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# Effects of a school-based programme on learners' rabies awareness in Machakos, Kenya

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## Abstract

Rabies is a fatal zoonotic disease causing an estimated 59000 annual human deaths globally and approximately 523 in Kenya, with children disproportionately affected. Despite evidence that school-based educational interventions effectively increase rabies awareness and prevention among children, its implementation in Kenya is limited. This study aimed at utilizing an education programme to increase rabies awareness among primary school learners and evaluate their knowledge uptake. A quasi-experimental study was conducted among 210 learners from four primary schools (two urban, two rural). Pre-tested questionnaires assessed rabies awareness before and after rabies training sessions. Differences between urban and rural schools were assessed using $\chi^2$ tests, while Wilcoxon signed-rank test was used for pre- and post-training scores. Post-training, overall knowledge scores improved from 6.14 to 7.61($p < 0.001$), with significant increase in learners' knowledge on rabies transmission, zoonosis, and the importance of annual dog vaccination. Attitudes and perceptions improved from 3.23 to 4.03 ($p < 0.001$), particularly health-seeking behaviour and reporting post dog bite. In conclusion, school-based rabies education significantly improved learners' awareness. Being the first report of such intervention in Kenya, it could serve as a model for other zoonoses.

## Introduction

Rabies is a zoonotic viral disease of serious public health importance due to its high fatality rate. Globally, human mortality from canine rabies is estimated to be 59000 deaths per year with 56% of these deaths in Asia and 44% in Africa in 2018 [1]. It is among the top five priority zoonoses in Kenya estimated to cause 523 (95% CI 134, 1100) deaths annually [2]. Rabies is mainly transmitted to humans through animal bites or scratches, particularly from dogs, with children under 15 years being at higher risk [3, 4].

Rabies is preventable through various strategies such as dog population management, community education, dog vaccination, rabies surveillance, and proper food waste management [1, 5]. Awareness campaigns and public education have been fronted as the most cost-effective methods of preventing the disease among children [6]. However, such campaigns targeting children in Kenya have been limited. The low awareness of rabies and its preventive healthcare in endemic areas has been associated with poor health outcomes such as increased mortality among the victims due to their poor health-seeking behaviour [3, 7].

Incorporation of rabies education in a school set-up has been shown to substantially increase the children's knowledge of the disease and how to be safe around dogs and prevent dog bites, hence rabies [6]. A few studies conducted in different countries have used varying approaches for rabies education such as one-hour educational intervention for school children [8], a curriculum integration programme for elementary school children, and rabies education information sessions [5]. These approaches have been shown to improve the control of rabies [9]. Interestingly, despite the review by Ngugi et al. [4] indicating that there is a high incidence of dog bites among school children, there is still limited education on the disease within the Kenyan school curriculum.

This study, therefore, aimed at utilizing an educational training programme for primary school learners in Machakos County, Kenya, to provide knowledge on rabies disease, promote

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safe dog interactions, and encourage positive health-seeking actions followed by assessment of learners' knowledge uptake. Specifically, this study assessed knowledge, attitude, and perceptions of primary school learners on rabies disease in selected primary schools and evaluated their knowledge uptake following a training programme. Through improving rabies awareness, this study contributes towards the elimination of dog-mediated human rabies as envisioned in the WHO's 'Zero Deaths by 2030' [10].

## Methods

### Study area

The study was conducted in Mwala Sub County, Machakos County, Kenya (Figure 1). Machakos County was purposively selected being one of the six counties that had collectively accounted for nearly two-thirds of reported rabies cases in both animals and humans in Kenya in the review by Bitek et al. [11]. Additionally, it is among the pilot counties under Kenya's strategy to eliminate dog-mediated human rabies by 2030 [1].

### Study design

This study employed a quasi-experimental design involving four randomly selected public primary schools (two urban and two rural) in Mwala Sub-County. Urban schools were defined as those located within 1 km of an urban centre, characterized by higher population density and mixed residential land use. Rural schools were defined as those located at least 10 km away from any urban centre, typically representing lower population density, dominated by agriculture and livestock keeping. This classification reflects the rural–urban transition patterns in Machakos County, where human population density and land use influence dog ownership and management practices [12]. Data were collected from learners in Grades 4, 5, and 6, as these age groups were considered more likely to comprehend and respond effectively to the questionnaire. Additionally, these grades were targeted because they typically include children aged 9–12 years, a group identified to be at higher risk of dog bites and, consequently, more vulnerable to rabies [3].

### Sampling and sample size calculation

The sample calculation was done using a formula by Colton et al. [13] to assess whether there is a change in two independent means.

$$n = 2\left[\frac{(z_\alpha + z_\beta)\sigma}{\delta}\right]^2$$

where:

- n = sample size per group (before and after)
- $Z_\alpha$ = *Z*-score corresponding to the desired significance level. For a two-tailed test at a 95% confidence level ($\alpha$ = 0.05), this is approximately 1.96.
- $Z_\beta$ = *Z*-score corresponding to the desired power level. For 80% power ($\beta$ = 0.80), $Z_\beta$ is approximately 0.84.

