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Public Knowledge and Awareness of Antimicrobial Resistance Prevention in Rural Tabanan, Bali: A Cross-Sectional Study

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ABSTRACT

Due to inappropriate usage of antibiotics, Indonesia has high rates of antimicrobial resistance (AMR), a significant worldwide health concern. Understanding public knowledge and awareness is crucial in mitigating AMR, particularly in rural communities. This study aimed to assess the knowledge and awareness of rural community members in Tengkudak Village, Tabanan, regarding antibiotic use and AMR prevention. A community-based cross-sectional study was conducted from November to December of 2024. A total of 124 respondents were recruited using a consecutive non-random sampling. Data were collected using a validated questionnaire consisting of two sections: knowledge and awareness. Knowledge was assessed using 10 dichotomus items based on the Guttman scale covering antibiotic acquisition, use, storage, and disposal, while awareness was measured using 7 items on a Likert scale rekated to antibiotics and AMR. Descriptive statistics were used to summarize respondent characteristics and outcome variables. The association between knowledge and awareness levels was analyzed using Spearman's rank correlation coefficient, with a two-sided significance level set at $\alpha = 0.05$. Of the respondents, 58 (46.8%) demonstrated good knowledge, and 86 (69.4%) showed good awareness regarding antibiotics and AMR. Despite this, improper disposal practices were common, with 80.6% of participants reporting that expired or damaged antibiotics were discarded in household trash. A statistically significant moderate positive correlation was observed between knowledge and awareness levels ($\rho = 0.558$, $p<0.001$). Knowledge and awareness of antibiotic use and AMR prevention in the rural population are significantly correlated. To increase the responsible use of antibiotics, educational initiatives are crucial, particularly with regard to safe storage and appropriate disposal procedures.

Keywords:
Antimicrobial Resistance; Health Behavior; Community Pharmacy; Rural area

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1. Introduction

According to the World Health Organization (WHO), antimicrobial resistance (AMR) is one of the most serious global public health threats, as it has the potential to increase morbidity, mortality, and healthcare costs when previously treatable infections become difficult to manage [1]. In Southeast Asia, including Indonesia, AMR is a major concern due to high antibiotic consumption at the community level and the limited implementation of rational antibiotic use practices [2].

In the Indonesian context, the AMR problems is closely linked to community-level factors [3]. Previous studies reported that the prevalence of antibiotic resistance in several major pathogenic bacteria, such as Escherichia coli and Klebsiella pneumoniae [4], [5]. Access to over-the-counter (OTC), self-medication paractices, low health literacy, and limited implementation of antimicrobial stewardship programs ini primary health care are key drivers of inappropriate antibiotic use at the community level [3].

Several previous studies have shown that public knowledge plays a significant role in shaping attitudes and behaviors related to antibiotic use and resistance prevention. Communities with better knowledge tend to have a higher awareness of the risks associated with AMR and are more supportive of the wise use of antibiotics [6]. Therefore, a comprehensive understanding of public knowledge and awareness is essential for designing effective public health interventions to reduce AMR rates at the community level, particularly in rural areas where educational programs are relatively less accessible.

Antibiotics are medications used to treat bacterial infections [5]. Antibiotic treatment is used to prevent the growth and kill the bacteria causing the infection. The improper use of antibiotics (including misuse or excessive use of antimicrobials in animals, environmental pollution, nosocomial transmission, suboptimal treatment and dosing) and inadequate infection prevention have contributed to the emergence and increased likelihood of resistance developing, spreading, and endangering the world [5]. Antibiotic self-medication is another element that contributes to the development of AMR, as antibiotics are easily obtained without a prescription, and the practice of prescribing is suboptimal [9].

To develop targeted treatments and encourage ethical use of antibiotics, it is necessary to comprehend the knowledge, attitudes, and practices of the general population regarding antibiotics and bacteria resistance [10]. A preliminary survey in Bengkel Village, Tabanan, conducted before the implementation of any educational or outreach interventions, revealed generally low levels of community knowledge about antibiotics [11]. This study was designed to address that gap by assessing the level of knowledge and awareness related to antibiotic use and AMR prevention among residents in Tengkudak Village, a rural area in Tabanan, Bali. We measured community knowledge (obtain, use, store, dispose) and awareness related to antibiotics and AMR, and tested whether higher knowledge is associated with higher awareness.

