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Flipchart-Based Education Improves Antibiotic and Antimicrobial Resistance Knowledge Among Rural Elementary Students: A Pre-Experimental Study

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ABSTRACT

Antimicrobial resistance (AMR) remains a major public health challenge, driven in part by inappropriate antibiotic use and limited public understanding of antibiotics and AMR. Early educational interventions for school-aged children may offer a sustainable approach to strengthening antibiotic literacy and promoting responsible health behaviors. This study evaluated the effectiveness of a flipchart-based educational intervention in improving elementary school students' knowledge of antibiotics and understanding of AMR in a rural area of Bali, Indonesia. A pre-experimental one-group pretest-posttest design was conducted among 76 students using a validated questionnaire covering basic antibiotic concepts, AMR mechanisms, and prevention strategies. The proportion of students categorized as having high knowledge increased from 19.7% (95% CI: 11.8–27.8) before the intervention to 63.8% (95% CI: 53.9–75.3) after the intervention, while the proportion with low knowledge decreased from 21.1% to 10.5%. Mean knowledge scores increased significantly from 58.82 ± 16.57 to 75.13 ± 18.00, with a mean difference of +16.32 (95% CI: 12.55–20.08; $p < 0.001$). The intervention also demonstrated a large practical effect (Cohen's d = 0.99). These findings indicate that flipchart-based education can effectively improve antibiotic knowledge and AMR understanding among rural elementary school students and may serve as a promising school-based health education approach to support early antibiotic literacy.

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ABSTRAK

Resistensi antimikroba atau *antimicrobial resistance* (AMR) masih menjadi tantangan besar dalam kesehatan masyarakat, yang sebagian dipicu oleh penggunaan antibiotik yang tidak tepat serta terbatasnya pemahaman masyarakat tentang antibiotik dan AMR. Intervensi edukasi sejak dini pada anak usia sekolah dapat menjadi pendekatan berkelanjutan untuk memperkuat literasi antibiotik dan mendorong perilaku kesehatan yang lebih bertanggung jawab. Penelitian ini bertujuan mengevaluasi efektivitas intervensi edukasi berbasis *flipchart* dalam meningkatkan pengetahuan siswa sekolah dasar tentang antibiotik dan pemahaman tentang AMR di wilayah pedesaan Bali, Indonesia. Penelitian menggunakan desain pra-eksperimental *one-group pretest-posttest* pada 76 siswa dengan instrumen kuesioner tervalidasi yang mencakup konsep dasar antibiotik, mekanisme AMR, dan strategi pencegahan. Proporsi siswa dengan kategori pengetahuan tinggi meningkat dari 19,7% (95% CI: 11,8–27,8) sebelum intervensi menjadi 63,8% (95% CI: 53,9–75,3) sesudah intervensi, sedangkan proporsi dengan pengetahuan rendah menurun dari 21,1% menjadi 10,5%. Nilai rerata pengetahuan meningkat secara signifikan dari 58,82 ± 16,57 menjadi 75,13 ± 18,00, dengan perbedaan rerata sebesar +16,32 (95% CI: 12,55–20,08; p < 0,001). Intervensi ini juga menunjukkan dampak praktis yang besar (Cohen's d = 0,99). Temuan ini menunjukkan bahwa edukasi berbasis *flipchart* efektif dalam meningkatkan pengetahuan antibiotik dan pemahaman AMR pada siswa sekolah dasar di wilayah pedesaan, serta berpotensi menjadi pendekatan edukasi kesehatan berbasis sekolah untuk mendukung literasi antibiotik sejak dini.

Kata Kunci: Resistensi antimikroba; Literasi antibiotik; Pendidikan kesehatan; Edukasi berbasis *flipchart*; Intervensi kesehatan berbasis sekolah

1. Introduction

Antibiotics are crucial in treating bacterial infections; however, their inappropriate and excessive use has accelerated the emergence of antimicrobial resistance (AMR), now recognized as a major global health concern. The World Health Organization (WHO) estimates that AMR was directly responsible for 1.27 million deaths in 2019 and contributed to an additional 3.68 million deaths worldwide [1]. Without coordinated and sustainable interventions, AMR threatens the effectiveness of modern medical procedures that rely on antibiotics, including surgery, cancer chemotherapy, and organ transplantation [2].

