



Collaborative learning to increase preventive attitude of elementary school children towards rabies: Potential implication for reducing the economic burden

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ABSTRACT

Background: Rabies remains a significant public health issue, causing substantial economic and social losses, with children being the most vulnerable group. This study aims to analyze the effectiveness of the Collaborative Learning Method in improving primary school children's preventive attitudes towards rabies risk and management, and to identify its potential impact on mitigating the economic burden. **Methods:** The design of this research used a quasi-experiment with pre-test and post-test. The intervention group used collaborative learning, while the control group followed the lecture method. The instrument was a structured questionnaire, validated by Pearson correlation and reliability tested with Alpha-Cronbach. Data was collected from interviewed elementary students in the Dompu and Woja sub-districts, Dompu District. The intervention group included 57 students, while the control group had 49. Pre-tests were conducted before the intervention, and post-tests were conducted three times: on the same day, one week, and one month after the intervention. The outcome data were analyzed using a chi-square test, an independent sample t-test, and Hake's formula. **Findings:** The collaborative method was found to be effective (n-gain score ≥ 0.7) in increasing attitudes than the lecture method. This improvement in cautious attitude and proper response capability (like wound washing) driven by collaborative learning is positively linked to reducing bite incidents and the cost of Anti-Rabies Vaccine (ARV), a key burden on regional health budgets. **Conclusion:** This finding suggests that investing in education focused on attitude modification is an effective and economic strategy under the One Health approach for controlling rabies. **Novelty/Originality of this article:** As the first in-depth study, this research applied and evaluated a specific Collaborative Learning method to modify the preventive attitudes of primary students against rabies in Dompu Regency, an endemic area in Indonesia. The findings yield a localized best-practice model for educational intervention.

KEYWORDS: collaborative learning; economic burden; elementary children; knowledge; preventive attitude; rabies.

1. Introduction

Rabies is a fatal zoonotic disease that remains a serious global public health challenge. This disease brings a substantial burden of loss, not only in terms of human morbidity and mortality, but also affecting the social and economic stability of endemic countries (Hampson et al., 2015; Thichumpa et al., 2025). Based on recent studies, the global economic

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loss due to rabies is estimated to reach USD 8.6 billion annually, which, when converted to Indonesian currency, can exceed Rp 129 trillion (Selleck et al., 2024; Hardianti et al., 2025). This loss is comprehensive, encompassing the direct costs of expensive post-exposure prophylaxis (PEP) or Anti-Rabies Vaccine (ARV) treatment, veterinary surveillance costs, and the largest indirect costs in the form of lost potential income due to early death and the burden of disability-adjusted life years (DALYs) (Ranaweera et al., 2021; Ayesha et al., 2025).

Children under 15 years old represent the most susceptible demographic, contributing to nearly 40–50% of all human rabies fatalities, mostly in rural regions of Asia and Africa (World Health Organization, 2024). Mostly, it is caused by interaction with rabies-transmitting animals (RTAs) without being monitored by parents, particularly domestic dogs, compounded by inadequate knowledge and poor preventive attitudes (Mustiana et al., 2015; Janeaim et al., 2024). There is a lack of public awareness, especially among students, regarding the clinical signs of rabid dogs, bite risks, and proper immediate care. It directly impacted the continued economic burden (Dilbato et al., 2025).

Indonesia is one of the countries affected by rabies and has not yet succeeded in eliminating the disease (Budayanti, 2020). In Indonesia, dogs are the main animals responsible for transmitting rabies, with an estimated average of 82,634 dog-bite cases reported up to 2023 (Ministry of Health of the Republic of Indonesia, 2023). The first rabies case in Indonesia was recorded in West Java and was continued reported on other islands, including Sumbawa Island in West Nusa Tenggara (Putra et al., 2013; Ministry of Agriculture of the Republic of Indonesia, 2019; Nurjumatun et al., 2023). West Nusa Tenggara was historically considered rabies-free. However, in 2019, the first rabies case was reported in Dompu Regency, located on Sumbawa Island (Ministry of Agriculture of the Republic of Indonesia, 2019). According to the Dompu Regency Health Office Report (2023), a total of 3,493 dog-bite cases were recorded between 2019 and 2023, many involving children under 15 years of age.

Limited knowledge of rabies among children increases their vulnerability to dog-bite incidents. Furthermore, insufficient awareness of stray dogs as potential rabies vectors in school and residential environments contributes to the rising incidence of dog bites (Aung et al., 2021). Children may also underreport dog-bite events due to fear of parental reprimand or inadequate understanding of the associated health risks. This underscores the importance of systematically involving children in rabies prevention and control initiatives (Angeline et al., 2020).