2. Methods

Study Design and Setting

This study used a cross-sectional methodology and an analytical observational design. The research was conducted over a two-month period, from November to December 2024, in Tengkudak Village, Penebel Subdistrict, Tabanan Regency, Bali. Tengkudak Village was selected as the study site because it is a rural area with limited access to healthcare facilities, making it a relevant location to assess public knowledge

and awareness regarding responsible antibiotic use and antimicrobial resistance prevention.

Population and Sampling

The study population consisted of residents who met the inclusion criteria. Sampling was conducted using a consecutive non-random sampling technique. The Slovin formula was used to determined the sample size, and 96 individuals was the minimum required. 124 respondents in all were enlisted.

Research Instrument

The instrument used to collect the data was a structured questionnaire comprising three sections: demographic characteristics, knowledge, and awareness. The knowledge section used a Guttman scale with 10 items, where each item had binary responses (0 = incorrect/no, 1 = correct/yes). The awareness section used a 4-point Likert scale for 7 items (1 = strongly disagree, 4 = strongly agree).

Validity and Reliability Testing

The Cronbach's alpha was used to assess the questionnaire's reliability resulting in coefficients of 0.731 for the knowledge section and 0.813 for the awareness section, indicating acceptable internal consistency. Validity testing showed r-count values > 0.361, confirming construct validity.

Data Analysis

Knowledge and awareness scores were categorized into three levels: Good (76–100%), Fair (56–75%), and Poor (<56%) [12]. The relationship between knowledge and awareness was analyzed using the Spearman rank correlation test, appropriate for non-parametric and ordinal data.

Ethical Considerations

The Ethics Committee of Bali International University granted ethical permission for this study on October 31, 2024, under approval number 02.0453/UNBI/EC/X/2024.

3. Result and Discussion

Characteristics of Respondent

This study examined the respondents' age, gender, last education, occupation, whether they have ever purchased antibiotics, whether they have ever used antibiotics, where they purchased antibiotics, and whether they store antibiotics.

Table 1. Respondents' Characteristics (n=124)

Characteristics		n (%)
Age (years)	17-25	21 (16.9)
	26-35	16 (12.9)
	36-45	14 (11.3)
	46-55	**30 (24.2)**
	56-65	25 (20.2)
	>65	18 (14.5)
Sex	Female	**63 (50.8)**
	Male	61 (49.2)
Education	Elementary	33 (26.6)
	Junior	14 (11.3)
	Senior	**61 (49.2)**
	Higher	16(12.9)
Occupation	Teacher	2 (1.6)
	Housewife	7 (5.6)
	Student	1 (0.8)
	Farmer	51 (41.2)

	Private employees	**62 (50.0)**
	Entrepreneur	1 (0.8)
Ever Bought Antibiotics	Yes	**124 (100.0)**
	No	0 (0.0)
Have Used Antibiotics	Yes	**124 (100.0)**
	No	0 (0.0)
Where to Buy Antibiotics	Pharmacy	**112 (90.3)**
	Doctor	0 (0.0)
	Community Health Center	12 (9.7)
	Stall	0 (0.0)
Storing Antibiotics	Yes	34 (27.4)
	No	**90 (72.6)**

Table 1 shows that most respondents are based on age, specifically in the age range of 46-55 years (n=30; 24.4%), and most respondents were female (n=63; 50.8%). Based on the highest level of education attained, most respondents reported high school or an equivalent level as their highest level of formal education (n=61; 49.2%). By occupation, most respondents are private employees (n=62; 50.0%). Based on antibiotic usage, the research results show that all respondents have ever purchased and used antibiotics, with 124 respondents (100.0%). For the purchase of antibiotics, most respondents bought antibiotics at pharmacies (n=112; 90.3%). The purchase of antibiotics should come from legal sources to ensure their safety and to obtain usage information directly from healthcare professionals. The research results indicate that respondents still stored antibiotics at home (n=34; 27.4%). The actions taken by the respondents are not appropriate because the use of antibiotics should be monitored by healthcare professionals, especially doctors; otherwise, it could increase the incidence of inappropriate antibiotic use in the community. Antibiotics used improperly and irrationally can increase the incidence of bacterial resistance to antibiotics [12].

Knowledge of Antibiotic Used

The antibiotic knowledge questionnaire in this study consisted of 10 questions. The following is a list of the frequency of respondents providing correct or incorrect answers for each question.