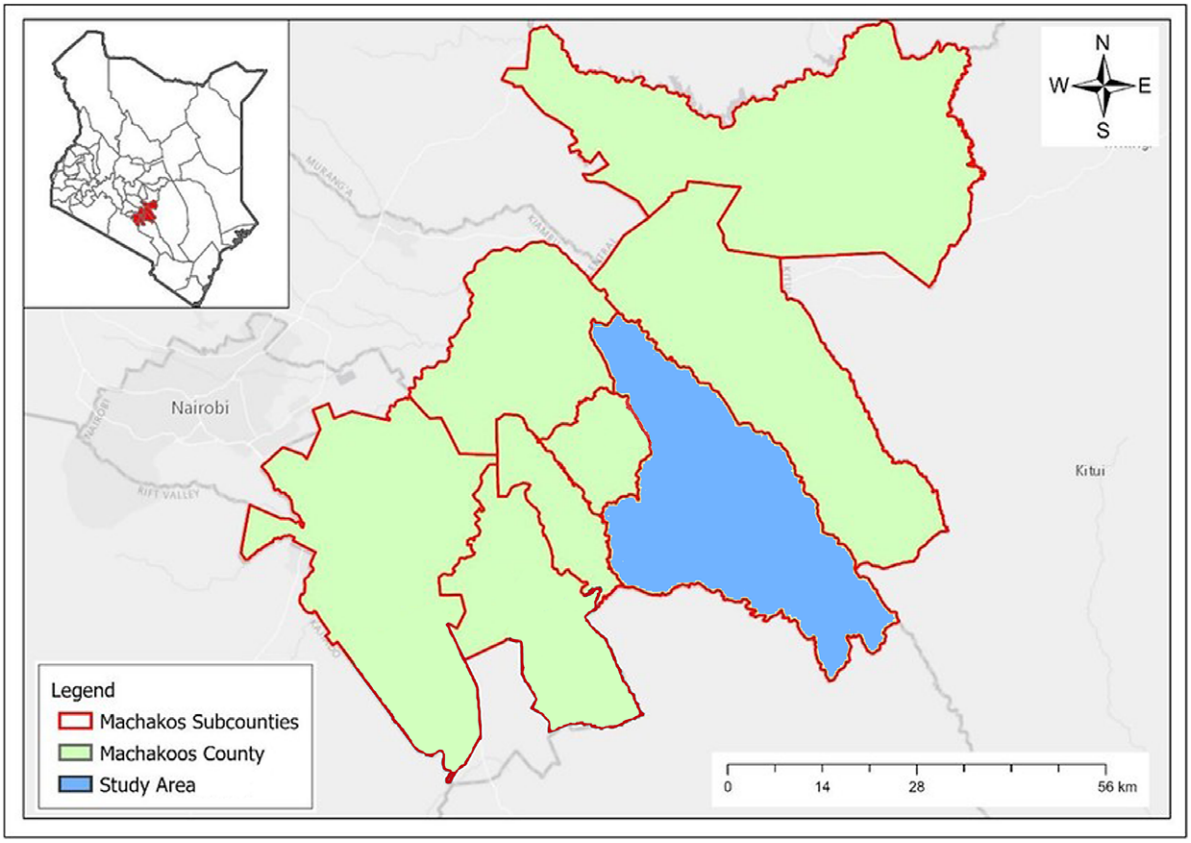



**Figure 1.** Map of Kenya showing the location of Machakos County (red shading) and its administrative units and major urban centres (Adopted from [40]). The blue shaded area shows the location of Mwala Sub-County.

- σ = estimated standard deviation of the differences between before and after measurements of 20%, which is higher than the 9.2% reported by Burdon et al. [6].
- $\delta$ = desired effect size, that is, 0.5, which is the medium effect-size.

This yielded a sample size of 251 learners in the four schools. After applying a finite population correction based on the Ministry of Education's estimated number of learners in the sub-county, and rounding off, the final sample size was adjusted to 246 learners. Thereafter, learners were proportionally distributed across the location of schools and then divided equally into the three grades. This resulted in 27 and 14 learners per grade from urban and rural schools, respectively. However, during actual data collection, some schools had fewer learners in certain grades than initially anticipated. In such cases, all available learners in the respective grades were included in the sample. Conversely, in schools where the number of learners, in respective grades, exceeded the required sample size, an equal number of boys and girls were randomly selected. At the end, data were collected from 210 learners.

### Data collection

The data were collected between July 2024 and August 2024. A pre-tested questionnaire covering various aspects of rabies, including its hosts, transmission, clinical signs, prevention, bite management, dog welfare, food waste management, and personal safety, was used to assess the knowledge, attitudes, and perceptions of the 210 learners (Supplementary Materials-Questionnaire). The teachers administered the questionnaire to the learners, and the same questionnaires were used to collect data 2 weeks after the rabies education intervention.

### Rabies education intervention

At each school, the teachers participated in a half-day training workshop aimed at training them on rabies disease, its transmission, control, and prevention. Thereafter, the teachers were allowed to translated the training materials initially developed by the research team into age-specific training materials for the learners drawing from their didactic expertise and experience with the learners. Teachers contributed insights on locally appropriate languages, examples, and classroom teaching strategies suitable for learners in Grades 4–6. The educational content was delivered using visual aids such as banners, PowerPoint presentations, videos, and printed brochures to enhance engagement and understanding among learners. In each school, the intervention comprised two sessions each lasting approximately 35–45 min. The initial training was done by the research team in the presence of the teachers, followed by another session by their teachers only 2 weeks later. The sessions were conducted in both English and Kiswahili and at times in the indigenous dialect (Kikamba) for clarity in cases where the concepts were not clear. After the initial session, all learners received brochures containing key messages on rabies disease extracted from the training materials used during the lesson.

### Data handling and analysis

Data were initially entered and organized using Microsoft Excel 2019 before being exported to IBM SPSS Statistics version 25.0 and R version 4.5 using packages 'readxl', 'dplyr', 'ggplot2', and 'ggpubr' for analysis. Descriptive statistics were used to summarize demographic characteristics and other categorical variables, which were reported as frequencies and percentages. Continuous variables were summarized using means and standard errors. Frequencies of the categorical variables related to demographic characteristics and management of dogs, dog bites, and health-seeking behaviour were compared between the rural and urban-based schools using Pearson's Chi-squared ($\chi^2$) test.

In this study, learners' knowledge was defined as a factual understanding of rabies, including its transmission routes, susceptible hosts, clinical signs in animals, and preventive measures such as dog vaccination and appropriate wound management. Questions assessing knowledge, therefore, focused on the learner's ability to identify scientific information about rabies correctly. Perception-related questions assessed the learner's behavioural intentions and interpretation of risk scenarios. These questions presented hypothetical situations, such as how learner(s) would respond if bitten by a free-roaming dog or having encountered a suspected rabid dog. These questions helped to capture how individuals interpret risk situations and subsequent actions they take. Because these actual practices could not be directly observed, these responses were used as indicators of learners' likely behavioural responses to rabies-related risks.

For knowledge questions, a score of '1' was awarded to responses aligned with established rabies prevention and control knowledge, while a score of '0' was given for incorrect answers (Supplementary Table 1). Each learner could achieve a maximum score of 18 points if all knowledge-related questions were answered correctly. For scenario-based questions, responses were scored based on their alignment with the recommended rabies prevention behaviours such as reporting suspected rabid animals, wound washing, and seeking medical care following exposure.

A maximum of six points could be obtained for correctly answering all perception-related questions (Supplementary Table 2). Pre- and post-intervention scores for both knowledge, attitude, and perception were compared using the Wilcoxon signed-rank test, due to the ordinal nature of the data and the non-normal distribution of scores with a $p$-value of ≤0.05 considered statistically significant for all tests.

## Results

The demographic characteristics of the 210 learners in the study are presented in Table 1. Approximately half of the participants were female 51.9% (109/210). All the learners were below 15 years with the highest proportion aged 11–12 years, 47.6% (100/210).

