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Muhammad Belal Hossain * , Sadia Choudhury Shimmi , M Tanveer Hossain Parash , Phoebe Tran

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Article

Public Health Communication on Emerging Vector-Borne Disease Risk in Remote Regions of South and Southeast Asia

Muhammad Belal Hossain [1]*, Sadia Choudhury Shimmi [2], M Tanveer Hossain Parash [3] and Phoebe Tran [4]

[1] Department of Ecology and Evolutionary Biology, University of Tennessee, Knoxville, TN 37996, USA
[2] Department of Biomedical Sciences, Faculty of Medicine and Health Sciences, Universiti Malaysia Sabah, Sabah, Malaysia
[3] Borneo Medical and Health Research Centre, Faculty of Medicine and Health Sciences, Universiti Malaysia Sabah, Sabah, Malaysia
[4] Department of Public Health, University of Tennessee, Knoxville, TN 37996, USA
* Correspondence: author: Muhammad Belal Hossain 447 Hesler Biology Building, Knoxville, TN 37996 mhossa21@vols.utk.edu

Abstract: Vector-borne diseases (VBDs) continue to pose a persistent global health challenge, disproportionately impacting low- and middle-income countries where surveillance and healthcare infrastructure are constrained. Within these countries, residents of remote island communities are particularly vulnerable to emerging VBD threats, however, they remain critically understudied. We conducted a community-based cross-sectional survey of 300 residents from Shahpori Island, Bangladesh, and Gaya Island, Malaysia, to assess knowledge, attitudes, and practices (KAP) related to VBDs. Using a structured questionnaire and mixed-effects Poisson regression modeling, we identified socio-demographic predictors of VBD-related knowledge and compared KAP outcomes across the two islands. Significant disparities were observed between two settings: Gaya Island residents demonstrated a higher level of awareness regarding VBDs and preventive practices compared to Shahpori residents. Education was a strong predictor of VBD knowledge, with individuals possessing secondary education or above exhibiting significantly better knowledge (β = 0.2024, p = 0.0003). Marital status was also a significant factor, with unmarried respondents showing lower levels of knowledge (β = –0.1657, p = 0.0372). Age was positively corelated with VBD knowledge (β = 0.0051, p = 0.0119), indicating gradual increase with age, while income, gender, occupation, and household size were not significantly associated. Despite basic awareness of VBD symptoms and transmission, detailed understanding of mosquito ecology, disease symptoms, and breeding prevention strategies was remarkably poor, especially among Shahpori residents. Our findings highlight critical gaps in VBDs related knowledge and prevention behaviors shaped by socio-economic and educational disparities. Community-focused public health strategies including educational campaigns, establishment of health infrastructure, access to trained health-care providers, and integrated vector control interventions are urgently needed to enhance resilience against emerging VBD threats such as drug-resistant malaria in remote island populations.

Keywords: Vector-borne disease; remote island communities; public health interventions; Asia

1. Introduction

Vector-borne diseases (VBDs) represent a significant global public and animal health challenge in the twenty-first century. These diseases are caused by pathogens transmitted through the bites of infected arthropods, including mosquitoes, fleas, sandflies, black flies, ticks, and bugs [1]. VBDs

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account for more than 17% of all cases of infectious diseases, resulting in more than 700,000 deaths per year worldwide [2]. A significant number of VBDs are prevalent in Asia such as dengue, malaria, chikungunya, leishmaniasis, yellow fever, lymphatic filariasis, Japanese encephalitis, and schistosomiasis [3]. Recently, highly infectious fatal tick-borne diseases such as Crimean-Congo haemorrhagic fever, Kyasanur forest disease, and fatal tick-borne encephalitis have emerged in South and Southeast Asia [4, 5]. Despite the significant vector borne disease burden, challenges persist in acquiring comprehensive data due to insufficient disease surveillance, inadequate diagnostics, and limited public health awareness.

