ Open 2019; 9(12): e033679.
http://dx.doi.org/10.1136/bmjopen-2019-033679 PMID: 31843850

[28] Hajma LPA, Karuniawati H, Mutmainah N. Antibiotic evaluation use towards diabetic foot ulcer inpatient at hospital in Surakarta. Pharmacon: J Farmasi Indonesia 2022; 19(2): 187-96.
http://dx.doi.org/10.23917/pharmacon.v19i2.20570

[29] Putri CK, Cholisoh Z. Evaluation of the Community's Level of knowledge about using antibiotics in Klaten District. Thesis, Muhammadiyah University of Surakarta 2017; 17.

[30] Tamayanti WD, Sari WDM, Dewi BDN. Antibiotic use in two pharmacies in Surabaya: identification of factors influencing patient compliance. Pharmaciana 2016; 6(2): 155-62.
http://dx.doi.org/10.12928/pharmaciana.v6i2.4038

[31] Notoatmodjo S. Promosi Kesehatan & Perilaku. Jakarta: Rineka Cipta 2007.