A major driver of AMR is inadequate public understanding of appropriate antibiotic use. In many low- and middle-income countries, including Indonesia, antibiotics are frequently obtained without prescriptions and used to treat viral infections, for which they are ineffective [3]–[5]. Studies have reported high rates of non-prescription antibiotic use and poor adherence to treatment regimens, practices that significantly contribute to resistance development. Weak regulatory enforcement, cultural norms surrounding medication use, and limited public health education further exacerbate the problem [3], [5]–[9].

The burden of AMR is particularly concerning in the Asia-Pacific region. Surveillance data indicate high prevalence rate of extended-spectrum β-lactamase (ESBL)-producing *Escherecia coli* and *Klebsiella pneumoniae* in Indonesia , especially in bloodstream and urinary tract infections [10], [11]. These trends not only compromise treatment effectiveness but also increase healthcare costs, prolong hospital stays, and threaten decades of progress in infectious disease management [12].

These significant gaps in the international health system emphasize the urgency of addressing AMR, particularly through public health campaigns, education, and responsible use of antibiotics. Multifaceted strategies are needed to combat the growing problem of antibiotic resistance. Increasing public education, enforcing laws governing the sale of antibiotics, reducing unnecessary use in agriculture and human health services, and encouraging global cooperation are important initiatives [13].

Recognizing the urgency of this crisis, Indonesia has implemented a National Action Plan for AMR control (2020–2024), aligned with the One Health framework [14]–[16]. While policy-level and healthcare-based interventions are advancing, public awareness initiatives remain largely focused on healthcare professionals and adult populations [17], [18]. Educational strategies targeting younger age groups remain limited, despite growing evidence that early health education can foster long-term health literacy and influence family health behaviors.

Children represent a strategic population for AMR prevention efforts. School-based education can establish foundational knowledge about microbes, hygiene, and responsible antibiotic use, while interactive and age-appropriate tools have been shown to enhance knowledge retention [14]. However, in Indonesia, there is limited evidence on structured, child-focused AMR educational interventions, particularly those employing culturally appropriate and low-cost teaching media suitable for rural settings [18], [19].

The primary novelty of this study lies in the development and evaluation of a low-cost, flipchart-based educational tool specifically tailored for rural Indonesian elementary students to address antimicrobial resistance. Unlike standard digital interventions, this approach prioritizes visual storytelling and interactive learning within resource-limited settings, backed by rigorous pre-post quantitative effect size reporting.

2. Methods

Study design and setting

This study employed a pre-experimental one-group pretest-posttest design [20], conducted to assess the effectiveness of a flipchart-based educational intervention in improving students' knowledge of antibiotics and understanding AMR. While this design is practical for resource-limited school settings, we explicitly acknowledged potential threats to internal validity, including: the testing effect, maturation, and history. To mitigate these, the posttest was administered immediately after the intervention to minimize the influence of maturation and external historical events.

The intervention was implemented in November 2024 at a public elementary school located in a rural area of Gianyar Regency, Bali, Indonesia. The location was purposively selected because of its limited access to health education resources and its increased vulnerability to inappropriate antibiotic use, a common challenge in Indonesian rural regions where low health literacy and easy access to over-the-counter medicines remain common. By focusing on a rural public school, this study addresses a critical gap in AMR awareness campaigns, which typically target adult or urban populations. Furthermore, targeting rural pupils leverages their potential as health changemakers within their families and communities.

Participants and sampling

Participants were students in grades 4 to 6, aged between 10 and 12 years. A non-probability consecutive sampling technique was used to recruit participants, selected sequentially until the required sample size was met. The sample size was calculated using Slovin's formula based on the known total population of students at the selected school. Inclusion criteria were: (1) students who obtained written informed consent from their parents or guardians; and (2) students who had not previously received formal education or interventions related to antibiotics. Students who, according to their teachers, had prior exposure to similar learning materials were excluded.

Education intervention tool

The intervention was delivered using interactive flipchart specifically designed for elementary school-aged children. The education was structured into 50-minute sessions, guided by trained facilitators. To ensure high engagement and individualized attention, the students were divided into approximately 15 pupils per facilitator. The curicullum was consisted of three-part framework: (1) introduction to germs and antibiotics, (2) the mechanism of resistance, and (3) prevention strategies. The lessons were delivered through two-way communication, including a 15-minutes discussion at the end of the session to clarify misconceptions. The flipchart utilized in this study has been officially registered with the Indonesian Ministry of Law and Human Rights under Intellectual Property Rights No. EC00202427924 (issued March 28, 2024).