VBD poses a risk to all nations irrespective of their socio-economic status, with vulnerability heightened where disease surveillance programs are absent particularly in low- and middle-income countries. Bangladesh and Malaysia, both characterized by high population density, rapid urbanization, geographic features conducive to VBD outbreaks, have recently faced significant VBD threats including dengue, Zika virus, and chikungunya. Dengue remains a major concern in both countries, with numerous outbreaks between 2010 and 2023 resulting in thousands of cases and several hundred deaths annually [6-9]. The geographic range of emerging VBDs, such as Zika virus, Japanese encephalitis, and yellow fever, has also expanded in South and Southeast Asia, with routine detection in both countries [10-13]. While malaria was once a major concern, it has been effectively controlled in both nations in recent years with a decline in mortalities attributed to continuous public health campaigns [5].

Despite the significant challenges posed by VBDs to global health, particularly in low- and middle-income countries, control efforts have predominantly targeted urban localities. The challenges are often more severe in remote areas where low literacy rate, social prejudice, climatic vulnerabilities, and inadequate healthcare infrastructures exacerbate the problems. Remote areas, such as islands and hill tracts, present even greater difficulties due to their perceived inaccessibility, harsh weather conditions, and limited resources. Gaya Island, the largest island in the Tunku Abdul Rahman (TAR) Marine Park, situated near Kota Kinabalu in Sabah province of Malaysia, and Shahpori Island in Bangladesh, located across the maritime borders between Bangladesh and Myanmar, share similar geographic characteristics. Both islands are highly vulnerable to climate change, isolated, and constrained by limited resources, resulting in a lack of medical care facilities for residents.

The level of public health preparedness and awareness of disease risks, especially regarding emerging vector-borne diseases remains largely unknown in these island communities. Given the challenges and resource constraints, understanding how these underserved populations address the threats posed by VBDs is critical for the development of effective prevention, intervention, and control strategies. Moreover, enhancing education and knowledge dissemination about VBDs and mosquito control practices could help change residents' attitudes and encourage the adoption of protective behaviors. Previous knowledge, attitude, and practice (KAP) studies conducted in various regions of Malaysia and Bangladesh have highlighted significant knowledge gaps regarding VBD transmission, prevention, vector biology, and control measures [14]. However, most of these studies have been conducted in highly accessible areas, such as cities or municipalities, and have not specifically targeted remote or marginalized island communities or focused on emerging VBDs. Therefore, this study aims to assess the knowledge, attitudes and practices towards VBDs in the remote localities of South and Southeast Asia.

2. Materials and Methods

2.1. Study Settings, Timeline, & Data Collection

We carried out a community based cross-sectional survey in two remote Islands: Gaya Island, Sabah, Malaysia (Figure 1), and Shahpori Island, Cox's Bazar, Bangladesh (Figure 2). A total of 300 adult participants (150 from Gaya Island and 150 from Shahpori Island) were enrolled from the local populations of both islands. Participants were selected using a simple random sampling method,

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with inclusion criteria specifying individuals who were native and had been residents of the study Islands for more than five years.

Between November 2018 and February 2020, we recruited study participants from the selected communities. Upon explaining the study objectives, participants provided oral consent and completed the pretested questionnaire The questionnaire covered various aspects of VBDs including demographics; socio-economic characteristics (such as gender, age, marital status, education level, employment status, occupation, income, and number of household members); knowledge and experiences with VBDs; attitudes and practices related to VBD prevention and control. Trained interviewers administered the questionnaire, simplifying questions as needed using the local dialect.

Participation was entirely voluntary, and no incentives were offered. The study protocol received approval from the University of Malaysia Sabah (UMS) Institutional Review Board for Research, prior to implementation in the field.

