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Economic burden of Dengue Fever and awareness among small-scale livestock farmers in Kerala

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Abstract
Dengue fever is a vector-borne disease that poses significant public health and economic challenges in tropical regions. This study combined a state-level economic burden assessment with a community-level awareness survey to provide complementary evidence on the economic impact of Dengue in Wayanad, Kerala. A longitudinal secondary data analysis and cross-sectional survey were conducted to understand the situation. Economic burden estimates used DALY data from the Institute for Health Metrics and Evaluation and Gross State Domestic Product per capita from the Government of Kerala, with a 3% discount rate. Primary data were collected from 382 dairy farmers using a validated KAP questionnaire. The findings showed a significant rise in the economic burden of Dengue in Kerala, from ₹924.95 million in 2011–12 to ₹1.65 billion in 2023–24. Even after discounting, it remained high at ₹1.15 billion in 2023–24. Awareness was good in 55.76% of the respondents, while 44.24% showed poor awareness. Knowledge was satisfactory, with 84.0% of the participants reporting moderate to high levels of knowledge. However, 64.70% had very low attitude scores, and 36.90% had very low preventive practice scores. No significant associations were found between awareness and socio-demographic or farm-level characteristics of the farmers. The study concludes that Dengue continues to exert a considerable economic burden on Kerala, while awareness gaps, particularly in attitudes and preventive behaviours, persist among rural dairy farmers. Community-based health education and behavioural change interventions are essential for strengthening Dengue prevention and reducing its long-term socioeconomic impact.

Introduction

Dengue fever is a vector-borne disease that spreads to humans through the bites of infected female mosquitoes, mainly Aedes aegypti, although other species in the genus can also act as secondary carriers (1, 2), but Dengue also has forest-associated transmission cycles involving non-human primates and Aedes mosquitoes, which makes Dengue zoonotic in a restricted sylvatic sense rather than in its dominant urban form (3, 4). This illness has become one of the most rapidly

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increasing public health concerns worldwide, with the World Health Organization (WHO) reporting a rise in cases from 505,430 in 2000 to 14.6 million in 2024 (5). This significant increase is fuelled by several factors, such as the widening geographic reach of Aedes aegypti and Aedes albopictus into areas previously unaffected by Dengue, climate change causing alterations in temperature, rainfall, and humidity, fragile and overtaxed healthcare systems, insufficient surveillance and reporting mechanisms, and political and financial instability in nations facing complex humanitarian crises and significant population movements (6, 7).

India exhibited a comparable trend. The first laboratory-confirmed case of Dengue in India was detected in Calcutta during 1945–46, with the initial outbreak occurring in 1963–64. Throughout this time, the disease progressively moved from the southern areas to the north, ultimately affecting the entire country by 1968 (8). The economic repercussions have been considerable, with Dengue's total financial burden in India estimated to be \$1.1 billion. Of these, 49% are attributed to direct medical costs, while 51% stem from indirect expenses related to lost productivity (9).

Aside from the clinical and financial factors, there is a notable gap in the behaviour and awareness levels. Research in Karnataka has revealed a deficiency in awareness and insufficient preventive actions against Dengue among local populations (10). Conversely, surveys from North India show that although awareness is adequate, preventive measures are lacking (11), demonstrating that knowledge does not always translate into protective behaviours. This gap is particularly crucial for occupational groups at a higher risk of exposure. For example, farmers have a Dengue infection risk nearly eight times higher than that of the general population (relative risk: 7.94; 95% CI: 2.29–27.55) (12). Similarly, farmers in Wayanad District, Kerala, show insufficient Dengue prevention practices (13), underscoring the link between occupational risk and lack of awareness in rural farming communities in India. Against this backdrop, understanding Dengue requires not only quantifying its economic consequences but also identifying behavioural factors that influence disease prevention. While estimating the economic burden highlights the magnitude of productivity losses attributable to Dengue at the state level, reducing this burden ultimately depends on effective community-level prevention and control measures. Since awareness is a key determinant of Dengue transmission, particularly among occupationally exposed groups such as dairy farmers, assessing their knowledge and practices provides complementary evidence for designing interventions that can reduce both disease incidence and its associated economic burden. Therefore, the present study had two objectives: (i) to estimate the economic burden of Dengue fever in Kerala using a DALY-based Human Capital Approach and (ii) to assess Dengue awareness among small-scale dairy farmers in Wayanad district.