Communication, information, and education represent a key strategic framework for strengthening public knowledge and awareness regarding rabies (Ministry of Agriculture of the Republic of Indonesia, 2019; Li et al., 2021). The effectiveness of rabies education is closely linked to its alignment with local social and cultural contexts, ensuring that educational communications are appropriately conveyed and accepted across diverse community groups (Budayanti, 2020). Educational strategies for rabies prevention generally differ between adult and pediatric populations, reflecting variations in cognitive development and learning needs (Kustiningsih et al., 2023). Although multiple rabies education interventions targeting children have been implemented in rabies-endemic countries such as a one-hour educational intervention for elementary school children in Sikkim, India (Auplish et al., 2017), rabies education information sessions via SMS in China (Wu et al., 2016), an “edutainment” campaign for elementary school students in Srilanka (Kanda et al., 2015), the development of rabies-related health promotion media in Bogor, Indonesia using posters and leaflets (Utomo et al., 2018), and rabies education in private elementary schools in Davao City, Philippines using brochures and videos (Lachica et al., 2021), and rabies education for elementary school students using a game involving hunting rabies-transmitting animals was implemented in Sarawak, Malaysia (Halim et al., 2021). However, that implementation continues to rely on facilitator-centered approaches, which may constrain participant engagement and limit sustained knowledge retention.

Collaborative learning is a learner-centered approach in which students learn together, sharing knowledge and experiences (Kustiningsih et al., 2023). Its implementation

integrates several instructional strategies, including a problem-based learning approach (Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia, 2023). This approach promotes social interaction, communication, joint problem-solving, and the development of social skills (Kouhsarian et al., 2023). Therefore, this study applies a collaborative learning method combined with a problem-based learning approach, tailored to elementary school learning processes, to enhance students' memory retention and understanding of rabies, thereby encouraging greater awareness and vigilance regarding rabies incidents. Therefore, an intervention strategy focused on and attitude formation is estimated to be an essential support and the most cost-effective approach within the One Health framework to achieve elimination (World Health Organization, 2024; Thichumpa et al., 2025). The hypothesis of this research is that the implementation of the Collaborative Learning Method will be significantly more effective than conventional methods in improving the preventive and responsive attitudes of elementary school children toward rabies. The successful shift in attitude is expected to have economic implications by reducing both the risk of exposure and the subsequent need for Post-Exposure Prophylaxis (PEP) or Anti-Rabies Vaccine (ARV), thereby directly impacting the reduction of rabies-related health expenditures (Carmo & Machado, 2021). Consequently, this study aims to analyze the post-intervention improvement in student attitudes and utilize these findings as the basis for policy recommendations toward effective rabies elimination strategies in Indonesia to decrease economic burden caused by rabies.

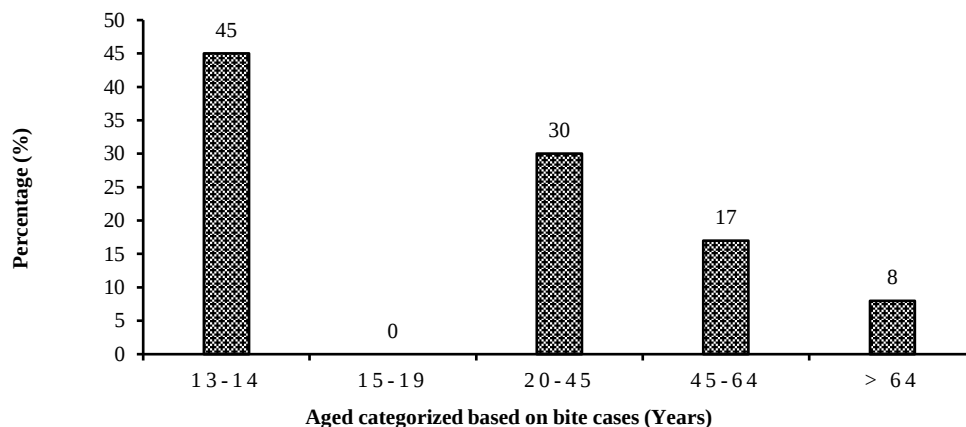


Fig. 1. Percentage of bite cases by age in Dompu Regency 2019-2023 (Dompu Regency Health Office, 2023)

2. Methods

2.1 Ethical approval

The study was conducted in accordance with established ethical standards for research involving human participants. The study received ethical approval from the Human Research Ethics Committee of Institut Pertanian Bogor under approval number 1151/IT3.KEPMSM-IPB/SK/2024. Informed consent was obtained from all participants prior to their involvement in the study, and confidentiality of the collected data was strictly maintained throughout the research process.