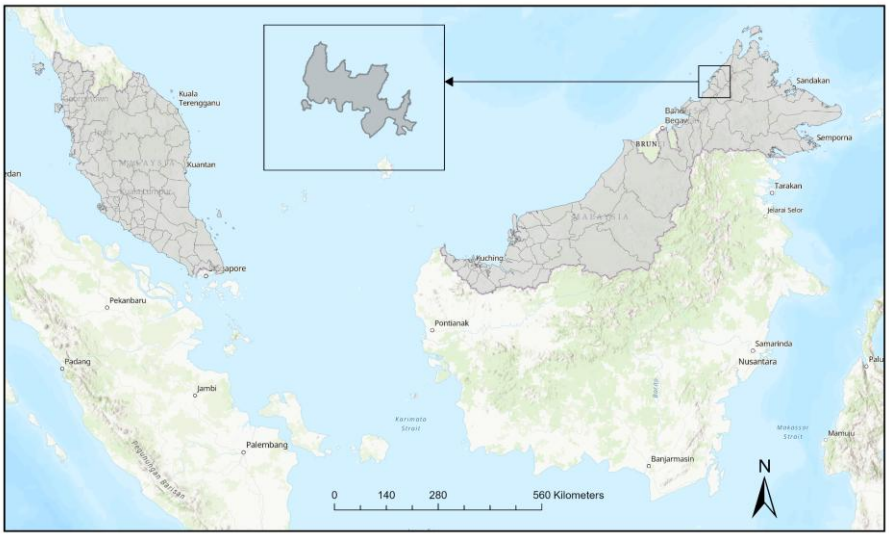

Figure 1. Map of the study area in Gaya Island, Sabah, Malaysia.

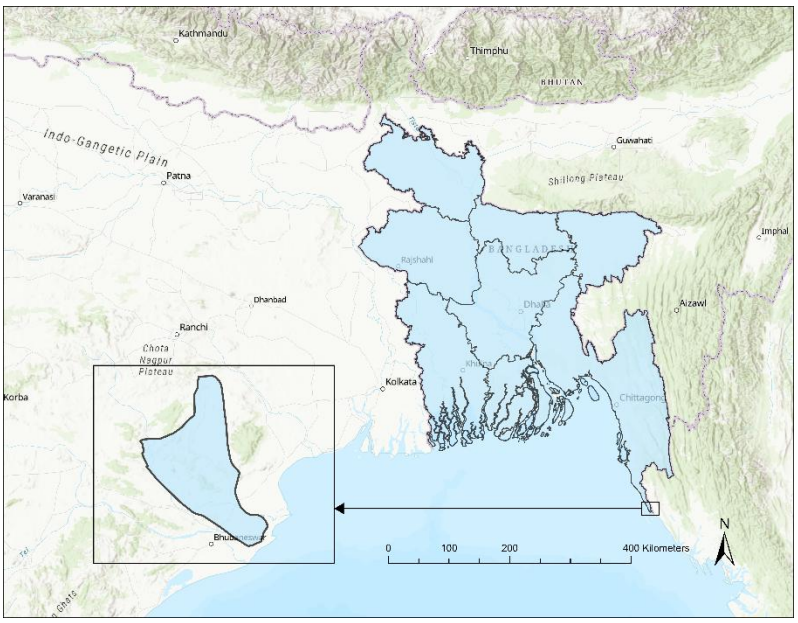

Figure 2. Map of the study site in Shahpori Island, Cox's Bazar, Bangladesh.

2.2. Data Analysis

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Descriptive statistics were used to summarize the socio-demographic and VBD-related characteristics of participants from Gaya Island, Malaysia and Shahpori Island, Bangladesh. Frequency distributions and percentages were calculated separately for each island and for the combined data across both locations. Comparative analyses were performed to assess socio-demographic differences between the islands, using chi-square tests for categorical variables and Wilcoxon rank-sum tests for continuous variables, when normality assumptions were violated. The normality of continuous variables was assessed using the Shapiro-Wilk test, and non-parametric tests were applied for variables that did not meet normality ($p < 0.05$). A questionnaire was administered to 150 residents on each island, focusing on VBD-related questions. For each participant, the percentage of correct answers was calculated to create a continuous outcome variable reflecting overall VBD knowledge. This measure represents the proportion of correct responses out of the total questions answered, providing a continuous measure of VBD knowledge for each participant.