Overall, all learners reported owning at least one dog, with higher proportion of urban learners 39.4% (50/127) owning more than one dog than the rural learners 20.5% (17/83) ($p$ = 0.012) (Table 2). Overall, dog sterilization (either castrated or spayed) was less common 54.3% (114/210), particularly in rural 61.4% (51/83) than urban areas 49.6% (63/127) ($p$ = 0.036). More dogs owned by learners in rural schools roamed freely at night 25.3% (21/83) compared to urban dogs 12.6% (16/127) ($p$ = 0.003) (Table 2).

### Learners' knowledge on rabies disease

As shown in Figure 2a,b, 95.3% (41/43) of the urban learners and 80.8% (135/167) of rural learners had heard of rabies disease. Urban learners primarily received information from teachers 40.9% (52/127), while rural learners received most of this information from friends or relatives 50.6% (42/83).

**Table 1.** Demographic characteristics of the learners who participated in the study in Machakos County, Kenya

| Variables | Total (n %) *N* = 210 | Location of learners' school (n (%)) | |
|---|---|---|---|
| | | Urban (*N* = 127) | Rural (*N* = 83) |
| Gender | | | |
| Male | 101 (48.1) | 61 (48.0) | 40 (48.2) |
| Female | 109 (51.9) | 66 (52.0) | 43 (51.8) |
| Age of learner (years) | | | |
| 8–10 | 84 (40.0) | 51 (40.2) | 33 (39.8) |
| 11–12 | 100 (47.6) | 61 (48.0) | 39 (47.0) |
| 13–15 | 26 (12.4) | 15 (11.8) | 11 (13.3) |
| Grade of learner | | | |
| Grade 4 | 69 (32.9) | 41 (32.3) | 28 (33.7) |
| Grade 5 | 53 (25.2) | 42 (33.1) | 11 (13.3) |
| Grade 6 | 88 (41.9) | 44 (34.6) | 44 (53.0) |

**Table 2.** Characteristics and management of dogs owned by learners' households from Machakos County, Kenya

| Variables | Total (n %) *N* = 210 | Location of learners' school (n (%)) | | χ2 *p*-value |
|---|---|---|---|---|
| | | Urban (*N* = 127) | Rural (*N* = 83) | |
| Number of dogs | | | | **0.012** |
| One dog | 143 (68.1) | 77 (60.6) | 66 (79.5) | |
| More than one dog | 67 (31.9) | 50 (39.4) | 17 (20.5) | |
| Dog vaccination status* | | | | 0.605 |
| No | 98 (46.7) | 57 (44.9) | 41 (49.4) | |
| Yes | 112 (53.3) | 70 (55.1) | 42 (50.6) | |
| Dog sterilization (castration or spay) status* | | | | **0.036** |
| No | 114 (54.3) | 63 (49.6) | 51 (61.4) | |
| Yes | 49 (23.3) | 28 (22.0) | 21 (25.3) | |
| I do not know | 47 (22.4) | 36 (28.3) | 11 (13.3) | |
| Do you feed your dog routinely | | | | 0.270 |
| No | 191 (91.0) | 114 (89.8) | 77 (92.8) | |
| Yes | 19 (9.0) | 13 (10.2) | 6 (7.2) | |
| Where did your dog come from** | | | | 0.200 |
| Adopted from the street | 9 (4.3) | 6 (4.7) | 3 (3.6) | |
| Given by a neighbour or friend | 155 (73.8) | 88 (69.3) | 67 (80.7) | |
| Purchased locally | 32 (15.2) | 23 (18.1) | 9 (10.8) | |
| Purchased from outside the county | 7 (3.3) | 3 (2.4) | 4 (4.8) | |
| I do not know | 14 (6.7) | 10 (7.9) | 4 (4.8) | |
| How is the dog kept** | | | | **0.003** |
| Roam freely all the time | 37 (17.6) | 27 (21.3) | 10 (12.0) | |
| Stay inside the house compound all the time | 123 (58.6) | 66 (52.0) | 57 (46.3) | |
| Roam freely outside during the day | 35 (16.7) | 17 (13.4) | 18 (21.7) | |
| Roam freely at night | 37 (17.6) | 16 (12.6) | 21 (25.3) | |
| It is often missing | 2 (1.0) | 2 (1.6) | 0 (0) | |

*Note:* *The frequency and percentage are based on the learner's responses. ** The questions allowed multiple responses from learners.

## Dog bites and health-seeking behaviour

In this study, 99.5% (209/210) of all the learners reported either being bitten or knowing someone who has been bitten by a dog (Table 3). An assessment of the health-seeking behaviour following dog bites in learners showed that 81.6% (169/210) of persons who had been bitten or scratched by a dog sought hospital care, with a significantly higher proportion in urban areas 87.9% (109/127) than in rural areas (Table 3). Additionally, 51.9% (109/210) of learners or people they knew received a rabies vaccine, post-bite, or scratch by a dog, with a significantly higher percentage in urban areas 62.2% (79/127) ($p$ = 0.001). For bite or scratch wounds, 42.3% (88/210) applied antiseptics and 29.8% (62/210) used local herbs or medicine, with rural learners more likely to use antiseptic and wash the wound with soap and water than learners in urban areas ($p$ = 0.005) (Table 3).

Table 4 shows learners' attitude and perceptions on environment and gender as relates to rabies disease. A significant difference was reported in the likelihood of seeking adult help after being bitten or scratched by a dog, with girls 61% (128/210) more likely than boys 13.8% (29/210) to seek help ($p$ = 0.001). Fifty-seven percent (119/210) of the learners reported separating food waste from household waste, and 78.8% (160/210) disposed food waste in waste dumps or compost pits with similar practices across urban and rural areas ($p$ = 0.619).

## Changes in learners' knowledge post-training

Figure 3 compares overall rabies knowledge scores before and after training with learners' knowledge scores being calculated on a scale of 0–18 as described in methods and Supplementary Table 1. The mean knowledge score improved significantly from 6.14 to 7.61 out of a maximum possible score of 18 ($p < 0.001$), with female learners showing significant increase in knowledge from 6.12 to 7.78 ($p < 0.001$) than males (from 6.16 to 7.44, $p$ = 0.024). Grade 5 learners showed the greatest improvement, with their scores rising from 6.57 to 8.83 ($p < 0.001$).