2.2. Study design

The design of this research was a quasi-experiment with a pre-test and post-test (Harris et al., 2006). Quasi-experiment is a method employed to implement a particular approach or teaching method in a classroom with respondents selected conveniently (already naturally formed). The process of assigning respondents was conducted non-randomly (non-random assignment). A pre-test was conducted before the intervention to

measure student's baseline attitude about rabies. Intervention in the study group used the collaborative learning method, and the control group used the lecture method. The post-test was conducted thrice on the same day after intervention (post-test-1), one week later (post-test-2), and one month later (post-test-3) after the intervention. The intervention was implemented using the collaborative learning method, which provided an opportunity for students to discuss information about rabies with their groups. The results of the discussion were written and drawn on student worksheets. Next, each group presented its work to the other groups. In addition, in the control group, the lecture method was conducted face-to-face with students, with the facilitator focused on them. The rabies material was presented as slides as supporting media for learning and ended with a question-and-answer session.

2.3 Sampling procedure

This study was conducted from February to April 2024 in Public Elementary Schools in Dompu and Woja Subdistrict, Dompu Regency, Nusa Tenggara Barat Province, Indonesia. The study sites were determined by purposive sampling (Swedberg et al., 2022). Study sites were selected using purposive sampling to ensure inclusion of public elementary schools located in areas with the highest reported dog-bite incidence. Four schools were selected, two in Dompu Subdistrict and two in Woja Subdistrict. To minimize contamination between groups, allocation was conducted at the school level rather than the individual level: one school in each subdistrict was assigned to the collaborative learning intervention and the other to the lecture-based control condition. It was also influenced by the considerable distance between schools, which led to the selection of schools located in areas with the highest reported incidence of dog-bite cases.

All 5th and 6th grade students in the selected schools who met inclusion criteria were invited to participate, resulting in 57 students in the intervention group and 49 students in the control group. It was in public elementary schools with the most dog bite cases. Four schools were selected for the study, two in the Dompu sub-district and two in the Woja sub-district, each with one treatment and one control school. Respondents were all 5th and 6th-grade students in the four schools, which consisted of 57 intervention group students and 49 control group students. The number of participants reflected the actual student population enrolled in grades 5 and 6 at each selected school. Schools within the study area generally have relatively small student populations. Additionally, student absence on the days of data collection contributed to variations in participation.

2.4 Data collection and analysis

Data were collected using a structured questionnaire that students completed during the pre-test and post-test. Before being used, the questionnaire was tested on 30 elementary school students to assess its validity and reliability. The validity and reliability of the questionnaire were analyzed using Pearson correlation and Cronbach's Alpha. The questionnaire was considered valid if the correlation coefficient between each item and the total score was greater than 0.3. It was considered reliable if the Cronbach's alpha value exceeded 0.70. Validity and reliability tests were conducted to ensure that the questionnaire produced consistent and stable results and did not vary across different measurement times (Swedberg et al., 2022). Students' attitude encompasses their opinions or beliefs related to first aid following a bite, scratch, or lick by a suspected rabid animal (dog), information concerning rabies prevention through vaccination, and information on proper dog care. Subsequently, the results of the pre-test and post-test were utilized to evaluate the effectiveness of the learning methods employed in the rabies education. The attitude questionnaire utilized a Likert scale with four response options: 'strongly agree' assigned a score of 4, 'agree' a score of 3, 'disagree' a score of 2, and 'strongly disagree' a score of 1. The data presented focuses only on 'agree' and 'disagree', where scores of 3 and 4 were aggregated as 'agree', and scores of 1 and 2 were aggregated as 'disagree'. The assessment

of the attitude levels of elementary school students was interpreted using a qualitative scale, namely negative, neutral, and positive (Wicaksono et al., 2017; Suherman et al., 2023).

The improvement in elementary school students' rabies-related attitude scores was analyzed using an independent samples t-test with a 95% confidence interval. The association between students' characteristics and rabies knowledge scores was analyzed using chi-square (Petrie & Watson, 2013). The effectiveness of the learning method in improving students' rabies-related knowledge scores was analyzed using Hake's formula based on the normalized gain (n-gain) score (Nisa et al., 2022). The n-gain score is calculated as the ratio between the knowledge improvement score and the difference between the ideal score (total score from correct answers=100) minus the attitude pre-test score. The assessment of the learning method's effectiveness was divided into three categories: effective, moderately effective, and not effective. The method was categorized as effective if the n-gain score was greater than 0.7. It was categorized as moderately effective if the n-gain score was between 0.3 and 0.7. Last, it was categorized as not effective, if the n-gain score was less than 0.3 (Nisa et al., 2022)."