Data collection instrument

A structured and validated questionnaire was used to measure students' knowledge and understanding regarding antibiotics use and AMR before and after the intervention. The term knowledge is used throughout this study as the instrument specifically measures factual comprehension rather than broad behavioral awareness. The questionnaire comprised two sections: the first gathered demographic data (age, gender, and class level, while second, adapted from previous research [19], assessed the intervention's effectiveness through 10 dichotomous questions (Yes/True =1); No/False = 0). Total scores were categorized as high (≥ 8), medium (6–7), or low (≤ 5).

Content validity was established through an expert review process involving a child psychologist and microbiologist, who evaluated the item relevance and linguistic appropriateness for the target age group. A pilot test (n = 30) was conducted to ensure face validity and internal consistency. Item validity was assessed using *Pearson Product-Moment Correlation*, all item were found to be valid as their coefficients exceeded the critical r table value of 0.361 ($p < 0.05$). Since the items were dichotomous scored, internal consistency was evaluated using the Kuder-Richardson 20 (KR-20) formula, yielding a coefficient of 0.78, indicating good internal consistency and suggesting that the instrument is reliable for futher use. Following the pilot test, minor adjustments were made to the phrasing of two questions to reduce ambiguity for younger students. Additionally, feedback was collected from students and teachers through semi-structured questions to explore their perceptions of the flipchart and its educational impact.

Data analysis

Data were analyzed using open-source statistical software. Descriptive statistics were used to summarize participant characteristics and response distributions. To ensure methodological rigor, the normality of the data was assessed using the *Shapiro-Wilk test* on the difference scores (posttest-pretest). A *paired-sample t-test* was then employed to evaluate the overall change in mean scores, with statistical significance set at $p<0.05$. For item-level analysis, since the data were paired and binary, the *McNemar* *test* was performed to determine the significance of changes in correct responses for each of the knowledge items. Cohen's h was used to evaluate the effect size per item, while Cohen's d was calculated to determine the practical significance of the overall improvement [21].

Ethical consideration

The study was conducted in accordance with the Declaration of Helsinki and recieved formal ethical approval from the Ethics Committee of Bali International University under certificate number 01.064/UNBI/EC/V/2024 (issued May 14, 2024). Written informed consent was obtained from parents or legal guardians of participating students. Participants were assured of the confidentiality of their responses and their right to withdraw at any stage of the study without any penalty or negative consequences. The overall study procedure is summarized in **Figure 1**.

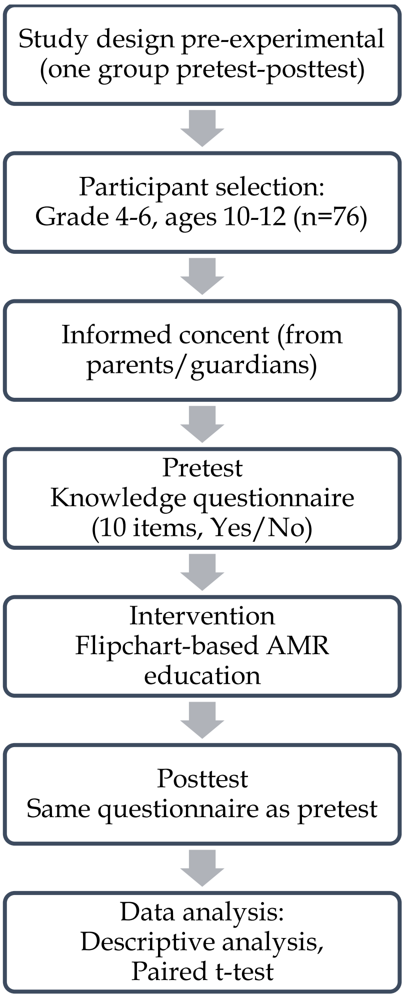

Figure 1. Flowchart of the research methodology

3. Results and Discussion

Respondents' Characteristics

A total of 76 elementary school students participated in the study. The respondents were aged 10 to 12 years and showed a relatively balanced distribution across age groups, gender, and grade levels, as presented in **Table 1**. Students aged 10 years and 12 years each accounted for 35.5% of the sample, whereas those aged 11 years represented 29.0%. The gender distribution was also relatively even, with 48.7% male students and 51.3% female students.