Table 5 highlights the specific knowledge changes among the learners regarding rabies and its control, comparing responses before and after training. A significant improvement was observed in understanding how rabies is transmitted, with 76.7% (161/210) of learners correctly identifying dog bites as the primary route post-training, compared to 66.7% (140/210) pre-training ($p < 0.001$). Understanding of rabies transmission via scratches from animals also improved from 25.7% (54/210) pre-training to 46.7% (98/210) post-training ($p < 0.001$). Additionally, learners became more aware that cats and livestock can also contract rabies ($p$ = 0.013).

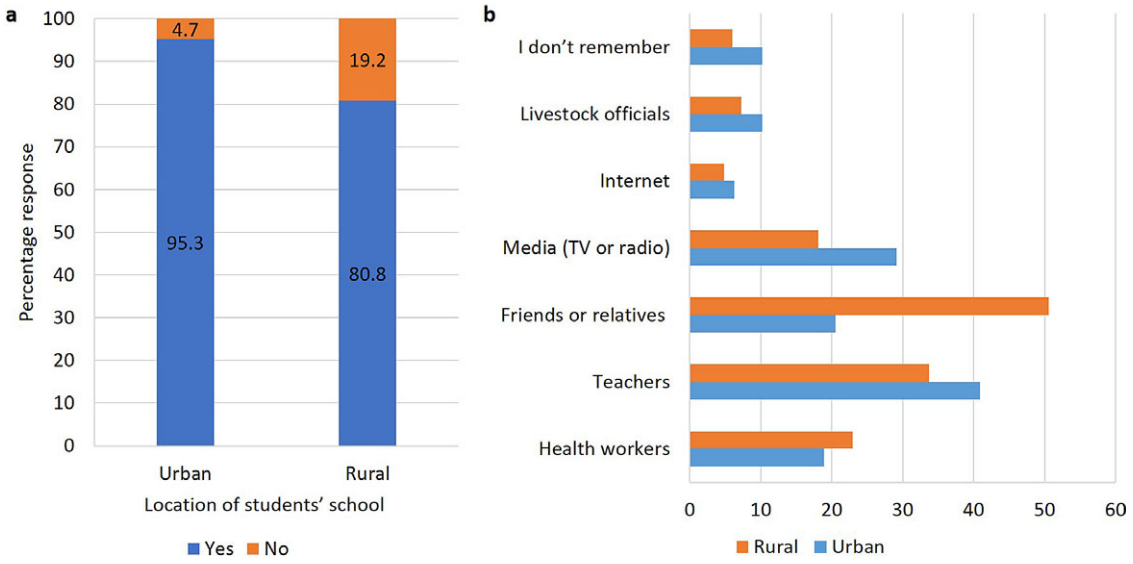



**Figure 2.** (a) Percentages of learners who had heard of rabies disease in urban and rural schools and (b) source of information on rabies among learners in urban and rural schools presented as percentages.

**Table 3.** Characteristics of dog bites and health-seeking behaviour among learners or people they know bitten by dogs in Machakos County, Kenya

| Variables | Total (n %) *N* = 210 | Location of learners' school (n (%)) Urban (*N* = 127) | Rural (*N* = 83) | χ2 *p*-value |
|---|---|---|---|---|
| Have you or anyone you know ever been bitten or scratched by a dog? | | | | 0.183 |
| Yes | 209 (99.5) | 127 (99.2) | 83 (100.0) | |
| No | 1 (0.5) | 1 (0.8) | 0 (0.0) | |
| Did you or the other person go to hospital? | | | | **0.013** |
| Yes | 169 (81.6) | 109 (87.9) | 60 (72.3) | |
| No | 38 (18.4) | 15 (12.1) | 23 (27.7) | |
| Which type of dog bit you/them? | | | | 0.136 |
| Pet dog | 83 (39.5) | 44 (34.6) | 39 (47.0) | |
| Stray dog | 68 (32.4) | 42 (33.1) | 26 (31.3) | |
| I do not know | 59 (28.1) | 41 (32.3) | 18 (21.7) | |
| What was the reason for the bite? | | | | 0.598 |
| Provoked bite | 114 (55.1) | 68 (54.8) | 46 (55.4) | |
| Unprovoked bite | 88 (42.5) | 53 (42.7) | 35 (42.2) | |
| I do not know | 5 (2.4) | 3 (2.4) | 2 (2.4) | |
| What happened to biting dog? | | | | 0.719 |
| It died | 22 (10.5) | 14 (11.0) | 8 (9.6) | |
| It disappeared | 29 (13.8) | 18 (14.2) | 11 (13.3) | |
| It stayed alive | 82 (39.0) | 53 (41.7) | 29 (34.9) | |
| The dog was killed | 35 (16.7) | 20 (15.7) | 15 (18.1) | |
| I do not know | 44 (21.0) | 23 (18.1) | 21 (25.3) | |
| What was done to the bite wound? | | | | **0.005** |
| Did nothing | 36 (17.3) | 20 (16.0) | 16 (19.3) | |
| Put antiseptics on the wound | 88 (42.3) | 52 (41.6) | 36 (43.4) | |
| Use local herbs or medicine | 62 (29.8) | 45 (36.0) | 17 (20.5) | |
| Wash bite with soap and water | 41 (19.7) | 16 (12.8) | 25 (30.1) | |
| Wash bite with just water | 11 (5.3) | 5 (4.0) | 6 (7.2) | |
| Did you/the other person get rabies vaccine? | | | | **0.001** |
| Yes | 109 (51.9) | 79 (62.2) | 30 (36.1) | |
| No | 45 (21.4) | 21 (16.5) | 24 (28.9) | |
| I do not know | 56 (26.7) | 27 (21.3) | 29 (34.9) | |

However, some misconceptions still persisted post-training, 31(14.8%) of the learners still incorrectly attributed rabies transmission to touching dog urine or faeces ($p < 0.010$). Similarly, recognition of vaccination as key in rabies prevention increased from 65.7% (138/210) to 85.7% (180/210) ($p < 0.001$) with more learners understanding the need for annual vaccination ($p < 0.001$). There was also a notable rise in learners who understood that rabies can infect humans, with awareness increasing from 71.9% (151/210) to 83.8% (176/210) ($p = 0.019$) (Table 5).