3. Results and Discussion

Rabies is a neglected disease that urgently needs to be controlled. Globally, 99% of rabies cases are caused by dogs (World Health Organization, 2024). It is fatal for victims who received treatment at the wrong time (Budayanti, 2020). Rabies can be prevented through dog vaccination, but public awareness is still low, causing rabies cases in the world to remain high, especially in children less than 15 years old (Global Alliance for Rabies Control, 2023). Improving children's knowledge about rabies influences their positive attitude to realize that rabies is a dangerous disease, but it can be prevented through rabies education (Hardianti et al., 2025).

Elementary school children are considered a vulnerable age group for dog-bite incidents, so appropriate positive actions can help accelerate proper response and management. Many children fail to report dog-bite incidents because they fear being scolded by their parents or lack awareness of the potential consequences (Angeline et al., 2020). In addition, children often ignore wounds after a dog bite because they perceive them as minor injuries. Responses from elementary school students in Dompu to attitude statements regarding what to do when chased by a dog showed that most students agreed that running away is the correct action. However, the appropriate response should be disagreement. Dogs infected with rabies are easily provoked by moving objects; therefore, the recommended action is to remain still, stay calm, and minimize movement (Global Alliance for Rabies Control, 2023). Regarding preventive behavior, students agreed that avoiding dog bites involves not disturbing dogs — for example, not throwing objects at them, not interfering while they are eating, and not disturbing a mother dog while she is with her puppies.

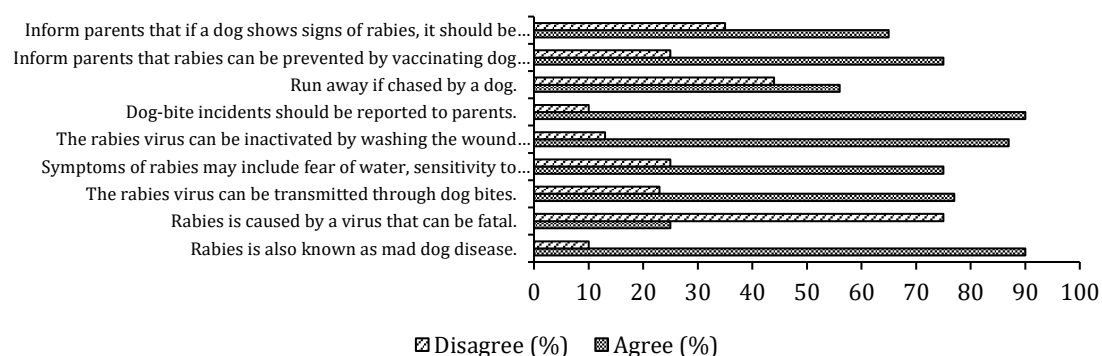


Fig. 2. The percentage of elementary school students' responses to attitude statements about rabies

Most students believed that if bitten by a dog, the wound should be washed immediately with running water and soap for 15 minutes, followed by reporting the incident to parents, teachers, and healthcare providers at the nearest clinic or hospital. However, only some students understood and believed that routine dog vaccination can prevent rabies transmission. Students also believed that proper dog care includes providing sufficient food and water and keeping dogs confined in a kennel or secured with a long leash. Students' agreement and disagreement responses to rabies-related attitude statements are presented in Fig. 2.

3.1 Preventive attitude score and its association with children's sociodemographic

Attitude creates an opinion and belief toward specific information received (Kondrotienė et al., 2024). Knowledge can be defined as actual experience stored in human awareness, thereby influencing attitude in responding to information or activities in their environments (Hanna et al., 2023). Student characteristics, sociodemographic, not only affect the level of student knowledge but also influence their attitude. According to Dilbato et al. (2025), good knowledge causes a positive attitude response from respondents, manifested as opinions and statements of agreement towards given information. Efforts to improve knowledge and attitude can be pursued through counseling or via education and training (Suherman, 2023). Li et al. (2021) reported that education is a factor that highly influences an individual's knowledge due to having longer learning opportunities. The higher level of knowledge influences an individual's attitude and actions. Rabies control can also be enhanced through multisectoral collaboration, mass dog vaccination, surveillance, and awareness campaigns, especially targeting children under 15 years old to improve their knowledge and attitude regarding rabies (Lungten et al., 2021; Ghimire et al., 2025).