Materials and Methods

Study type

A longitudinal secondary data and cross-sectional study was conducted among dairy farmers in Wayanad District using multi-stage sampling.

Participants

The study involved small-scale dairy farmers, with the inclusion criteria that participants be residents of Wayanad district, Kerala, for over a decade and possess at least 5 years of experience in dairy farming. Informed consent was collected from participants who fulfilled the criteria, and those who didn't were excluded from the study.

Study area

Kerala is the south-western coastal state in India with a unique climatic condition, characterised by heavy rainfall and humidity, which makes it a perfect breeding ground for vector-borne diseases. While, Wayanad is the 12th revenue district in Kerala and a rural district with 74.2 percent of its total land area covered with forest. The livestock sector is one of the major sub-sectors in the district's agriculture sector, with 29 per cent of Gross State Value Added (GSVA) (14) contributed to the state economy.

Sample size determination

According to the Dairy Development Department (2022), Wayanad district is home to 19,129 dairy farmers, and livestock farming, particularly cattle, is a key source of income (15). Using the Krejcie & Morgan formula for sample size determination (16), it was calculated that a sample of 377 farmers would be suitable for the study. Consequently, a questionnaire was distributed to 400 dairy farmers to gather insights and responses. After excluding incomplete data, the analysis was conducted on a final sample of 382 farmers from the study area, divided into three geographical clusters: Sulthan Bathery (n = 155), Kalpetta (n = 136), and Mananthavady (n = 91).

Study instrument and validation

A well-structured questionnaire was used in the primary survey to understand the Knowledge, Attitude, and Practice (KAP) of dairy farmers. The researcher designed a questionnaire containing 04 questions regarding knowledge of Dengue fever, followed by 03 questions on Attitude, and 02 questions on practices used to prevent the disease. The content of the questionnaire was validated by experts (Scale-Level Content Validity Index (S-CVI) of 0.98 and test-retest reliability of 0.8 (17), which is within the acceptable range.

Data analysis

The secondary data on Disease-Adjusted Life Years (DALYs) were collected from the Institute of Health Metrics Global Disease Burden (IHME-GBD) Database (18, 19), followed by the Gross State Domestic Product (GSDP) Per Capita (in Constant prices) from the Department of Economics and Statistics, Government of Kerala (14). The DALYs were taken for the entire population for all ages and genders from the database, while the GSDP was interpolated to convert the financial year to calendar year calculation (taking 2011 as the base year) using the formula:

$$GSDP_{Calendar\ Year} = 0.25 \times FY_{2011-12} + 0.75\ FY_{2012-13}$$

Using the Human-Capital Approach, the economic burden (20) of Dengue fever was calculated using the formula:

$$Economic\ Burden = DALY \times GSDP$$

To facilitate comparison of the economic burden across the study period, all annual economic burden estimates were additionally discounted to a common 2011–12 present-value base using the WHO-recommended annual discount rate of 3% (21), adjusting the value of future health loss to the present value, using the formula:

$$PV = \frac{E}{(1+r)^t}$$

Where E is the Economic Burden, r is the 3 percent discount rate, and t is the number of years elapsed from the start of the study (22). Although discounting is commonly applied to future costs and health outcomes in economic evaluations, it was applied retrospectively in this study to express historical burden estimates in comparable present-value terms by accounting for the time value of money.