To identify the factors associated with knowledge of VBDs, a mixed-effects Poisson regression model was employed. This approach allowed us to account for both individual-level predictors and island-level differences between Shahpori and Gaya islands. The fixed effects in the model included demographic variables such as age, gender, education level, income, household size, occupation, and exposure to health communication. Random effects were incorporated to account for variability at the island level, capturing unobserved island-specific factors, as well as individual-level variations in VBD knowledge not explained by the fixed effects. Model fit was evaluated using a range of statistics, including Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), -2 Res Log Pseudo-Likelihood, and Generalized Chi-Square/DF ratio. These fit statistics helped us to assess the adequacy of the model in accounting for the observed data. Specifically, the Generalized Chi-Square/DF ratio of 0.98 indicated a good model fit, with no evidence of over- or under dispersion. The significance of the fixed effects was evaluated through Wald tests or likelihood ratio tests. Statistical significance was considered at $p < 0.05$ for all analyses. Data analysis was conducted using SAS version 9.4.

3. Results

A total of 300 participants were surveyed, with 150 from each island. There was a significant disparity in the gender distribution between the islands. Due to the absence of female interviewers in Shahpori Island, only one female respondent was included, which resulted in 99.3% of participants from Shahpori Island being male. In contrast, Gaya Island had a balanced gender distribution, with 50% male and 50% female participants. No significant difference in marital status was observed between the islands ($p = 0.5139$). A higher proportion of respondents from Gaya Island reported higher education levels compared to those from Shahpori Island, with 54.6% of Gaya respondents having completed secondary school or higher, compared to just 22.6% on Shahpori Island ($p < 0.0001$). Gaya islanders also reported significantly higher average monthly incomes (USD 170.97) compared to Shahpori islanders (USD 130.03) ($p < 0.0001$). The mean age of respondents from Shahpori Island (35.64 years) was significantly younger than that of Gaya Island (39.4 years) ($p = 0.0107$), while mean household size did not differ significantly between the islands ($p = 0.9775$).

Knowledge of VBDs varied significantly between the two islands. A significantly higher proportion of Gaya islanders (98.7%) had heard of vector-borne diseases such as malaria, dengue, chikungunya, and other VBDs, compared to 89.3% of Shahpori islanders ($p = 0.001$). While most respondents from both islands recognized fever as a symptom of VBDs, Gaya islanders demonstrated much greater awareness, with 89.3% correctly identified that fever as a symptom, compared to only 42.7% on Shahpori Island ($p < 0.0001$). Gaya respondents also had a better understanding of the primary cause of these diseases, with 94.7% identifying mosquito bites as the main transmission route, compared to 70% on Shahpori Island ($p < 0.0001$; Table 2).

A higher proportion of Gaya islanders (42.7%) were aware of the importance of preventing or destroying mosquito breeding sites, while none of the respondents from Shahpori Island were aware of this practice ($p < 0.0001$). Regarding prevention methods, residents of Shahpori Island were more

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likely to report using bed nets (52.7%) compared to Gaya islanders (24%), whereas Gaya islanders preferred a combination of bed nets and mosquito coils (23.3%). In terms of treatment costs, significantly more Gaya islanders (54%) reported spending money on treatment for mosquito-borne diseases than Shahpori islanders (16%) ($p < 0.0001$). Furthermore, Gaya islanders primarily sought medical care from government hospitals (98.7%), while Shahpori islanders tended to use rural unregistered healthcare providers (61.3%) ($p < 0.0001$; Table 3).