The characteristic of students that showed a significant association with student attitude was the experience of accessing rabies information, whereas other characteristics, such as dog ownership, the number of dogs owned, and the purpose of dog ownership, showed no significant relationship with student attitude (Table 1). This is attributed to students' experience of receiving substantial information from parents or teachers, as well as directly observing the condition of suspected rabid dogs in their vicinity, consequently influencing their attitude toward rabies. It processes may influenced by several internal factors, such as education, occupation, and age, and external factors like environment and culture (Hanna et al., 2023). An individual's motivation to adopt a positive or negative attitude and their opinion toward an object are significantly influenced by their experience or knowledge (Suherman et al., 2023).

Table 1. Association between attitude and sociodemographic characteristics

		Attitude categorized (n=106)				p-value
Characteristic	Category	Positive		Neutral + Negative		
		n	%	n	%	
Gender	Male	44	83.0	9	17.0	0.071
	Female	36	32.1	17	67.9	
Father's Occupation	Farmer	57	75	19	25	0.857
	Other	23	23.3	7	76.7	
Dog Ownership	Yes	8	38.5	5	61.5	0.299
	No	72	77.4	21	22.6	
Number of dogs owned	1-5 dogs	8	38.5	5	61.5	0.299
	None	72	77.4	21	22.6	
Purpose of keeping dogs	Garden/House Guard	8	38.5	5	61.5	0.299
	Don't know	72	77.4	21	22.6	
Experience accessing rabies information	Yes	74	78.7	20	23.1	0.029*
	No	6	50.0	6	50.0	
Rabies information source	Parents/teacher	52	49.8	14	16.2	0.355
	Other	28	30.2	12	9.8	

3.2 The attitude of elementary school student

The attitude scores of elementary school students in both the intervention and control groups increased on the same day (Day 0), one week later (Day 7), and one month later (Day 30) after the intervention. These results indicate that the application of both collaborative learning and lecture methods can improve students' positive attitudes regarding rabies (Table 2). This likely occurred due to students' interest in interacting with other students, thereby creating a condition of shared learning information. Furthermore, the direct interaction and observation of the condition or presence of dogs as Rabies Transmitting Animals (RTAs) directly around the community's settlements enhanced their cautious attitude toward rabies. The Collaborative Intervention Group demonstrated a significantly higher and more sustained increase in attitude scores compared to the Lecture Control Group from T1 to T3. This suggests that the collaborative methodology is not only higher in immediate attitude improvement but also in promoting long-term attitude retention.

The information on table 2 shown that the collaborative learning promotes peer-to-peer interaction and collective responsibility (Afriani et al., 2025). In the context of rabies education, students are encouraged to discuss not only facts (knowledge), but also how they should behave (preventive) and act (responsive) (Sarifah & Hanif, 2025). This process allows students to internalize the values of caution and care through group consensus, rather than simply passive reception (Zhang & Ma, 2023). The significant difference between the Post-test 7 days (T2) and 30 days (T3) shows that attitudes formed through the collaborative method are more stable and less likely to be lost compared to the lecture method. This mechanism is crucial for health issues like rabies, where behavioral consistency (e.g., always washing a bite wound) determines the clinical outcome. The success of this attitude retention is a major added value of the collaborative method in health education (Fakoya et al., 2023).

Individual improvements in knowledge and attitudes depend on the capacity to retain information over the long term. According to Chen & Yang (2020), memory enhancement is influenced by exposure, where visual presentation of material combined with repeated reinforcement tends to improve comprehension, retention, and awareness. Knowledge serves as a key factor in strengthening vigilance toward rabies, and knowledge scores generally increase with greater access to education and information (Li et al., 2021). Angeline et al. (2020) reported that several studies have successfully improved children's knowledge through awareness campaigns. Consistent with these findings, the mean rabies-related knowledge scores of elementary school students in Dompu increased following both intervention methods implemented in this study, namely collaborative learning and lecture-based instruction.

Tale 2. The improvement attitude score of elementary study after rabies educational approach

Variable	Mean $\pm$ SD	t-value (CI 95%)	p-value
T0: Pre-test			
Intervention score (n = 57)	0	0	NA
Control score (n = 49)	0		
T1: Post-test-1			
Intervention score (n = 57)	15.63 $\pm$ 16.50	9.18 (3.65 – 14.71)	0.001*
Control score (n = 49)	6.45 $\pm$ 11.26		
T2: Post-test-2			
Intervention score (n = 57)	16.68 $\pm$ 18.25	9.41 (3.41 – 15.41)	0.002*
Control score (n = 49)	7.27 $\pm$ 11.57		
T3: Post-test-3			
Intervention score (n = 57)	17.11 $\pm$ 17.90	9.98 (4.32 – 15.64)	0.001*
Control score (n = 49)	7.12 $\pm$ 11.06		

Note: SD = Standard Deviation; (*) indicates a significant difference in mean ($p < 0.05$).