Methodology

There are different methods which are used to understand the health literacy, but there is no particular method to analyse the level of awareness (23). Thus, the primary data collected were analysed using the chi-square test and percentage analysis. To assess overall awareness of Dengue fever, each correct or appropriate response was awarded one mark, with no negative marking for incorrect responses (22). The knowledge domain had a maximum score of 8, with one mark awarded for each correct response. Single-response items were scored as one for a correct answer and zero for an incorrect or "Don't know" response, while multiple-response items were scored by awarding one mark for each correctly identified option. The attitude domain comprised three statements measured on a five-point Likert scale ranging from

Strongly Agree to Strongly Disagree. Responses reflecting a positive attitude towards Dengue prevention and control were assigned one mark, while all other responses received zero, yielding a maximum score of 3. The practice domain had a maximum score of 6, with one mark awarded for each appropriate preventive practice reported or correctly identified. The total KAP score ranged from 0 to 17, with higher scores indicating greater awareness of Dengue, which was then converted into a percentage of the maximum possible score. Awareness levels were classified as very low (0–39.9%), low (40–59.9%), moderate (60–79.9%), and high (≥80%). For further analysis, respondents with moderate and high awareness were grouped as having good awareness, whereas those with low and very low awareness were classified as having poor awareness. In addition to the composite awareness score, the knowledge, attitude, and practice domains were analysed and reported separately to provide domain-specific interpretation. The Chi-square test and Fishers-Exact Test was used to examine the association between overall awareness and socio-demographic and farm-level variables.

Results

Socio-demographic and farm-level characters

Among the small-scale dairy farmers, 61.8 percent were male, while 38.2 percent was female, with majority of 65.18 percent living in small household, followed by 34.55 percent in medium and 0.26 percent in large household size. Considering the educational background of the participant, 37.18 percent have primary education. 30.62 with secondary education qualification and 32.20 percent with Higher Secondary and more educational qualification. Moreover, the farm-level variable, herd size emphasised the fact that 36.91 percent with 2 cattle, 36.13 percent with 3 to 5 cattle and 26.96 percent with single cattle as their livestock. Additionally, all the small-scale dairy farmers belong to the Socio-Economic Class I, with ≥9130 Per Capita Income (Rupees per month) in the study (as per B.G Prasad Scale). Overall, this indicates that the small-scale dairy farmers in the study area are economically stable, moderately educated, and actively engaged in livestock rearing within small family-based farming systems.

Table 1. Economic Burden of Dengue Fever in Kerala.

Year	Kerala GSDP Per Capita (in Rs.)	Year	GSDP Per Capita (In Rs.)	DALYs of Dengue in Kerala	Economic Burden of Dengue (in Rs.)	Discounted Economic Burden (3% WHO Standards)
2011-12	108666	2011	108666	8511.86	924949257	924949257
2012-13	115158	2012	113535	9221.81	1046998626	1016503520
2013-14	119105	2013	118118.25	10225.47	1207814485	1138480993
2014-15	123573	2014	122456	10947.48	1340584421	1226824651
2015-16	132116	2015	129980.25	11356.89	1476171671	1311559410
2016-17	141396	2016	139076	11600.69	1613377337	1391713463
2017-18	149650	2017	147586.5	11610.95	1713619492	1435129347
2018-19	159878	2018	157321	11002.20	1730876416	1407360921
2019-20	160506	2019	160349	10656.80	1708806431	1348947576
2020-21	146139	2020	149730.75	9902.50	1482709074	1136373044
2021-22	160791	2021	157128	8723.99	1370783249	1019991474
2022-23	166938	2022	165401.25	9673.39	1599991267	1155867734
2023-24	176072	2023	173788.5	9467.75	1645385539	1154040312

Economic burden of Dengue Fever

The economic burden of Dengue (in absolute term) in Kerala indicated an increasing trend during the study period irrespective of some year-to-year fluctuations. In 2011–12 (Table 1), the estimated economic burden was ₹924.95 million, which increased steadily over subsequent years. A noteworthy rise was observed between 2013–14 and 2017–18, where the burden increased from approximately ₹1.21 billion to ₹1.73 billion. The highest economic burden was recorded in 2018–19 at ₹1.71 billion, indicating the substantial financial impact associated with Dengue-related morbidity and productivity losses during this period.