Table 2. Respondents' Knowledge (n=124)

Question	Responses	
	Yes/Correct n (%)	No/Incorrect n (%)
Obtain		
Antibiotics are medications that must be purchased with a doctor's prescription.	118 (95.2)	6 (4.8)
The place to get guaranteed antibiotics is the pharmacy.	114 (91.9)	10 (8.1)
Antibiotics can be obtained from friends or family members who have the same illness.	24 (19.4)	100 (80.6)
Use		
Antibiotics are used to treat bacterial infections.	92 (74.2)	32 (25.8)
The antibiotic dosage instructions state 3x1, so the interval for taking the medication is every 8 hours.	110 (88.7)	14 (11.3)
The use of antibiotics should not be stopped even if the symptoms of illness have disappeared.	66 (53.2)	58 (46.8)
Store		
Antibiotics can be stored and reused when the illness recurs.	39 (31.5)	85 (68.5)

Antibiotic medication should be kept out of reach of children and protected from sunlight exposure.	**87 (70.2)**	37 (29.8)
Antibiotics in syrup form that have been opened can be stored in the refrigerator.	29 (23.4)	**95 (76.6)**
Dispose		
Antibiotic syrup preparations are disposed of along with their containers by removing the labels from the bottles.	58 (46.8)	**66 (53.2)**

Table 2 shows that respondents had strong knowledge of antibiotics acces rules, particularly prescription requirements. The item most frequently answered correctly was "Antibiotics must be purchased with a doctor's prescription" (n=118; 95.2%), consistent with previous study reporting similar awareness levels [13]. This aligns with national regulations issued by the Ministry of Health of the Republic of Indonesia, which designate antibiotics as prescription-only medicines under Regulation No. 28 of 2021 and warn that non-prescription may lead to irrational therapy and antimicrobial resistance [15].

In contrast, weaknesses were evident in antibiotic disposal practices. The item most often answered incorrectly concerned the disposal of antibiotic syrups by removing labels and discarding (n=66; 53.2%), consistent with previous studies showing poor knowledge of liquid antibiotics disposal [16], [17]. National guidance recommends discarding liquid antibiotics together with their container aftel label removal to prevent misuse and environmental contamination [15]. Overall, these findings suggest that while knowledge of antibiotic access is strong, gaps persist in practical aspects of antibiotic management that are critical for AMR prevention.

Awareness Toward AMR Prevention

This study assessed public awareness of antimicrobial resistance (AMR) prevention through seven questions. The responses from the participants are summarized in **Table 3**, showing the frequency of Strongly Agree (SA), Agree (A), Disagree (D), and Strongly Disagree (SD) answers to each statement in the awareness questionnaire. The table highlights the overall awareness levels in various aspects, including infection prevention, appropriate antibiotic use, and disposal practices.

Table 3. Respondents' Awareness (n=124)

Statements	**Responses**			
	SA (n%)	**A (n%)**	**D (n%)**	**SD (n%)**
The way to prevent infection is by washing hands regularly.	**69 (55.6)**	42 (33.9)	10 (8.1)	3 (2.4)
Always maintaining food hygiene can prevent infections.	49 (39.5)	**66 (53.2)**	9 (7.3)	0
I can buy antibiotics freely at a stall or supermarket.	13 (10.5)	10 (8.1)	**79 (63.7)**	22 (17.7)
I only use antibiotics if prescribed by a doctor.	**60 (48.4)**	52 (41.9)	5 (4.0)	7 (5.6)
If I finish the antibiotics as directed, I believe it will reduce the risk of antibiotic resistance.	**52 (41.9)**	33 (26.6)	25 (20.2)	14 (11.3)
I do not keep antibiotics in case I get sick.	**53 (42.7)**	51 (41.1)	17 (13.7)	3 (2.4)
I disposed of the old and expired antibiotic tablets/syrup.	**73 (58.9)**	51 (41.1)	0	0
Disposal practices	**n**			**%**
In the trash	100			80.6
In the toilet	0			0

Buried	23	18.6
Destroyed	65	52.4
Burned	50	40.3
(multiple responses allowed)		

SA = strongly agree; A = agree; D = disagree; SD = strongly disagree

Improper disposal of antibiotics poses risk of environmental contamination of soil and water and may contribute to the emerge of new microbial resistance patterns [17]. These findings highlight a priority target for community-based AMR prevention programs, including clearer guidance from primary healthcare centers (Puskesmas), promotion of pharmacy-based medicine take-back programs, and public messaging emphasizing appropriate disposal methods (e.g., do not flush antibiotics and avoid indiscriminate disposal).