The Collaborative Learning Method achieved an average N-Gain score of 0.73, placing it in the Effective category (above the 0.70 threshold). This determines that the method successfully brought students closer to the ideal attitude transformation. The Lecture Method achieved an average N-Gain score of 0.38, which is categorized as Moderately Effective. It confirms that the Collaborative Learning Method is significantly effective in modifying students' preventive attitudes compared to the Lecture Method (Table 3).

Collaborative learning is a learner-centered instructional approach (Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia, 2023). This method increases participant engagement in understanding information, and learners who possess foundational knowledge tend to demonstrate more significant learning outcomes (Kustiningsih et al., 2023). Based on field simulations, Mustafa-Kamal et al. (2022) applied a problem-based learning approach in health education using a One Health framework and reported positive improvements in students' learning experiences. This approach facilitates interaction among students (Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia, 2023).

The observed increase in elementary school students' attitude scores indicates that collaborative learning encourages students to actively explore additional information sources, thereby strengthening their understanding of rabies. Moreover, students remained continuously exposed to rabies-related information because their group work was displayed on classroom walls as learning media, supporting memory retention and comprehension. Utomo et al. (2018) reported that the use of media in rabies education creates learning situations that closely resemble real-life contexts for the target audience. Xie & Deng (2023) found that children who engage in drawing and are repeatedly exposed to learned information show increased learning motivation and significantly improved memory retention. Integrating health education into the elementary school curriculum can enhance children's health awareness, promote healthier habits, and encourage the adoption of recommended health practices (Xin et al., 2022). Hamidah et al. (2020) further noted that collaborative learning emphasizes topics directly connected to real-life environmental conditions.

Rabies education delivered through lecture-based instruction also improved elementary students' knowledge scores. The lecture method was selected as the control condition because it is widely used in educational settings, including rabies education. Manoharan et al. (2023) reported increased rabies knowledge scores following a 30-minute audiovisual lecture intervention covering rabies epidemiology, clinical presentation, prophylaxis, management, and program guidelines, followed by a 30-minute short film. Similarly, Kanda et al. (2015) and Utomo et al. (2018) observed improvements in elementary students' rabies-related knowledge through lecture-based health promotion. However, this method has limitations, as students tend to assume a passive role, and the material delivered may be less effectively retained in long-term memory.

Table 3. Effectiveness of the method

Category	Intervention group	Control group
N-gain score	0.73	0.38
Effectivity categorized	Effective	Moderately effective
p-value	P<0.001	P<0.001

The level of knowledge of adults and children differs, and the way they respond to an object is also different. Children under the age of 15 tend to be easily receptive to information because their brains are in the process of development (Stephanie et al., 2016). In addition, at this age, children are in the concrete operational stage, meaning they have the ability to receive information quickly and store it in long-term memory (Hasan, 2021). Memory types are divided into two: short-term memory and long-term memory. Short-term memory is relatively brief and limited; information will be lost within 20-30 seconds if it is not constantly repeated. In contrast, long-term memory is a place for permanent information storage, and many things can be retained in this memory for a long time. This

memory has unlimited capacity and can hold information for a longer duration, but often requires hard effort to encode information into it (Kalat, 2009; Sthepanie et al., 2016; Hasan, 2021). The increase in an individual's knowledge and attitude depends on their ability to store information for the long term. Chen & Yang (2020) presented research findings showing that memory increases based on exposure (visual presentation of material). This continuous increase occurs under similar conditions for both short-term memory performance and long-term memory at intervals of 10 minutes and 1 day. Therefore, an elaborative strategy of presenting information visually and repeatedly can enhance individual memory. Children's knowledge regarding rabies control is crucial for the formation of an appropriate action (World Health Organization, 2024). Teaching about infectious diseases like rabies in the elementary school curriculum can increase knowledge (Al-Musthopa et al., 2022; Carlino, 2023). Knowledge can influence a child's awareness of rabies occurrences in their environment (Lungten et al., 2021). Knowledge also significantly affects a child's actions in communicating and conveying information about rabies to playmates, family, or the community in their surroundings (Laorujisawat et al., 2022).