### *Changes in the learners' attitude and perceptions towards rabies disease*

Learners' attitude and perception scores were calculated on a scale of 0–6, as described in Supplementary Table 2. Higher scores

**Table 4.** Learners' attitudes and perceptions on environmental and gender aspects related to rabies disease in Machakos County, Kenya

| Variables | Total (n %) N = 210 | Location school (n (%)) Urban (N = 127) | Rural (N = 83) | χ2 p-value |
|---|---|---|---|---|
| If bitten or scratched by animal who is likely to seek adult? | | | | **0.001** |
| Boys | 29 (13.8) | 11 (8.7) | 18 (21.7) | |
| Girls | 128 (61.0) | 73 (57.5) | 55 (66.3) | |
| Both equally | 46 (21.9) | 37 (29.1) | 9 (10.8) | |
| Do not know | 7 (3.3) | 6 (4.7) | 1 (1.2) | |
| Do you separate food waste from household waste? | | | | 0.619 |
| Yes | s | 70 (55.6) | 49 (59.0) | |
| No | 90 (43.1) | 56 (44.4) | 34 (41.0) | |
| How do you get rid of food waste? | | | | 0.382 |
| Throw it anywhere | 42 (20.7) | 23 (19.2) | 19 (22.9) | |
| Waste dumps/ compost pits | 160 (78.8) | 97 (80.8) | 63 (75.9) | |
| Others | 1 (0.5) | 0 (0) | 1 (1.2) | |
| Are their specific duties related to animals done by boys and girls? | | | | 0.075 |
| Yes | 158 (75.2) | 101 (79.5) | 57 (68.7) | |
| No | 52 (24.8) | 26 (20.5) | 26 (31.3) | |
| Who is more likely to approach stray animals? | | | | 0.111 |
| Boys | 133 (63.6) | 75 (59.5) | 58 (69.9) | |
| Girls | 37 (17.7) | 22 (17.5) | 15 (18.1) | |
| Both equally | 20 (9.6) | 17 (13.5) | 3 (3.6) | |
| Do not know | 19 (9.1) | 12 (9.5) | 7 (8.4) | |
| Who are more cautious around animals? | | | | 0.587 |
| Boys | 81 (38.8) | 47 (37.3) | 34 (41) | |
| Girls | 103 (49.3) | 61 (48.4) | 42 (50.6) | |
| Both equally | 12 (5.7) | 8 (6.3) | 4 (4.8) | |
| Do not know | 13 (6.2) | 10 (7.9) | 3 (3.6) | |
| Who spends more time playing with animals? | | | | 0.184 |
| Boys | 167 (79.5) | 96 (75.6) | 71 (85.5) | |
| Girls | 25 (11.9) | 16 (12.6) | 9 (10.8) | |
| Both equally | 14 (6.7) | 12 (9.4) | 2 (2.4) | |
| Do not know | 4 (1.9) | 3 (2.4) | 1 (1.2) | |

indicated more appropriate attitudes and perceptions regarding rabies prevention. Comparison of the mean attitude and perceptions scores before and after training revealed a significant improvement in learners' overall perceptions, with mean scores rising from 3.23 to 4.03 out of a maximum of 6 ($p < 0.001$) (Figure 4). Female learners had a significant improvement (from 3.09 to 4.26, $p < 0.001$) compared to males (from 3.39 to 3.79, $p = 0.013$). Grade 5 learners showed the greatest improvement, with their perception scores increasing from 2.85 to 4.06 ($p < 0.001$). Additionally, younger learners (8–10 years) and urban learners showed a significant improvement in perceptions scores from 3.57 to 4.22 ($p = 0.002$) and from 3.05 to 4.30, $p < 0.001$), respectively (Figure 4).

Table 6 describes the specific changes in the learners' attitude and perceptions post-training. The proportion of learners who would go to the hospital after being bitten by a dog increased significantly from 31.0% (65/210) pre-training to 74.8% (157/210) post-training ($p < 0.001$). Post-training, a higher proportion of learners 50.0% (105/210) reported that they would notify teachers upon encountering a suspected rabid dog compared to 34.8% (73/210) pre-training ($p < 0.001$). There was also an increase in learners recognizing that food waste attracts free-roaming dogs ($p = 0.001$) (Table 6).

## Discussion

This study aimed at assessing the knowledge, attitude, and perceptions of primary school learners on rabies and thereafter evaluating their knowledge uptake after a training programme. Majority of the learners had previously heard of rabies disease, similar to findings by Amparo in Philippines [14] but lower than those from Nigeria [15]. This may be attributed to multiple rabies interventions within the community in Machakos County, which is one of the pilot counties for rabies elimination in Kenya. In urban schools, teachers were the main source of the rabies education. Teachers are the trusted sources of information in schools [14], and a collaboration with researchers for effective delivery of content [16] is important. In contrast, rural learners cited their friends and relatives as the primary source of rabies information, consistent with findings from Nigeria [15]. This highlight the importance of community awareness to ensure that accurate information is conveyed to the learners.

All the learners reported owning at least one dog with nearly a third mainly urban owning more than one dog in concurrence to a recent dog demographic study by Murungi et al. [12] in the same area. In rural areas, dogs are commonly kept for security or livestock protection and often roam freely, increasing children's exposure to dog bites, whereas urban households typically restrict the movement of their dogs [17]. Variation in household socioeconomic conditions and access to veterinary services has also been shown to influence dog ownership influence [12]. The night free roaming of the dogs was also reported similar to other studies in other parts of Kenya and Uganda [18, 19]. The free roaming has been associated with movement in search for food [19] and has been associated with the increased risk of human bites, hence increasing the rabies transmission. Therefore, with the high dog ownership, responsible dog ownership is imperative to prevent dogs from free roaming, hence reducing the risk of rabies.

More than half of the dogs were reported not sterilized especially from rural households similar to other reports in Kenya [18] and Thailand [17]. This has been associated with unavailability of veterinary service [17], misconceptions, and cultural beliefs [20], with some households in rural areas not being aware of this procedure or just not interested in it [19]. This, combined with the free roaming dogs, would lead to uncontrolled breeding that often results in high dog population and a risk for rabies transmission.