The economic burden increased from ₹924.95 million in 2011–12 to a peak of ₹1.44 billion in 2017–18, after which it gradually declined, reaching ₹1.15 billion in 2023–24. The fluctuations in economic burden appear to correspond with changes in DALYs and per capita income over time. Overall, the findings indicate that Dengue continues to impose a significant and persistent economic burden on the state economy.

After applying a 3% discount rate according to WHO standards, the discounted economic burden (Table 1) also demonstrated a generally increasing pattern across the study years. The Burden increased from ₹924.95 million in 2011–12 to a peak of ₹1.44 billion in 2017–18, after which it declined over the subsequent years before showing a modest increase to ₹1.16 billion in 2022–23 and remaining relatively stable at ₹1.15 billion in 2023–24. Unlike the undiscounted estimates, the discounted burden did not exhibit a continuous increasing trend throughout the study period.

The highest discounted economic burden was observed in 2017–18, reflecting the combined effect of increasing income levels and sustained disease burden. However, discounting reduced the magnitude of the economic burden estimates compared to the undiscounted values. These findings suggest that even after adjusting for time preference and future value considerations, Dengue imposes a considerable long-term economic burden on Kerala.

Awareness about Dengue Fever

When assessing Dengue fever separately (Figure 1), the composite awareness score regarding Dengue among the study population revealed that a majority of the respondents possessed poor awareness about the disease. According to the findings, 55.76 percent of the respondents fell under the category of “Good Awareness” while 44.24 per cent demonstrated “Poor Awareness”. This indicates that nearly half of the study population lacks adequate knowledge and understanding regarding Dengue fever, its transmission, prevention, and management, with the mean total awareness score for Dengue fever was found to be 10.75 ± 2.03, reflecting a moderate level of overall awareness among the study population.

Looking into the individual components (Figure 2), knowledge regarding Dengue fever showed that the majority of respondents possessed either high or moderate levels of knowledge. About 42.10 percent of the respondents had a high level of knowledge, while 41.90 percent demonstrated a moderate level of knowledge regarding Dengue fever. In contrast, 16 percent of the respondents had a low level of knowledge, and none of the respondents fell under the category of very low knowledge with mean knowledge score was 6.07 ± 1.16, indicating comparatively better understanding among the respondents.

Attitude towards Dengue revealed generally poor attitudes among the respondents, with a mean attitude score of 1.25 ± 0.91 (maximum possible score = 3). A majority of the respondents (64.70%) were classified as having a "Very Low Attitude" towards Dengue prevention and control, indicating limited concern or seriousness regarding the disease. In contrast, 24.30% demonstrated a "Moderate Attitude", while only 11.0% exhibited a "High Attitude". Because the attitude domain comprised only three items, these categories should be interpreted cautiously, as the limited number of attainable scores results in relatively coarse classification. While, practices towards Dengue prevention showed mixed levels of preventive behaviour among the respondents. The largest proportion of respondents (36.90 percent) belonged to the “Very Low Practice” category, indicating inadequate adoption of preventive measures against Dengue. Meanwhile, 28.80 percent of the respondents demonstrated moderate practices, and 25.70 percent showed high levels of preventive practices. Only 8.60 percent of respondents were classified under the “Low Practice” category, with the mean practice score was 3.43 ± 1.54.

Looking into the relationship with socio-demographic and farm-level variables with awareness (Table 2), gender (*p-value* = 0.843), level of education (*p-value* = 0.117), household size (*p-value* = 0.442), and herd size (*p-value* = 0.076) reinforces the lack of significant relationships across these variables with the awareness.