3.2 Economic potential implications of attitude improvement

Fig. 1. Illustrates the distribution of elementary school students' responses to rabies-related attitude statements. A high proportion of students agreed with key statements concerning rabies transmission, first-aid measures, and reporting of dog-bite incidents, indicating strong awareness of essential preventive behaviors. However, variability in responses related to situational safety and vaccination awareness suggests areas requiring continued educational reinforcement. From a public health perspective, improved student attitudes toward rabies prevention may contribute to earlier wound management, increased reporting, and stronger support for dog vaccination practices. Collectively, these behaviors have the potential to reduce healthcare expenditures associated with post-exposure treatment, minimize productivity losses, and alleviate the broader economic burden of rabies control at the community level.

The mean improvement in rabies-related attitude scores among elementary school students following the intervention shown in Table 2 and Fig. 3. At baseline, no improvement was observed in either group. After implementation of the educational interventions, both groups demonstrated increases in attitude scores across all post-test measurements; however, the magnitude and persistence of improvement differed between instructional approaches. Students in the collaborative learning group exhibited a substantial and progressive increase in mean attitude scores, rising from 15.63 at post-test-1 to 16.68 at post-test-2 and 17.11 at post-test-3. This pattern indicates sustained reinforcement of positive attitudes over time. In comparison, the lecture-based control group showed more modest gains, with mean improvements of 6.45, 7.27, and 7.12 at post-test-1, post-test-2, and post-test-3, respectively. Although improvements were observed in both groups, the collaborative learning intervention consistently produced higher mean gains across all follow-up assessments.

The sustained improvement observed in the collaborative learning group suggests stronger retention of rabies-related preventive attitudes, which may translate into safer behavioral practices, earlier reporting of dog-bite incidents, and appropriate first-aid responses. From a broader public health perspective, such behavioral reinforcement has the potential to reduce the incidence and severity of rabies exposure. Consequently, improved preventive attitudes may contribute to lowering healthcare expenditures associated with post-exposure treatment, minimizing productivity losses within affected households, and reducing the economic burden of rabies control efforts at the community level.

The implementation of the Collaborative Learning Method successfully increased the preventive attitude of elementary school students in Dompu significantly and stably over a 30-day period. This method was measured by the Effective category (N-Gain = 0.73), demonstrates that an approach based on interaction and shared responsibility is highly

effective in introducing health behaviors. This change in attitude functions as a preventive investment that reduces the risk of rabies transmission, which ultimately suppresses public health expenditures for high ARV treatment costs, making it a cost-effective elimination strategy. The collaborative method is higher in facilitating change in the affective domain, which includes attitudes and values, compared to the unidirectional information transfer method (Boke et al., 2025; Nguyen & Oanh, 2025).

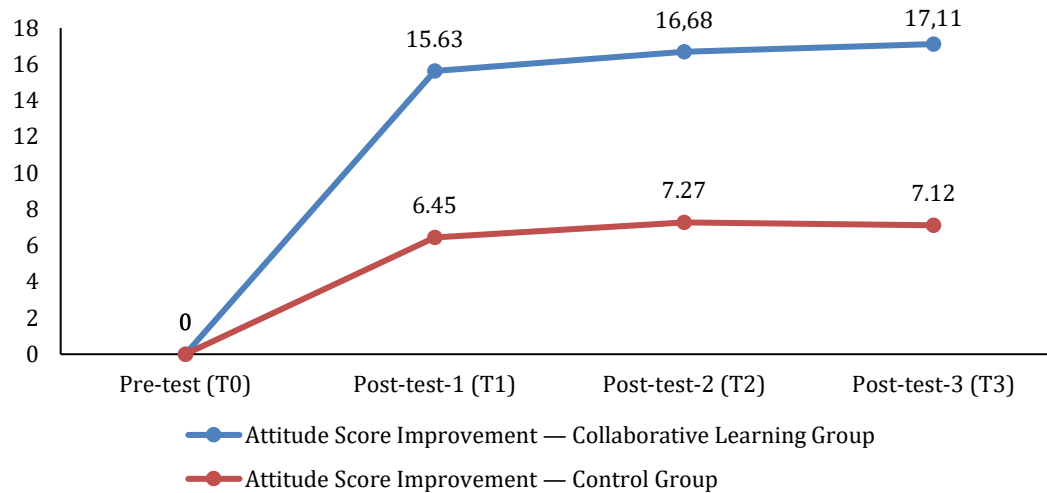


Fig. 3. Improvement in rabies-related attitude scores among primary school students in Dompu Regency following the intervention