Dog bites remain common in this area, with majority of the learners reporting being bitten or knowing someone bitten by a dog similar to other findings in Kenya [21], China [22], and the United States [23]. Although the reason for the bite whether provoked or unprovoked was not significant, emphasis on safe behaviour around dogs is essential for children to prevent dog bites. Majority

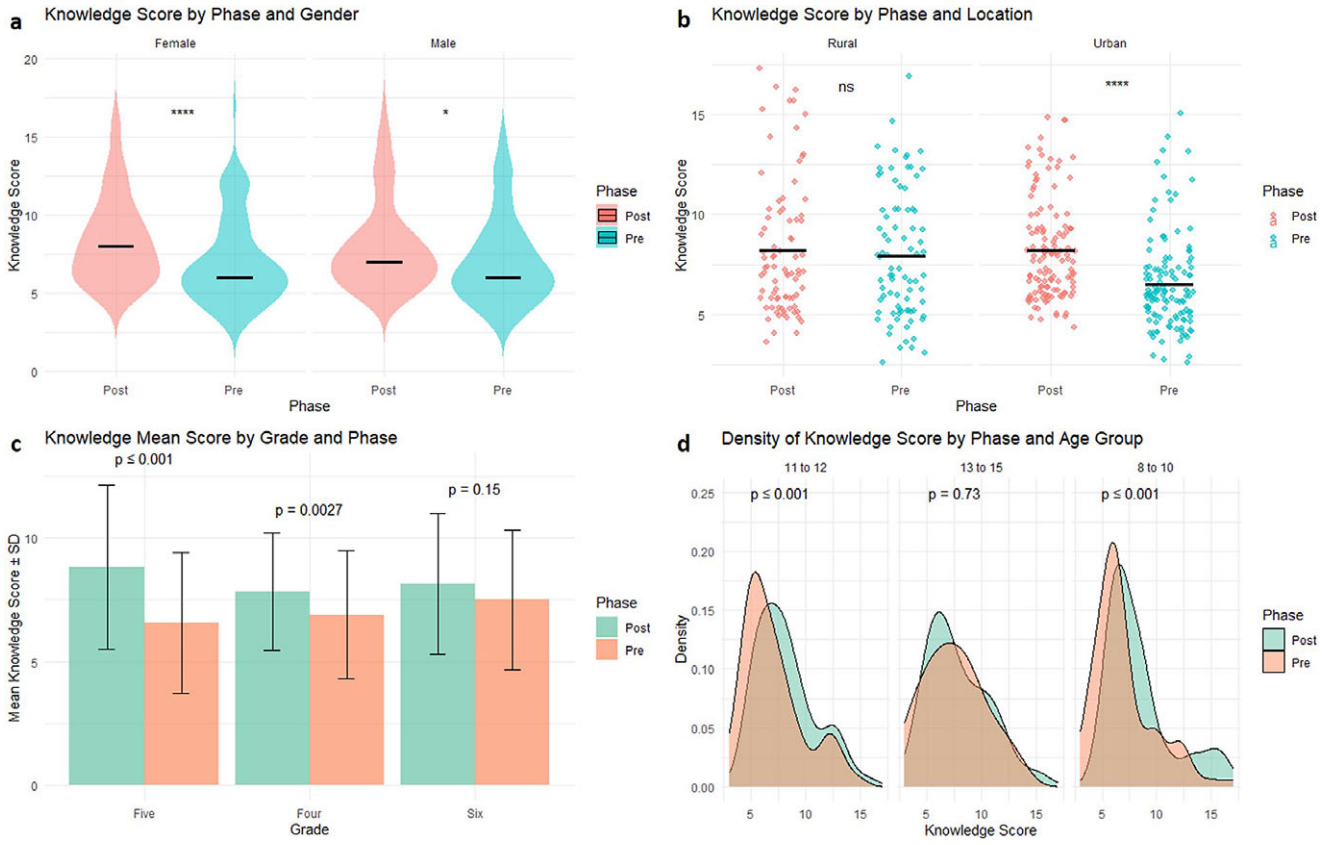



**Figure 3.** Distribution and mean differences in knowledge scores by study phase across gender, location, grade and age group. Green colored plots and charts represent the knowledge scores before the training intervention (Pre), while the red colored plots and charts represent the knowledge scores after the training intervention (Post). The *p* value of the comparisons is indicated on the plots or charts. (a) Violin plot by gender. (b) Strip chart by location. For plot a and chart b, * = $p < 0.05$, ** $p < 0.001$, and ns = Not significant. (c) Bar plot by grade. The bars indicate the mean knowledge scores. (d) Density plot by age group.

of the people bitten washed the wound with an antiseptic, sort health care, and received post-exposure prophylaxis similar to findings of a study in India [24]. However, other reports such as a review by Nyasulu et al. [3] and studies in China [25] and Cameroon [7] reported non-compliance by the dog-bite victims to the recommended post-bite measures. These differences may be attributed to variations in the target populations or possibly as a result of multiple rabies prevention programmes that have been conducted within Machakos County. Despite the appropriate post-bite practice reported, it would be interesting to understand the post-exposure prophylaxis (PEP) compliance as recommended by WHO [10].

Overall, post-training assessment indicated that there was an improvement on the learners' knowledge, attitude, and perception on rabies disease. This is in agreement with studies from Malawi [6], Philippines [14], and the United Kingdom [26] that showed such training improved the knowledge, attitude, and perceptions both the short and long terms. Despite this significant improvement, the overall scores remained relatively low. This may reflect limited prior exposure to rabies education and persistent misconceptions about transmission and prevention. Sustaining these interventions with educators would be impactful on the learners' behaviour change [27], hence protecting them against the risk of rabies transmission. Such training intervention could be reinforced if delivered through existing school forums, such as co-curriculum activities, school assemblies [28], and health clubs, with the potential to serve as useful models for other zoonoses [14].

Particularly, there was an increase in learners' knowledge of animals that can be infected with rabies, for instance, cats and other livestock. The dog is the main domestic host of rabies virus in Africa [10], but in Kenya, there is a wide range of other animals that can be infected and transmit the virus with livestock ranking second to the dogs [11]. Limited awareness on the role of alternative rabies hosts such as livestock and cats may lead learners to underestimate rabies risk in case of a bite, thereby the need for emphasis during such trainings.

Although a high number of learners already knew that humans can be infected with rabies, this number significantly increased post-training similar to findings in India [8], Malawi [6], and Philippines [29]. As to how this transmission occurs, the learners gained significant knowledge on the other routes of transmission such as animal scratches in addition to the dog bites as reported in Malawi [6]. However, some misconceptions such as transmission by touching dog urine and faeces persisted post-training as reported elsewhere [16]. A consistent and creative information delivery approach such as storytelling and role plays [27] may be useful for learners to understand complex constructs such as transmission.

