

Mpox preventive practices and associated factors among adults in a travel-connected setting in Southern Sarawak, Malaysia: a community-based cross-sectional study

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Abstract

Background Mpox remains a relevant public health concern in non-endemic, travel-connected settings, where imported cases may occur despite the absence of sustained local transmission. Southern Sarawak, Malaysia, is a socio-demographically diverse region that includes Kuching District, a major administrative and travel hub, and Padawan sub-district, which includes peri-urban and rural communities. This study aimed to assess Mpox preventive practices and factors associated with good preventive practices among adults in Southern Sarawak.

Methods A community-based cross-sectional study was conducted from January to August 2025 among 442 adults in Southern Sarawak, Malaysia. The minimum sample size was estimated using a single-proportion formula and increased by 15% to account for anticipated non-response, including possible refusals, vacant households, and ineligible respondents unavailable during field recruitment. A multistage sampling design was used: Kuching District and Padawan sub-district within Southern Sarawak were purposively selected, residential localities were selected using simple random sampling, households were selected using systematic random sampling, household members were screened for eligibility, and one eligible adult was randomly selected when more than one eligible respondent was present in a household. A structured questionnaire assessed sociodemographic characteristics, Mpox knowledge, attitudes, digital health literacy, and preventive practice. Preventive practice was measured using six Likert-type items covering precautionary measures, quarantine or isolation, avoidance of crowds, mask use and hand hygiene, public awareness, and perceived adequacy of local authority action, and dichotomised as good and poor, with scores ≥ 22 indicating good preventive practice. Knowledge was assessed using 10 items; scores ≥ 7 indicated good knowledge. Attitude was assessed using seven Likert-scale items; scores ≥ 26 indicated a positive attitude. Digital health literacy was assessed using 10 items adapted from the HLS19-DIGI framework, with scores $\geq 76.19\%$ classified as good digital health literacy. Factors associated with good preventive practice were examined using multivariable binary logistic regression.

Results Among the 442 adults who participated, the median age was 37.5 years (IQR: 30–47), 50.5% were male, and 61.8% resided in urban areas. Overall, 95.0% reported good Mpox preventive practice and 95.2% had a positive attitude, although 64.7% had poor Mpox knowledge and 56.3% had good digital health literacy. The

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final model was statistically significant ($\chi^2(10)=102.66, p<0.001$) and showed that good preventive practice was independently associated with younger age, male gender, self-employment, unemployment, positive attitude, and good digital health literacy.

Conclusion Adults in Southern Sarawak reported high levels of Mpox preventive practices, but this favourable practice coexisted with poor Mpox-specific knowledge and uneven digital health literacy. Targeted risk communication, strengthening digital health literacy, workplace-based guidance, and locally adapted community engagement are needed to support sustained preventive practice in travel-connected settings.

Keywords Mpox · Preventive practice · Knowledge · Attitudes · Digital health literacy · Health literacy · Sarawak · Malaysia · Cross-sectional study

Background

Mpox was formally recognised by the World Health Organization (WHO) in November 2022 as the preferred name for the disease, following a global consultation to reduce stigma and support neutral and inclusive public discussion [1]. Since May 2022, Mpox has re-emerged beyond historically endemic areas and has been reported in multiple non-endemic countries, highlighting the need for preparedness in settings where travel-related importation may occur [2]. On 23 July 2022, the WHO declared the multi-country Mpox outbreak a Public Health Emergency of International Concern, reflecting the need for stronger international coordination and public health response [3]. Although transmission patterns and affected populations have varied across settings, the 2022 outbreak demonstrated that non-endemic areas remain vulnerable to importation via travel and population movement, necessitating rapid, credible, and equitable public-facing prevention guidance [2, 3]. Mpox is generally described as a self-limiting infection, but its morbidity burden can be considerable. Symptoms usually develop within 1–21 days after exposure and may last for approximately 2–4 weeks, during which affected individuals may experience pain, functional limitation, and increased use of health services [4]. The global spread of Mpox since 2022 indicates that preparedness is no longer relevant only to historically endemic regions, but also to travel-connected and non-endemic settings [5].