Significant predictors of KAP regarding VBDs were identified through Poisson regression analysis. Occupation categories did not exhibit significant associations with VBD-related knowledge. Specifically, the β for the "business" category (β = 0.05840) suggested a marginal increase in VBD knowledge among individuals in this category, but this effect was not statistically significant ($p = 0.4042$). Similarly, the occupation categories "private job" (β = -0.02526), "housewife" (β = -0.03913), and "other occupation" (β = 0.01046) showed no significant associations with VBD knowledge, with p-values exceeding 0.05 ($p = 0.7621$, $p = 0.6980$, and $p = 0.8770$, respectively). Education was identified as a significant predictor of VBD knowledge, attitudes, and practices. Individuals with higher education levels (secondary school or above) demonstrated significantly better knowledge of VBDs (β = 0.2024, $p = 0.0003$). Marital status was also a significant predictor, with unmarried or single respondents exhibiting lower knowledge levels compared to their married counterparts (β = -0.1657, $p = 0.0372$). Age was a positive predictor of VBD knowledge, with each additional year of age contributing to a slight increase in VBD awareness (β = 0.005125, $p = 0.0119$). Income did not emerge as a significant predictor of VBD knowledge, as the negative β (β = -0.00017) suggested a marginal decrease in VBD knowledge with higher income, but this effect was not statistically significant ($p = 0.5589$). Household members/size also did not significantly impact VBD knowledge (β = 0.001985, $p = 0.8086$). Gender was not significant also.

Table 1. Comparative socio-demographic characteristics between Shahpori and Gaya islands.

Variables	Shahpori Island N=150 n (%)	Gaya Island N=150 n (%)	Total (Combined for Both Islands) N = 300 n (%)	*p* Value
Gender identity				
Male	149 (99.3)	75 (50)	224 (74.7)	
Female	1 (0.7)	75 (50)	76 (25.3)	
Marital status				0.5139
Single	20 (13.3)	24 (16)	44 (14.7)	
Married	130 (86.7)	126 (84)	256 (85.3)	
Education level				**<0.0001**
Low (elementary)	116 (77.3)	68 (45.3)	184 (61.3)	
High (secondary and above)	34 (22.6)	82 (54.6)	116 (38.6)	
Current occupation				**<.0001**
Business	47 (31.3)	18 (12)	65 (21.6)	
Day labor	57 (38)	22 (14.6)	79 (26.3)	
Private service	24 (16)	11 (7.3)	35 (11.6)	
Housewife	0 (0)	50 (33.3)	50 (16.6)	
Other occupation	22 (14.6)	49 (32.6)	71 (23.6)	
Mean age in years	35.64	39.4	37.52	**0.0107**
Mean household members	6.63	6.77	6.69	0.9775
Mean income (USD)	130.03	170.97	150.5	**<.0001**

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Table 2. Population knowledge concerning vector-borne disease transmission, symptoms, and other factors among the respondents between two islands.

Characteristics/ Questions	Shahpori Island N=150 n (%)	Gaya Island N=150 n (%)	Total N=300 n (%)	*p* value
Have you ever heard about malaria/ dengue/ chikungunya/ Zika/ yellow fever/ Japanese encephalitis/ filariasis or other emerging vector-borne disease?				
Yes	134 (89.3)	148 (98.7)	282 (94)	**0.001**
No	16 (10.67)	2 (1.3)	18 (6)	
How long have you known about vector-borne emerging disease?				
Mean duration (in months)	17.06	27.77		0.8616
Do you know the symptoms of vector-borne diseases?				
Fever	64 (42.7)	134 (89.3)	198 (66)	**<0.0001**
Fever with shivering, joint pain, rash, lymph node swelling, seizure, convulsion, eye problems, or anaemia	50 (33.3)	14 (9.3)	64 (21.3)	
Other compatible symptoms	0 (0)	1 (0.7)	1 (0.3)	
Do not know	36 (24)	1 (0.7)	37 (12.3)	
Do you know about the possible causes of vector-borne emerging diseases?				
Mosquito bite	105 (70)	142 (94.7)	247 (82.3)	**<0.0001**
Not maintaining environmental cleanliness	0 (0)	4 (2.7)	4 (1.3)	
Reasons unrelated to mosquito or cleanliness	0 (0)	4 (2.7)	4 (1.3)	
Do not know	45 (30)	0 (0)	45 (15)	
Do you know why someone can get infected with vector-borne diseases?				
Bite from a mosquito	103 (68.7)	132 (88)	235 (78.3)	**<0.0001**
Exposure to flies, ticks, or insects	1 (0.7)	0 (0)	1 (0.3)	
Not maintaining cleanliness in the surrounding environment	0 (0)	7 (4.7)	7 (2.3)	
Do not know	46 (30.7)	11 (7.3)	57 (19)	