Post-training, there was a significant improvement on the learner's knowledge on the annual vaccination for prevention of rabies. Hasanov et al. [9] report that people who had gone through an awareness campaign were more likely to take their dogs for vaccination. Vaccination is one of the strategies identified in the WHO Global framework for elimination of dog-mediated rabies 'Zero

**Table 5.** Changes in learners' knowledge regarding rabies disease and its control after the training intervention in Machakos County, Kenya

| Parameter | Phase of interview (n (%)) | | χ2 *p*-value |
|---|---|---|---|
| | Pre (*N* = 210) | Post (*N* = 210) | |
| What animals can spread rabies | | | 0.286 |
| Dogs | 180 (86.1) | 174 (82.9) | |
| Cats | 37 (17.7) | 53 (25.2) | |
| Livestock, i.e., cows, donkey, sheep | 21 (10.0) | 21 (10.0) | |
| Bats | 9 (4.3) | 6 (2.9) | |
| What causes rabies | | | 0.672 |
| Eating something poisonous | 53 (25.2) | 52 (24.8) | |
| Psychological problems | 30 (14.3) | 35 (16.7) | |
| Being very hungry or thirsty | 14 (6.7) | 21 (10) | |
| Spirits | 10 (4.8) | 6 (2.9) | |
| Virus | 71 (33.8) | 77 (36.7) | |
| Bacteria | 16 (7.6) | 13 (6.2) | |
| I do not know | 45 (21.4) | 35 (16.7) | |
| What animals can be infected with rabies | | | **0.013** |
| Dogs | 172 (81.9) | 182 (86.7) | |
| Livestock, i.e., cattle, pigs, horses | 58 (27.6) | 83 (39.5) | |
| Cats | 74 (35.3) | 76 (36.2) | |
| Bats | 7 (3.3) | 12 (5.7) | |
| I do not know | 10 (4.8) | 1 (0.5) | |
| Can rabies infect humans | | | **0.019** |
| Yes | 151 (71.9) | 176 (83.8) | |
| No | 38 (18.1) | 19 (9.0) | |
| I do not know | 21 (10.0) | 15 (7.1) | |
| How do you think rabies is transmitted | | | **<0.001** |
| Is it through dog bites | 140 (66.7) | 161 (76.7) | |
| Scratches from animals | 54 (25.7) | 98 (46.7) | |
| Touching animal saliva when you have a cut | 67 (31.9) | 56 (26.7) | |
| Drinking milk/eating food | 16 (7.6) | 12 (5.7) | |
| Touching dog urine and faeces | 31 (14.8) | 20 (9.5) | |
| Contaminated water | 11 (5.2) | 4 (1.9) | |
| Contaminated soil | 9 (4.3) | 0 (0) | |
| Other | 0 (0) | 1 (0.5) | |
| Clinical signs of a rabid dog | | | **<0.001** |
| Does it become aggressive | 85 (40.5) | 70 (33.3) | |
| Fear water | 47 (22.4) | 128 (61.0) | |
| Excessively saliva | 133 (63.3) | 90 (42.9) | |
| Cough | 13 (6.2) | 1 (0.5) | |
| Diarrhoea | 14 (6.7) | 8 (3.8) | |
| Other | 2 (1.0) | 1 (0.5) | |
| How can we prevent rabies | | | **<0.001** |
| By giving vaccinations | 138 (65.7) | 180 (85.7) | |
| Preventing dogs from contacting stray dogs | 71 (33.8) | 89 (42.4) | |
| Washing dogs with shampoo | 53 (25.2) | 22 (10.5) | |
| Not allowing the dogs to feed on garbage | 36 (17.1) | 31 (14.8) | |
| Regular deworming | 17 (8.1) | 7 (3.3) | |
| Vaccination frequency | | | **<0.001** |
| Every month | 81 (38.6) | 64 (30.5) | |
| Every week | 43 (20.5) | 39 (18.6) | |
| When necessary | 22 (10.5) | 17 (8.1) | |
| Once a year | 35 (16.7) | 81 (38.6) | |
| I do not know | 43 (20.5) | 22 (10.5) | |

Deaths by 2030' [1]. With the key role played by children in caring for the dogs and taking the dogs for the mass vaccination [30], this improvement in knowledge is important in rabies control.

Positive actions that learners would take post dog-bite such as washing with soap and water and application of antiseptic and seeking medical attention increased post-training as reported in different districts in India [31]. However, a high proportion would still use local herbs on the wound as also reported in South Bhutan [16, 32] and Nigeria [15]. In this study, some bite incidents involved dogs that, based on the reports, remained alive or healthy after the incident, which may explain why treatment was not always sought. Additionally, the cost of post-exposure prophylaxis (PEP) can represent a significant barrier to accessing treatment in many settings [33]. Reinforcing the correct information may require training the community simultaneously with the learners [28], since learners' knowledge and perceptions on rabies are often influenced by the adults they interact with in the community [34].

In this study, female learners showed a significant improvement in their knowledge, attitude, and perceptions towards rabies disease similar to the study by Baatz et al. [35] in the United Kingdom. These learners had a lower baseline knowledge than their counterparts, and this difference commonly allows for greater room for improvement post-training. Moreover, female learners may have a high motivation on the topic due to their increased perceived vulnerability [36].

Younger learners had a significant improvement on their attitude and perceptions on rabies diseases, a similar finding by Amparo et al. [14]. Younger learners may have had limited prior information on rabies, therefore more receptive to new information compared to older cohorts that had been exposed to various information sources that could be.

Initially, boys were less likely to report dog-bite incidents to an adult; however, post training, there was a significant improvement consistent with a study in Thailand [36]. The non-reporting may be linked to the children's perception that they will be punished for their dangerous activities with the dogs [37]. Reporting animal bites