Table 1. Respondents' characteristics (n=76)

Characteristics	n	%
Age (years)		
10	27	35.5
11	22	29.0
12	27	35.5
Gender		
Male	37	48.7
Female	39	51.3
Grade		
4th	27	35.5
5th	22	29.0
6th	27	35.5

In terms of grade level, students from grades 4 and 6 each contributed 35.5% of the total sample, while grade 5 students accounted for 29.0%. Overall, these findings indicate that the participants represented a relatively balanced composition of upper elementary school students, which is appropriate for evaluating the educational intervention across the targeted school-age range. Because the intervention was delivered to students in grades 4–6, the respondent profile supports the relevance of the study population to the intended educational context.

Item-Level Improvement in Antibiotic Knowledge and Understanding of AMR

Improvements were observed across all knowledge domains following the intervention, as shown in **Table 2**. The largest improvement was found in students' knowledge of how to take antibiotics correctly, which increased from 25.0% before the intervention to 76.3% after the intervention ($\Delta = +51.3\%$; Cohen's $h = 1.07$), indicating a large effect. Medium effects were observed for understanding how antibiotics work ($h = 0.42$), recognition of antibiotic drug names ($h = 0.36$), knowledge of antibiotic forms ($h = 0.39$), and knowledge of how to store antibiotics correctly ($h = 0.31$). A small effect was observed for knowledge of diseases that can be treated with antibiotics ($h = 0.29$), while correct purchasing practices ($h = 0.18$) and understanding of the dangers of incorrect use ($h = 0.03$) showed only small to negligible effects. Overall, the intervention demonstrated small to large practical effects, with the strongest impact occurring in domains that had relatively low baseline knowledge.

The item-level analysis using the McNemar test further showed that the intervention significantly improved 8 out of the 10 knowledge items ($p < 0.05$). The most notable change was seen in students' understanding of how to take antibiotics correctly, whereas no statistically significant change was observed for the items on correct antibiotic purchasing and the dangers of incorrect use. The limited change in these two domains is likely related to their relatively high baseline scores, which may have reduced the room for measurable improvement after the intervention.

Table 2. Percentage of Correct Responses Before and After the Educational Intervention and Effect Size (n = 76)

No	Knowledge Item	Before (%)	After (%)	Δ (%)	McNemar (*p*-value)	Cohen's (*h*)	Interpretation Effect size
1	What are antibiotics?	73.7	86.8	+13.1	0.013	0.34	Medium
2	How do antibiotics work?	22.4	42.1	+19.7	0.004	0.42	Medium
3	What are the uses of antibiotics?	77.6	88.2	+10.6	0.039	0.30	Medium
4	What diseases can antibiotics cure?	50.0	64.5	+14.5	0.022	0.29	Small
5	What are the forms of antibiotics?	55.3	73.7	+18.4	0.006	0.39	Medium
6	Drug names that include antibiotics	30.3	47.4	+17.1	0.011	0.36	Medium
7	How to take antibiotics correctly	25.0	76.3	+51.3	<0.001	1.07	Large
8	How to buy antibiotics correctly	88.2	93.4	+5.2	0.125	0.18	Small
9	How to store antibiotics correctly	75.0	86.8	+11.8	0.021	0.31	Medium
10	Dangers of incorrect use	75.0	76.3	+1.3	1.000	0.03	Negligible

Changes in Overall Knowledge Scores

The educational intervention using a flipchart led to a substantial improvement in students' knowledge regarding antibiotics and antimicrobial resistance ($p < 0.001$). As shown in **Table 3**, knowledge levels improved substantially after the intervention. The proportion of students in the high-knowledge category increased from 19.7% to 63.8%, whereas the proportion in the low-knowledge category decreased from 21.1% to 10.5%. The paired-sample t-test further confirmed a statistically significant increase in overall knowledge scores, with the mean score rising from 58.82 ± 16.57 at pretest to 75.13 ± 18.00 at posttest. The mean Post–Pre difference was 16.32 ± 16.48 (95% CI: 12.55–20.08; $p < 0.001$), with a large practical effect size (Cohen's d = 0.99). These results demonstrate that even a single, brief intervention using age-appropriate, visually engaging material can meaningfully enhance understanding of antibiotics among primary school students.