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Table 3. Population attitude and prevention practices of vector-borne disease between two islands.

Characteristics	Shahpori Island N=150 n (%)	Gaya Island N=150 n (%)	Total N=300 n (%)	*p*-Value
Do you know how to prevent or control mosquito-borne diseases?				**<0.0001**
Prevent or destroy breeding site of mosquito	0 (0)	64 (42.7)	64 (21.3)	
Using bed nets	79 (52.7)	36 (24)	115 (38.3)	
Using mosquito repellent coils	24 (16)	3 (2)	27 (9)	
Combination of bed nets and coils	0 (0)	35 (23.3)	35 (11.7)	
Others	0 (0)	9 (6)	9 (3)	
Do not know	47 (31.3)	3 (2)	50 (16.7)	
How do you confirm/diagnose a case of mosquito-borne disease?				**<0.0001**
Presence of fever	28 (18.7)	144 (96.6)	172 (57.3)	
Blood test results	23 (15.3)	0 (0)	23 (7.7)	
Do not know	99 (66)	4 (2.7)	103 (34.3)	
Others/traditional	0 (0)	1 (0.7)	1 (0.3)	
Have you ever spent money on the treatment of mosquito-borne diseases?				**<0.0001**
Yes	24 (16)	81 (54)	105 (35)	
No	95 (63.3)	68 (45.3)	163 (54.3)	
Unsure/ Don't know	31 (20.7)	1 (0.7)	32 (10.7)	
Where do you usually seek medical treatment?				**<0.0001**
Government hospital	10 (6.7)	148 (98.7)	158 (52.7)	
Private health-care Center	3 (2)	2 (1.3)	5 (1.7)	
Rural unregistered health-care provider	92 (61.3)	0 (0)	92 (30.7)	
Unsure/ family or neighbours' suggestion	45 (30)	0 (0)	45 (15)	
What are the measures you would like to take to tackle vector-borne disease in future?				**<0.0001**
Destroying larva/mosquito breeding sites	1 (0.7)	49 (32.7)	50 (16.7)	
Using bed nets	92 (61.3)	47 (31.3)	139 (46.3)	
Administering insecticide & practice of bed nets	3 (2)	1 (0.7)	4 (1.3)	
Mosquito repellent coil	9 (6)	33 (22)	42 (14)	
Others/traditional protective measures	0 (0)	17 (11.3)	17 (5.7)	
Do not know	45 (30)	3 (2)	48 (16)	
Where could you receive treatment if you were diagnosed with a mosquito-borne disease?				**<0.0001**
Government hospital	44 (29.3)	150 (100)	194 (64.7)	
Private hospital or health-care center	6 (4)	0 (0)	6 (2)	

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Unregistered health-care providers/ pharmacy salesperson	55 (36.7)	0 (0)	55 (18.3)
Do not know	45 (30)	0 (0)	45 (15)

Table 4. Predictors of vector-borne disease knowledge, attitude and practices among residents of both islands in Bangladesh and Malaysia.