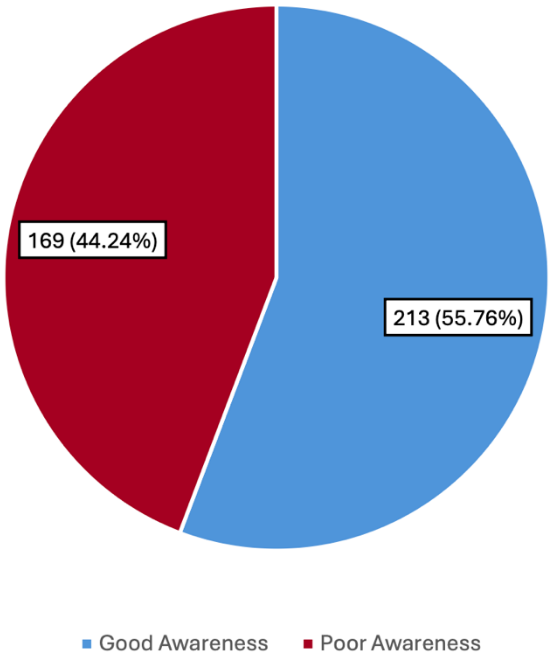

Fig. 1. Overall Awareness of Dengue Fever

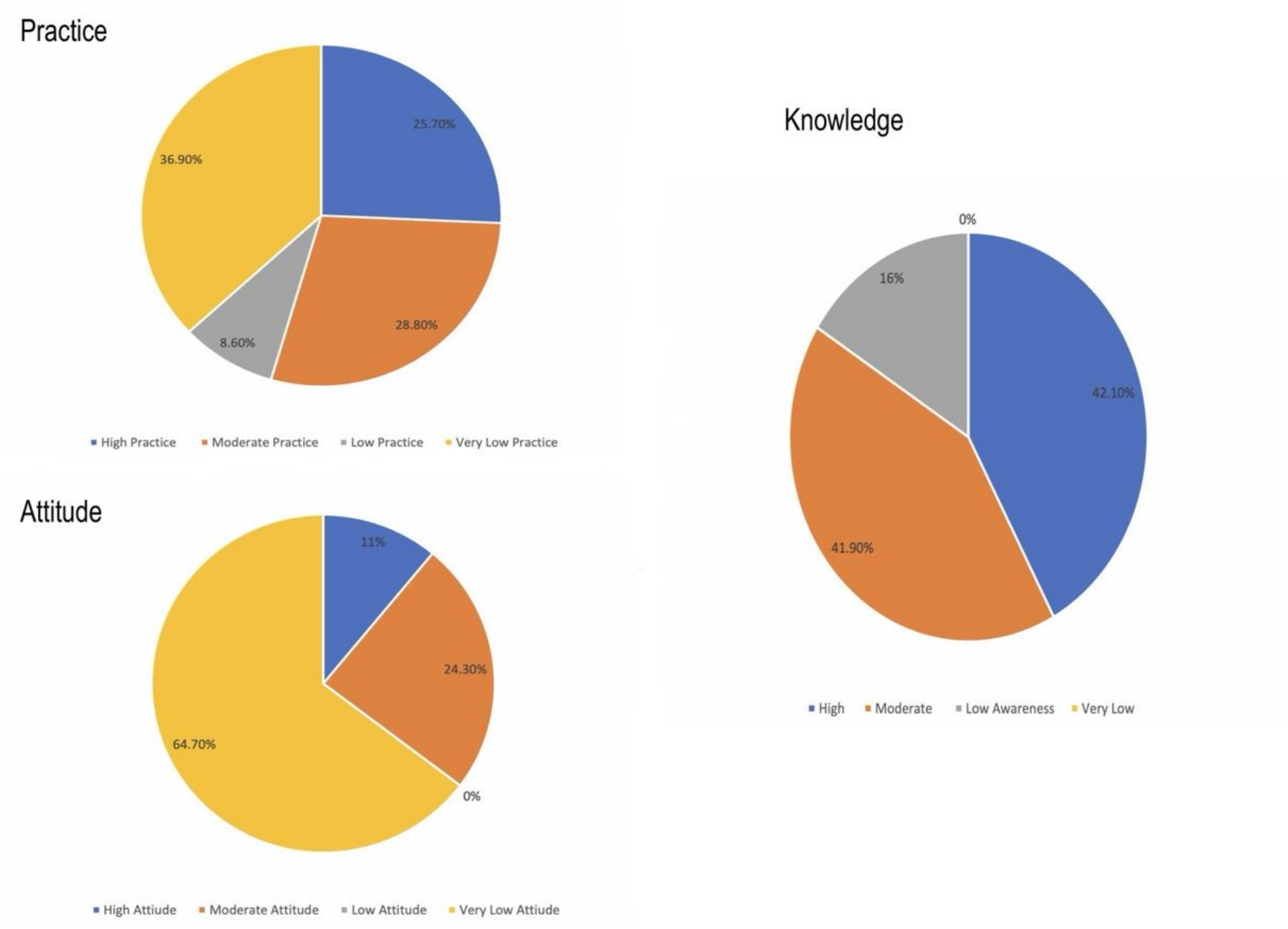

Fig. 2. KAP of Dengue Fever

Table 2. Association between awareness and socio-demographic and farm-level variables

		Dengue Awareness Good	Dengue Awareness Poor	Test	Value	df	Asymptotic Sig. (2-sided)
Gender	Female	110	89	χ^2	0.039	1	0.843
	Male	103	80				
Level of Education	Higher Secondary and more	52	54	χ^2	4.298	2	0.117
	Primary	91	56				
	Secondary	70	59				
Household Size	Large	0	1	Fisher Exact Test			0.475
	Medium	71	61				
	Small	142	107				
Herd Size	1	67	71	χ^2	5.15	2	0.076
	2	83	58				
	3	64	39				

*significant at 0.01 & 0.05 level

Discussion

The present study provides a comprehensive assessment of Dengue in Kerala by combining a state-level estimation of its economic burden with a community-level evaluation of awareness among small-scale dairy farmers. While the economic burden analysis quantifies the financial impact of Dengue on the state economy, the awareness assessment identifies behavioural factors that may influence disease transmission and prevention. Together, these findings provide complementary evidence to inform public health policies aimed at reducing both the incidence and socioeconomic consequences of Dengue.

The study revealed that the economic burden of Dengue fever in Kerala increased considerably from ₹924.95 million in 2011–12 to ₹1.65 billion in 2023–24, indicating the growing financial impact of Dengue on the state economy. Even after applying a 3 per cent discount rate, the burden remained substantially high, emphasising the long-term economic consequences of Dengue-related morbidity and productivity losses. The discounted estimates should be interpreted as present-value equivalents referenced to the 2011–12 base year