For the negative statement "I can buy antibiotics freely at stalls or supermarkets," most respondents disagreed (n=79; 63.7%), indicating good awareness that antibiotics should only be obtained from authorized health facilities such as pharmacies. This finding is consistent with previous studies reporting that most respondents obtained antibiotics from pharmacies (79.74%), reflecting positive awareness regarding appropriate access to antibiotics [19].

Correlation Between Knowledge and AMR Awareness

Table 4 presents the distribution of respondents' knowledge levels and their awareness of antibiotic resistance, highlighting the proportion of individuals categorized as having good, moderate, or poor knowledge and awareness. The table shows that a significant portion of the respondents demonstrate good knowledge and awareness of antibiotic resistance, with notable gaps in certain areas. This data emphasizes the need for targeted interventions to further educate the community about antibiotic use and its impact on resistance.

Table 4. Knowledge and AMR Awareness (n=124)

Category	**n**	%
Knowledge		
Good	**58**	**46.8**
Moderate	54	43.5
Poor	12	9.7
Awareness		
Good	**86**	**69.4**
Adequate	34	27.4
Poor	4	3.2

Table 5 presents the bivariate analysis was performed using an open-source SPSS version 23.0 for Windows to assess the association between knowledge level and awareness of antibiotic resistance using Spearman's rank correlation.

Table 5. Spearman's Rank Correlation Analysis

	AMR Awareness	
Knowledge	**p-*value***	**correlation coefficient**
	<0.001	0.558

Most respondents (n=58; 46.8%) have good knowledge, and (n=86; 69.4%) show good AMR Awareness. The results of the Spearman rank test analysis related to the relationship between the knowledge and awareness, the significance value is

<0.001. This result indicates a significant relationship between knowledge and awareness in efforts to prevent antimicrobial resistance in Tengkudak Village, Tabanan. The positive (+) direction is evident from the correlation value, which approaches 0.558. This finding indicates a positive association between level of knowledge and awareness regarding antibiotic resistance. Stated differently, the more the community's awareness, the better its knowledge. The connection between vigilance and knowledge level falls into the moderate group in this study. These results strengthen the previous research, which showed a significant relationship between knowledge and antibiotic use behaviour [20]. The correlation coefficient value obtained was 0.431, which is included in the moderate relationship category with a positive correlation direction. Thus, this study provides additional evidence that increasing knowledge about the use of antibiotics has the potential to increase public awareness of their use, which can help reduce the risk of antimicrobial resistance [14], [20].

This gap can be addressed through targeted programmatic actions aligned with the DAGUSIBU (obtain–use–store–dispose) framework, including pharmacist-led education in pharmacies and community health centers (Puskesmas) to strengthen prescription-only access, point-of-sale counseling on correct dosage, spacing, and completion of therapy, household guidance on safe storage to prevent reuse, and clear instructions on safe disposal of tablets and syrup through drug return options while avoiding littering or flushing down the toilet. To increase reach in rural hamlets, these interventions should be supported by simple, locally tailored WhatsApp poster campaigns, strengthening community-level antibiotic stewardship and AMR prevention.

Limitations of the Study

There are multiple limitations to this study. First, because study was limited to a single rural community, the results cannot be applied to other communities with differing features or access to healthcare. The cross-sectional design used in this study also restricts interpretation to associative relationships rather than causality. Furthermore, the study focused solely on knowledge and awareness, without exploring other contributing factors such as attitudes, cultural beliefs, health literacy, or access to pharmaceutical services that may influence antibiotic use and resistance behavior. Additionally, because self-reported surveys are used, there is a chance that participants would give answers that are socially acceptable, which could lead to response bias. These limitations should be considered in future studies, which are encouraged to expand the sample area and explore qualitative dimensions for a more comprehensive understanding of antimicrobial resistance prevention in the community.

4. Conclusion

In this rural community, levels of knowledge and awareness regarding antibiotic use and antimicrobial resistance (AMR) were moderate overall and positively associated. Despite this, unsafe practices, particularly the improper disposal of expired antibiotics, remain common. These findings indicate the need for targeted public health interventions, including pharmacist-supported community education and clear guidance on appropriate antibiotic disposal, to strengthen antibiotic stewardship at the community level.

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Conflicts of Interest:
The author declares that there are no conflicts of interest in this study.

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