Variables	Estimate	Standard Error	t-Value	Pr > |t|
Occupation				
Business	0.05840	0.06991	0.84	0.4042
Private job	-0.02526	0.08337	-0.30	0.7621
Housewife	-0.03913	0.1007	-0.39	0.6980
Other occupation	0.01046	0.06752	0.15	0.8770
Day labor (Ref)	0			
Education				
High (high school and above)	0.2024	0.05489	3.69	**0.0003**
Low (elementary - ref)	0			
Marital status				
Unmarried or single	-0.1657	0.07914	-2.09	**0.0372**
Married (Ref)	0			
Gender				
Female	0.04335	0.08104	0.53	0.5931
Male (Ref)	0			
Age (in years)	0.005125	0.002025	2.53	**0.0119**
Income (USD)	-0.00017	0.000287	-0.59	0.5589
Household size	0.001985	0.008190	0.24	0.8086

4. Discussion

Our study revealed considerable disparities in knowledge, attitude, and prevention practices regarding VBDs between the islands of Shahpori (Bangladesh) and Gaya (Malaysia), despite their similar remote geographical settings. The socio-economic and educational status significantly differed between the two islands. Only 22.6% of Shahpori residents had completed their post-high school education, whereas 54.6% of Gaya residents had attained a similar level of education. Education has long been recognized as a key determinant of health, and our findings align with previous studies that suggest a correlation between low educational attainment and limited VBD-related knowledge [15-19]. While both islands have a limited number of educational institutions, Shahpori Island suffers from an insufficient provision of educational facilities in contrast to its counterpart.

The occupational distribution among the residents of both islands exhibited similarities, encompassing roles such as small-scale business owners, day laborers, low-income private service, housewife, fishermen, and farmers. In Gaya, many participants were housewives but contributed to the family income by selling handmade mats, crafts made from shells and other sea products in the nearby market. A small proportion of these homemakers made shell ornaments and sold them in the nearby municipalities for their livelihood. The residents of Gaya often commuted to Kota Kinabalu, the capital of Sabah, where they engaged in various occupations such as day laborers, small-scale business, or shopkeepers. Meanwhile, we observed a slightly different pattern in Shahpori Island, where all the participants were predominantly male workforce, with men playing the primary role in supporting family income. Most of our respondents were day laborer in Gaya Island (38%).

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Residents from both islands frequently commute to nearby municipalities by engine boat or speed boat, however, during dry season, residents of Shahpori can commute to the mainland on foot.

Despite these socio-economic differences, participants from both islands exhibited a basic level of awareness regarding VBDs, with only a small fraction of respondents (6%) reporting no prior knowledge or having never heard of mosquito-borne diseases. In our study, 12.3% of respondents were unaware of symptoms associated with emerging VBDs such as Zika virus and Chikungunya. The majority of the participants on both islands recognized that mosquito bites could lead to mosquito-borne diseases, consistent with the findings reported in different other settings in both countries and other geographic regions of different countries [20-22]. Interestingly, only 2.6% of our respondents were aware of other potential causes of VBDs other than mosquito bites, suggesting significant gaps in understanding the broader etiologies of VBDs.

In terms of preventive measures, Gaya Island residents demonstrated better awareness than those from Shahpori counterparts. However, both populations lack knowledge of the detailed life cycle of mosquitoes, mosquito breeding sites, and the natural history of the diseases. While respondents from both islands recognized mosquito bites as a key risk factor and reported using preventive measures such as mosquito nets and repellents, the actual prevalence and implementation of these measures were relatively low compared to other regions [23, 24]. The disparity in prevalence may arise from spatial and socio-economic discrepancies, limited resources, and the rural nature of these areas. Strategies to prevent the mosquito breeding sites are not commonly adopted in the rural areas of Bangladesh, although some urban areas have implemented mosquito breeding prevention measures [25]. However, at Shahpori island, these practices have never been adopted. Similarly, while there is a comprehensive mosquito prevention program in operation in urban areas of Malaysia [26], no such program has been reported on Gaya Island.