rather than as the actual annual economic losses incurred in each year. The retrospective application of the WHO-recommended 3% discount rate was intended to express the economic burden on a common present-value basis, thereby facilitating comparison across the study period. Consequently, the lower discounted estimates observed in the later years primarily reflect the cumulative effect of discounting, in addition to variations in DALYs and GSDP per capita, rather than indicating a decline in the actual economic burden of Dengue. Similar findings have been reported in earlier studies, highlighting the increasing healthcare expenditures and socioeconomic burden associated with Dengue outbreaks (24). The rising financial burden further highlights the importance of strengthening vector control measures, surveillance systems, and preventive public health strategies to reduce the economic impact of Dengue (25). In addition, climatic and environmental changes may further intensify Dengue transmission and increase health care costs in endemic regions (26). Therefore, adopting evidence-based prevention frameworks and detailed costing approaches is essential for efficient resource allocation and disease management (27). Although the economic burden analysis demonstrates the magnitude of productivity losses associated with Dengue in Kerala, reducing this burden requires effective preventive measures at the community level. Behavioural interventions, supported by adequate knowledge and appropriate preventive practices, remain essential components of Dengue control. Therefore, the awareness assessment among dairy farmers complements the economic burden findings by identifying gaps that may contribute to the continued transmission of Dengue and the persistence of its associated economic burden.