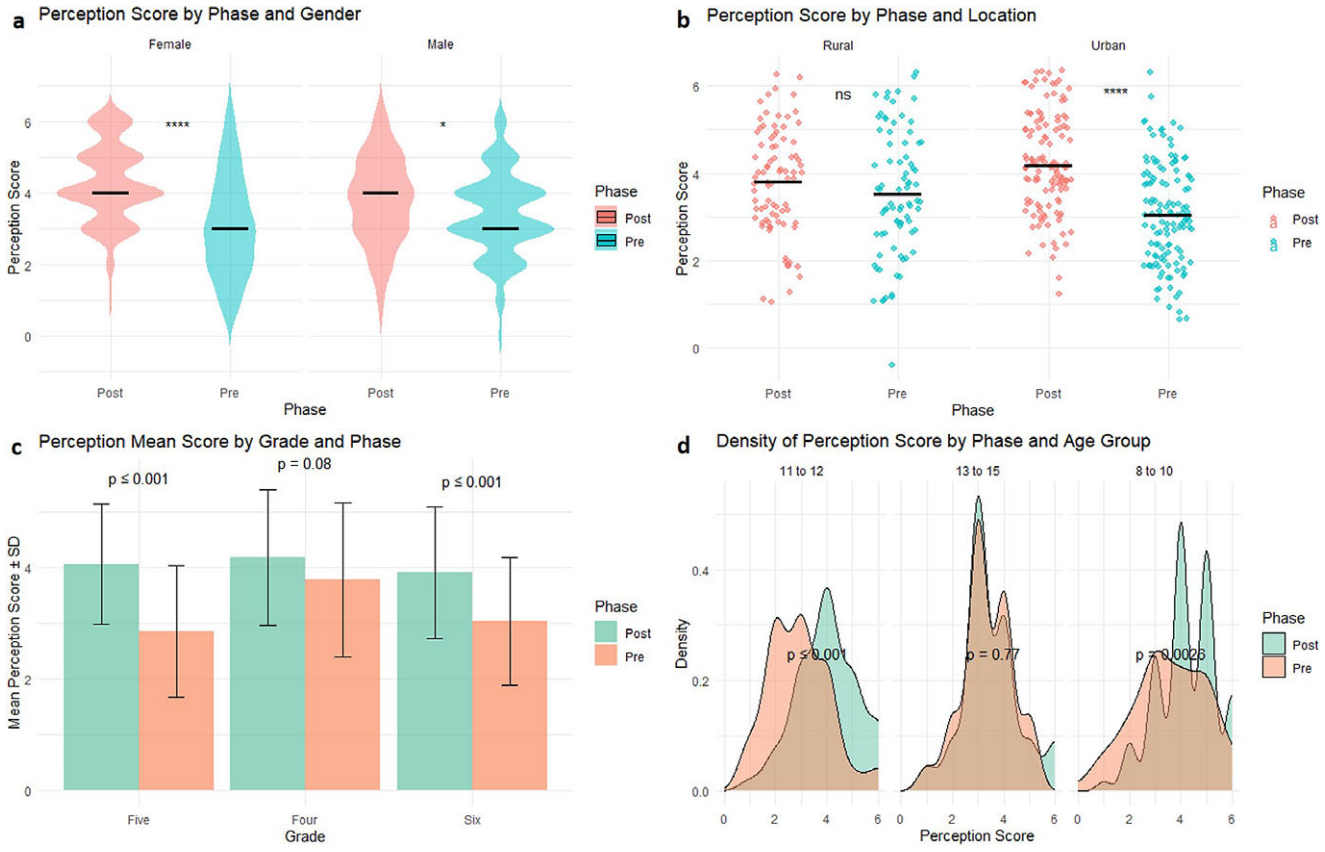



**Figure 4.** Distribution and mean differences in perception scores by study phase across gender, location, grade and age group. Green colored plots and charts represent the perceptions scores before the training intervention (Pre), while the red colored plots and charts represent the knowledge scores after the training intervention (Post). The *p* values of the comparisons are indicated on the charts or plots. (a) Violin plot by gender. (b) Strip chart by location. For plot a and chart b, * = $p < 0.05$, ** $p < 0.001$, and ns = Not significant. (c) Bar plot by grade. The bars indicate the mean perceptions scores. (d) Density plot by age group.

**Table 6.** Changes in learners' attitude and perception on free roaming dogs as it relates to rabies post-training in Machakos County, Kenya

| Variables | Phase of interview (*n* (%)) | | χ2 *p*-value |
|---|---|---|---|
| | Pre (*N* = 210) | Post (*N* = 210) | |
| What would you do if a free roaming dog bit you? | | | **<0.001** |
| Go to the hospital to get injections | 65 (31.0) | 157 (74.8) | |
| Applying local medicines only | 151 (71.9) | 128 (61.0) | |
| Doing nothing | 46 (21.9) | 10 (4.8) | |
| Other | 9 (4.3) | 2 (1.0) | |
| What would you do if you saw a suspected rabid dog? | | | **<0.001** |
| Try to catch the dog and take it to the animal hospital for treatment | 51 (24.3) | 10 (4.8) | |
| Reporting to teachers | 73 (34.8) | 105 (50.0) | |
| Doing nothing | 23 (11.0) | 15 (7.1) | |
| Killing the dogs | 24 (11.4) | 16 (7.6) | |
| Run away | 113 (53.8) | 130 (61.9) | |
| Does poor food waste management attract free roaming dogs? | | | **0.001** |
| Yes | 154 (73.7) | 175 (83.3) | |
| No | 26 (12.4) | 29 (13.8) | |
| I do not know | 29 (13.9) | 6 (2.9) | |
| How do you minimize free-roaming dogs from coming to your homestead? | | | 0.726 |
| Prepare and store food indoors | 69 (33.0) | 83 (39.5) | |
| Use appropriate tightly covered trash cans | 76 (36.4) | 83 (39.5) | |
| Chase them away | 81 (38.8) | 83 (39.5) | |

is important because it enables timely intervention to the bite victim [15], resulting in positive health outcomes. Increasing children's awareness on the risk of rabies and building trust with the available adults, teachers, parents, or guardians may improve on this communication, thereby safeguarding against rabies. There was also improved perception of learners that poor food wastes management attract free roaming dogs. Inappropriate food waste management has been identified as a neglected major driver for rabies in the environment as it supports the survival and proliferation of free-

roaming dogs [5], subsequently risk of rabies [38]. Therefore, the inclusion of proper food waste management in rabies control programmes has been advocated [39].

The limitations of this study were the short follow-up period to assess the learners' knowledge uptake; a follow-up after one year or more would better capture the long-term impact of such a training. The variability in teaching across the schools and reliance on learners' self-reporting may have affected the responses.

In conclusion, the school-based rabies education programme significantly improved the knowledge, attitude, and perceptions scores of learners towards rabies disease. This study provides the first interventional study on rabies education in primary schools in Kenya. Utilizing existing school forums, such as school clubs and school projects, and in the future integrating rabies education into the school curriculum through science-related learning areas would be important.

**Supplementary material.** The supplementary material for this article can be found at http://doi.org/10.1017/S0950268826101769.

**Data availability statement.** The data are available upon request from the corresponding author: shepelo@uonbi.ac.ke

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**Ethical standards.** The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki declaration of 1975, as revised in 2008. The study ethical approval from the institutional review and ethics committee (IREC) at Moi university and Moi teaching and referral hospital (IREC/769/2024). A research license from the National Commission for Science, Technology and Innovation (NACOSTI) in Kenya (NACOSTI/p/24/36572). Permission was sought from the county director of education, Machakos County. The parents of the learners participating in this study provided a written consent to allow their children to participate, and the learners filled their own assent forms.

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