The successful attitude transformation measured in this study has a direct impact on the economic issues posed by rabies. Rabies is known for its high-cost burden, particularly the expense of PEP/ARV management. Current global elimination strategies strongly emphasize cost-effective preventive investments (World Health Organization, 2024). Rabies incurs substantial annual global economic losses (Selleck et al., 2024). The cost of ARV treatment constitutes a significant component of public health expenditure (Ayesha et al., 2025). The improvement in students' Responsive Attitude toward first aid (washing the bite wound with soap and running water for 15 minutes) is key to risk mitigation. This improvement in attitude can clinically inactivate the rabies virus at the wound site, which, for low-risk bite categories, can eliminate the need for ARV injection (World Health Organization, 2024). Economically, a reduction in cases requiring ARV means a reduction in direct costs borne by the regional/national budget (Carmo & Machado, 2021; Ranaweera et al., 2021). The success of the collaborative method in instilling this attitude in Dompu represents a form of cost-effective preventive investment that must be considered in health fiscal policy.

The increase in students' awareness Attitude (avoiding and recognizing RTAs) contributes to a reduction in bite incidence (Janeaim et al., 2024). The decrease in bite incidence not only reduces treatment costs but also supports the achievement of the global rabies elimination target, Zero by 2030 (World Health Organization, 2024). Rabies fatalities primarily occur in children. Preventing premature death at this age means saving Disability-Adjusted Life Years (DALYs) and potential human resources, which represent the largest indirect economic loss due to zoonoses (Hampson et al., 2015; Thichumpa et al., 2025). Therefore, investing in attitude education through collaborative methods is an intervention with a high socio-economic impact.

4. Conclusions

Collaborative learning was proved to be an effective and low-cost strategy for strengthening rabies-related preventive attitudes among elementary school children. The sustained attitude improvements observed in this study support safer behavioral

responses, early reporting, and appropriate first-aid practices, all of which are essential for reducing rabies exposure risk. From a public health and economic perspective, these preventive behaviors have the potential to decrease reliance on post-exposure prophylaxis and other costly medical interventions, thereby mitigating the financial burden on both households and the healthcare system. The findings reinforce the role of education and community awareness as critical components of the One Health framework, highlighting school-based rabies education as a cost-effective pillar of integrated rabies control (Boke et al., 2025).

These results provide practical policy implications for the Dompu Regency Government, including the integration of collaborative learning into elementary school rabies education curricula in endemic areas, continued support for community-based preparedness initiatives such as the *kader siaga rabies* (KASIRA) program, and alignment of educational investments with mass dog vaccination campaigns to promote sustainable rabies elimination consistent with national goals. Nevertheless, this study is subject to limitations inherent to quasi-experimental designs, including restricted control over potential confounding variables. In addition, the reliance on self-reported data from children introduces the potential for social desirability bias, students may have selected 'Strongly Agree' for preventive measures because they recognized them as the socially 'correct' answers. Additionally, the one-month follow-up duration limits our ability to conclude whether these attitude changes are permanent. While collaborative learning significantly improved 30-day retention compared to the lecture group, further longitudinal studies are required to determine the decay rate of these attitudes over a longer period for example in one year (6-12 months). Overall, the projected economic benefits described here are theoretical and based on risk mitigation potential rather than direct cost measurements. Future research should quantify actual reductions in post-exposure prophylaxis expenditures following systematic educational implementation and explore technology-enhanced collaborative learning platforms to extend program reach, efficiency, and long-term impact.

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Author Contribution

NHH: Project conceptualization, project administration, data curation, formal analysis, writing original drafts, review, and editing. ESS: Proficient supervisor and expert in conceptualization, data curation, formal analysis, writing original drafts, review, and editing. DWL: Proficient supervisor and contributor in conceptualization, writing original drafts, reviewing, and editing.

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Ethical Review Board Statement

The ethical clearance of this study was established by the Human Research Ethics Committee of IPB University with reference number 1151/IT3.KEPMSM-IPB/SK/2024.

Informed Consent Statement

Informed consent was obtained from participants involved in the study, including publishing data in this paper.

Data Availability Statement

Data related to this research is available to access.

Conflicts of Interest

The authors declare no conflict of interest.

Declaration of Generative AI Use

During the preparation of this work, the authors used Google's Gemini and Grammarly models to assist in refining the clarity, grammar, and overall academic tone of the manuscript, and to structure arguments more cohesively. After using this tool, the authors reviewed and edited the content as needed and took full responsibility for the content of the publication.

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