The socio-demographic analysis revealed that the majority of small-scale dairy farmers were men, came from small families, and had either primary or secondary education. Despite all participants belonging to Socio-Economic Class I, over half exhibited limited awareness of Dengue fever. The average awareness score reflected only a moderate level of understanding, indicating that favourable socioeconomic conditions alone might not guarantee sufficient knowledge and preventive actions against Dengue. In rural regions of South Asia, Dengue comprehension is generally limited, often ranging from low to moderate levels. For example, in rural Tamil Nadu, only approximately one-third of the population demonstrated adequate knowledge of diabetes (28). In central Nepal, only 40.6% of individuals were aware of Dengue, with only 2.3% achieving a high knowledge score (29). In the high-risk lowland areas of Nepal, the knowledge level was moderate rather than high (30).

In Bangladesh, although initial awareness is relatively high, the depth of understanding remains inadequate. Nationally, 93.8% of the population had heard of Dengue; however, misconceptions regarding Aedes mosquito breeding sites and biting times persisted (31). In rural Bangladesh, respondents correctly answered an average of 66.15% of knowledge questions, which the authors still considered moderate, and preventive practices averaged only 53.69% (32). Similar findings have been observed in rural and agricultural populations in earlier studies (13).

The research revealed that the participants possessed relatively good knowledge of Dengue, with the majority demonstrating moderate to high levels of knowledge. However, this knowledge did not translate into positive attitudes or adequate preventive practices. A substantial proportion of participants exhibited very low attitude scores and inadequate preventive behaviours, highlighting a clear gap between knowledge and behavioural change. A significant number of participants showed a very low inclination towards Dengue prevention, and a notable portion exhibited insufficient preventive actions. These results highlight a disconnect between knowledge and actual behaviour, a pattern observed in previous studies on mosquito-borne illnesses (33). Misunderstandings about mosquito breeding, environmental cleanliness, and transmission methods may lead to poor preventive behaviour and reactive disease management strategies (34). Additionally, the lack of ongoing health education and community involvement programs may hinder the conversion of knowledge into effective preventive measures (35). The association analysis did not find any significant connections between awareness and socio-demographic or farm-level factors, including gender, education, household size, and herd size. This implies that a lack of awareness was consistently present across the study population, regardless of their background characteristics. Previous studies have reported similar outcomes, where socioeconomic factors were not significant indicators of Dengue awareness (29). Consequently, it is essential to implement community-wide health education and behavioural change programs to enhance awareness, attitudes, and preventive practices related to Dengue fever among small-scale dairy farming communities.

Conclusion

Dengue fever continues to place a significant and growing economic strain on Kerala, with both absolute and adjusted estimates showing an upward trend during the study period. Although the participants were from a relatively stable socioeconomic background with moderate education levels, the majority lacked sufficient awareness of Dengue fever. While their knowledge of Dengue was relatively adequate, their attitudes and preventive measures were lacking, highlighting a notable gap between understanding and practical application. Additionally, no significant link was found between awareness and socio-demographic or farm-level factors, implying that awareness gaps were evenly spread across the population. Taken together, the state-level economic burden estimates and the community-level awareness findings indicate that reducing the financial impact of Dengue requires not only improved surveillance and vector control but also strengthened public awareness and behavioural change interventions among high-risk populations. These results underscore the urgent need for comprehensive community-based health education initiatives, behavioural change interventions, and enhanced vector control strategies to improve Dengue prevention practices and alleviate the long-term socioeconomic impact of Dengue fever among small-scale dairy farming communities.

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Conflict of Interest

The author declares no competing interests.

Ethical approval

The study was granted ethical clearance from the Institutional Ethical Committee on Human Subjects (IECH) at Vellore Institute of Technology (Ref. no. VIT/IECH/XIV/2023/18) for conducting the study and was performed in accordance with the ethical standards down by 1964 Declaration of Helsinki and its amendments.

Artificial Intelligence Statement

The author(s) would like to declare that no LLM model was used to create the methodology, analysis or interpretation of the paper. Any use of AI-assisted tools, were strictly limited to language editing and improving the clarity and readability of the manuscript.

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