Table 3. Changes in Knowledge Levels and Mean Scores Before and After the Intervention

A. Distribution of Knowledge Categories (n = 76)

Knowledge Level	Pre-intervention n (%)	95% CI	Post-intervention n (%)	95% CI
Low	16 (21.1)	11.8–33.0	8 (10.5)	3.9–18.5
Moderate	45 (59.2)	48.5–68.6	18 (23.7)	15.8–34.3
High	15 (19.7)	11.8–27.8	50 (63.8)	53.9–75.3

B. Comparison of Mean Knowledge Scores

Variable	Mean ± SD	95% CI	Mean Difference ± SD	95% CI	t	p-value	Cohen's d
Pretest	58.82 ± 16.57	54.73–64.72	–	–	–	–	–
Posttest	75.13 ± 18.00	70.89–77.72	–	–	–	–	–

Post–Pre Difference	–	–	16.32 ± 16.48	12.55–20.08	8.631

Figure 2 presents the comparison of students' average scores before (pretest) and after (posttest) intervention (n=76). The bar diagram clarifies the interpretation of the average value (Mean), while the vertical line shows the standard deviation (SD). A *paired t-test* showed a statistically significant increase (t=8.631; p<0.001) with a large effect size (Cohen's *d* =0.99). Posttest scores showed an overall improvement compared to pretest scores, with a decrease in scattering observed at the post-intervention assessment. These findings demonstrate a marked increase in knowledge and understanding after the intervention.

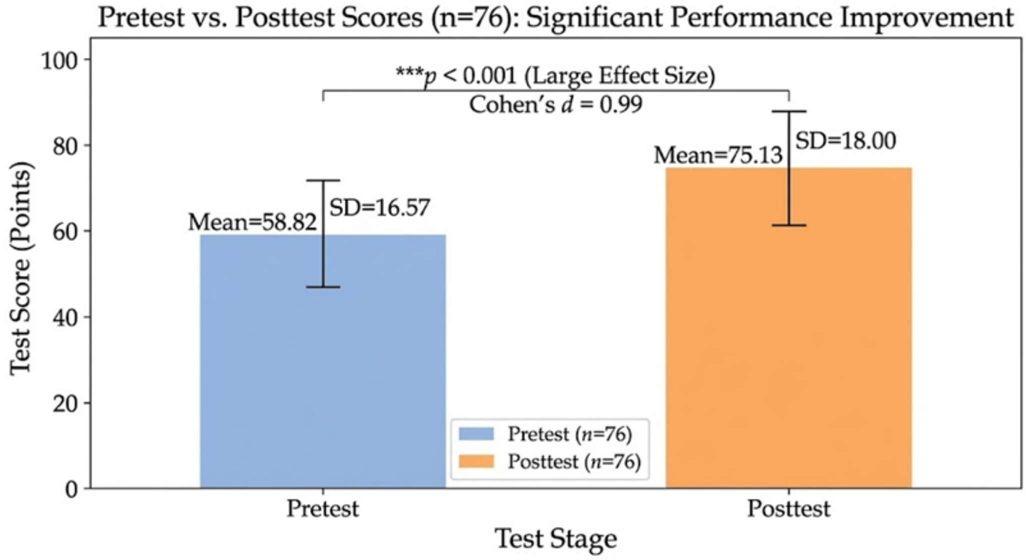

Figure 2. Comparison of students' average scores before (pretest) and after (posttest) intervention (n=76)

Improvement in Antibiotic Knowledge and AMR Understanding

This study demonstrates that a flipchart-based educational intervention can significantly improve elementary students' knowledge about antibiotics and AMR understanding. Beyond statistical improvement, the magnitude of change suggests that visually guided and cognitively tailored materials can effectively facilitate early antibiotic literacy. Such findings are particularly relevant in the context of antimicrobial stewardship (AMS), where preventive educational strategies are increasingly recognized as complementary to clinical stewardship efforts.

At baseline, most students exhibited low to moderate knowledge levels, reflecting limited exposure to structured antibiotic education. Misconceptions observed among students may partially mirror parental misunderstandings, including inappropriate use of leftover antibiotics and the belief that antibiotics are effective against viral infections, as reported in previous studies [8], [17]. These intergenerational knowledge gaps highlight the importance of early, school-based interventions as a potential entry point for broader community awareness [22].