The medical infrastructure and diagnostic capabilities on both islands are significantly limited as reflected in our study findings. While all individuals on Gaya Island reported receiving medical treatment at government health facilities, residents of Shahpori predominantly sought medical care from rural, non-registered practitioners or minimally educated rural pharmacy staff, with government and private healthcare facilities serving as secondary options. The absence of registered medical practitioners in both locations indicates a significant healthcare infrastructure gap. Notably, Gaya Island does not have any 'bomoh' or traditional village healers commonly found in other rural areas of Malysia [26]. The absence of these traditional healers suggests that Gaya residents neither rely on nor perceive traditional healers as primary healthcare providers. This contrasts with the situation on Shahpori Island, where participants frequently depend on non-registered rural practitioners due to the lack of registered medical professionals and infrastructure. Access to healthcare on Shahpori is particularly challenging, as residents must undertake strenuous journeys to the nearest municipality to receive medical care. Previous research in Bangladesh has shown a preference among the majority of individuals to seek medical care from rural, non-registered practitioners, attributed to inadequate medical infrastructure, high poverty rates, and limited availability of registered medical physicians [25].

Although respondents from both islands have limited knowledge about VBDs including their causes, symptoms, and preventive measures, they demonstrated positive attitudes toward VBD prevention. This may be linked to the significant public health implications of VBDs, and the existence of some awareness initiatives disseminated through mass media channels. However, these efforts remain remarkably insufficient given the severe adverse effects of VBDs. Most importantly, VBDs frequently evade diagnosis due to the absence of well-equipped laboratories, technicians, and trained medical professionals, leading to treatments based on presumptive diagnoses or left untreated. Furthermore, Shahpori Island is particularly vulnerable due to ongoing refugee crisis, socio-political unrest, armed conflicts, inadequate immunization, massive ecological degradation, and reports of drug-resistant malaria in the regions [27, 28].

This study has some limitations, including a relatively small sample size and the exclusion of female participants from Shahpori Island due to logistical challenges. The random selection of

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participants in these remote island territories was based on transportation convenience, which may have introduced sampling bias. As a result, the gender comparison between the islands was not possible. Nevertheless, our study provides valuable insights into the gaps in knowledge and prevention practices related to VBDs in remote islands of South and Southeast Asia. These findings underscore the need for targeted public health interventions tailored to the unique socio-economic and geographic contexts of these populations. Furthermore, the implementation of integrated vector control programs is critical for mitigating the health risks associated with VBDs in these vulnerable communities. Coordinated outreach and educational campaigns, particularly those focused on increasing awareness of mosquito breeding sites and encouraging appropriate medical care-seeking behaviors, are crucial steps toward improving the prevention and management of VBDs on both islands.

Ethical approval: The study was approved by the Ethics Committee of Universiti Malaysia Sabah. Written informed consent was obtained from all participants prior to data collection.

CRediT authorship contribution statement: Muhammad Belal Hossain: Conceptualization, Writing – review & editing, Writing – original draft, Software, Project administration, Methodology, Investigation, Formal analysis, Data curation. **Sadia Chowdhury Shimmi**: Conceptualization, Writing – review & editing, Project administration, Visualization, Validation, Supervision, Data curation. **M Tanveer Hossain Parash**: Writing – review & editing, Investigation, Software, Visualization. **Phoebe Tran**: Writing – review & editing, Validation, Methodology, Formal analysis.

Declaration of competing Interests: The authors declare no competing interests.

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Appendix A. Supplementary Table

Table A1. Comparative model fit statistics.

Fit Statistic	Poisson	Negative Binomial
-2 Log Likelihood	1422.77	1463.00
AIC	1446.77	1489.00
AICC	1447.87	1490.29
BIC	1491.01	1536.93
CAIC	1503.01	1549.93
HQIC	1464.48	1508.19
Pearson Chi-Square	276.94	358.75
Pearson Chi-Square / DF	0.98	1.27

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