The marked increase in high-knowledge categorization from 19.7% to 63.8% indicates that even brief, focused educational sessions can produce meaningful gains when content is adapted to the learners' cognitive level. Improvements were particularly evident in practical domains, such as correct antibiotic administration and identification, suggesting that structured visual tools may enhance applied understanding rather than mere factual recall. Strengthening applied antibiotic literacy at an early age may contribute to long-term rational medicine use behaviors and aligns with global antimicrobial stewardship strategies emphasizing public education and pharmacist involvement [23].

The most significant improvement occurred in the "How to take antibiotics correctly" domain, which showed a 51.3% increase with a large effect size (h = 1.07). This finding may be explained by the pedagogical features of the flipchart, particularly its use of visual narratives, step-by-step illustrations, and age-appropriate language, which likely helped students understand practical procedures that might otherwise seem abstract. In addition, the interactive discussion session may have reinforced comprehension by allowing students to clarify misconceptions immediately. By contrast, the "Dangers of incorrect use" domain showed only a minimal increase of 1.3%. This limited change may reflect a ceiling effect, as the baseline score for this item was already relatively high (75.0%), leaving less room for measurable improvement. It is also possible that the concept of antimicrobial resistance remains cognitively challenging for elementary school students, despite simplified educational delivery [24].

Comparison with previous studies

The findings of this study are consistent with similar school-based AMR educational interventions conducted internationally. A pharmacist-led campaign among Lebanese schoolchildren reported significant improvements in AMR awareness [25], while interactive educational strategies implemented in Jordan also demonstrated measurable knowledge gains among students [19]. These parallels suggest that structured, interactive approaches regardless of specific delivery format are effective in improving antibiotic literacy across diverse cultural contexts. Importantly, our study extends this evidence by demonstrating that low-cost visual tools such as flipcharts can achieve substantial educational impact in rural, resource-limited school settings in Indonesia. This contextual contribution is particularly relevant for countries where access to digital learning platforms may be limited.

Furthermore, feedback from teachers in this study aligns with previous reports that support the integration of AMR education into primary school curricula as part of broader national strategies [14], [26]. This aligns with previous studies, that students are more motivated to use antibiotics appropriately when they learn that misuse can result in more serious infections, limited treatment options, prolonged hospitalizations, or more complex health issues [25], [27].

Educational and policy implications

Early education represents an important yet underutilized component of national and global AMR strategies. Indonesia's National Action Plan on AMR (2020–2024) adopts a multisectoral "One Health" framework but provides limited operational emphasis on structured child-targeted educational programs [16]. The present findings suggest that simple, low-cost, visually guided interventions may help address this gap and could be considered for integration into broader school-based health promotion initiatives. The use of structured visual tools such as flipcharts may facilitate the delivery of complex topics, including antibiotic use and AMR, in a manner appropriate to elementary-level cognitive development. Such tools may also support educators in conveying essential health messages without requiring extensive specialized medical training. These observations align with previous studies demonstrating that developmentally tailored educational materials enhance comprehension and retention among school-aged children [19], [26]. Consistent with prior reports indicating that games, videos, and booklets can improve knowledge outcomes [28], [29], the present findings reinforce the value of interactive and accessible educational formats in AMR awareness programs.

This study has several limitations. First, the use of a pre-experimental one-group design without a control group limits the ability to attribute improvements solely to the intervention, as external influences cannot be fully ruled out. Second, the sample size was relatively small and drawn from a single rural school, limiting the generalizability of the findings to other regions or populations. Third, the study focused only on immediate knowledge gains; it did not assess whether knowledge was retained over time or translated into behavioral change. Finally, although the flipchart content was reviewed by a psychologist, no formal cognitive testing was conducted to ensure comprehension across different age subgroups.

Despite these limitations, the findings provide preliminary evidence supporting the feasibility of structured, school-based AMR education. Further studies employing controlled designs, larger and more diverse samples, and longitudinal follow-up are warranted to strengthen the evidence base and inform community-oriented antimicrobial stewardship strategies.

4. Conclusion

This study demonstrates that a structured, flipchart-based educational intervention is an effective and practical tool for improving antibiotic knowledge and AMR understanding among elementary school students in rural settings. The significant increase in post-intervention scores highlights the feasibility of using simple, age-appropriate visual media to enhance early health literacy. These findings suggest that integrating such interventions into primary education could serve as a preliminary step toward broader community-oriented awareness. By fostering individual understanding at an early age, these school-based approaches may provide a foundational support for future antimicrobial stewardship initiatives within underserved communities.

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Conflict of Interest:

The authors declare no conflict of interest related to this study.

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