In Malaysia, Mpox was first reported in July 2023, with early cases mainly detected in Kuala Lumpur and Selangor. However, at least one case was also reported in Sarawak, indicating that the risk is not limited to Peninsular Malaysia [6]. Although Malaysia has experienced intermittent rather than sustained Mpox transmission, the presence of confirmed cases and continued regional vigilance indicate the need for preparedness in locations with travel connectivity [7–9]. Therefore, imported Mpox cases remain a plausible public health concern, particularly in areas where travel, tourism, and population movement may facilitate exposure.

Preparedness for Mpox requires more than surveillance and clinical readiness. It also depends on community capacity to understand risk information, identify credible sources, and translate public health guidance into preventive behaviour [10, 11]. This is particularly important because outbreak-related information is increasingly disseminated through digital platforms, where accurate guidance competes with misinformation, stigma, and commercially driven content. Digital health literacy refers to the ability to locate, access, understand, evaluate, verify, and use health-related information from electronic sources [12]. Communities with stronger digital health literacy may be better able to appraise outbreak information and act on credible recommendations, while digital inequity may limit access to accurate public health messages [13].

Sarawak provides an important setting for examining Mpox preventive practice because of its travel connectivity, ecotourism profile, and diverse urban-rural population. Kuching serves as a major administrative, tourism, and travel hub, while surrounding areas, such as Padawan, include peri-urban and rural communities with potentially varying levels of access to health information and public health services [14, 15]. Sarawak's large land area, dispersed settlements, and geographic barriers may contribute to inequalities in access to health information

and digital health literacy [13, 15]. These characteristics make Southern Sarawak a relevant setting for assessing community preparedness for Mpox and other emerging infectious disease threats.

Although international interest in Mpox has increased since 2022, evidence from general adult populations in non-endemic Asian settings remains limited. Much of the existing literature has focused on healthcare workers, healthcare students, or specific high-risk groups. In contrast, fewer studies have examined how knowledge, attitudes, and digital health literacy relate to preventive practices in the general community [16–20]. This gap is important because community cooperation is essential for early recognition, timely care-seeking, stigma reduction, and adherence to prevention guidance during emerging infectious disease events.

Therefore, this study aimed to assess Mpox preventive practices and the sociodemographic, attitudinal, and digital health literacy factors associated with good preventive practices among adults in Southern Sarawak, Malaysia, specifically in Kuching District and Padawan sub-district. By focusing on a travel-connected and socio-demographically diverse setting, this study provides community-level evidence to inform targeted risk communication, digital health literacy interventions, and preparedness planning for Mpox and other emerging infectious disease threats.

Methods

Study design, setting and duration

This study utilised a community-based cross-sectional design to assess Mpox preventive practices and identify factors associated with good Mpox preventive practices among adults in Southern Sarawak, Malaysia. Reporting adhered to the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines for observational studies, specifically aligning with the cross-sectional checklist to ensure thoroughness and transparency in methodology [21, 22]. The study was conducted in Southern Sarawak, Malaysia, specifically in the Kuching District and the Padawan sub-district (Fig. 1). This region was selected for its unique demographic characteristics and varying levels of awareness of infectious diseases among its residents. Southern Sarawak was selected because Kuching functions as a major administrative, tourism, and travel hub, while Padawan includes suburban and rural communities. This combination allows assessment of preventive practices across communities with potentially different levels of access to health information and public health services. Its connectivity through air travel and tourism enhances vulnerability to importation events in non-endemic regions. The study was conducted from January to August 2025, enabling a comprehensive examination of the community's socio-demographic, knowledge, attitudes, digital health literacy, and practices related to Mpox prevention strategies.

Study population and sampling procedure

Adults aged 18 years and older who had resided in the study area for a minimum of six consecutive months were deemed eligible for participation in this research study. To ensure a focus on the general adult population, individuals who were unable to provide informed consent, individuals who were unable to complete the interview due to severe illness or communication difficulties, and healthcare workers were excluded from the analysis. Healthcare workers were excluded because their occupational exposure, professional training, and access to health information may substantially differ from those of the general population, potentially leading to an overestimation of knowledge and preventive practices. The required minimum sample size was calculated to be 384 participants using the single-proportion formula, based on a 95% confidence level, a 5% margin of error, and an expected response distribution of 0.50 [23]. To ensure that the minimum required sample size would be achieved during community-based household recruitment, the sample size was increased by 15% to account for anticipated non-response. Non-response was defined as refusal to participate, vacant households, absence of an eligible respondent during the visit, or inability to complete the interview after eligibility screening. After this

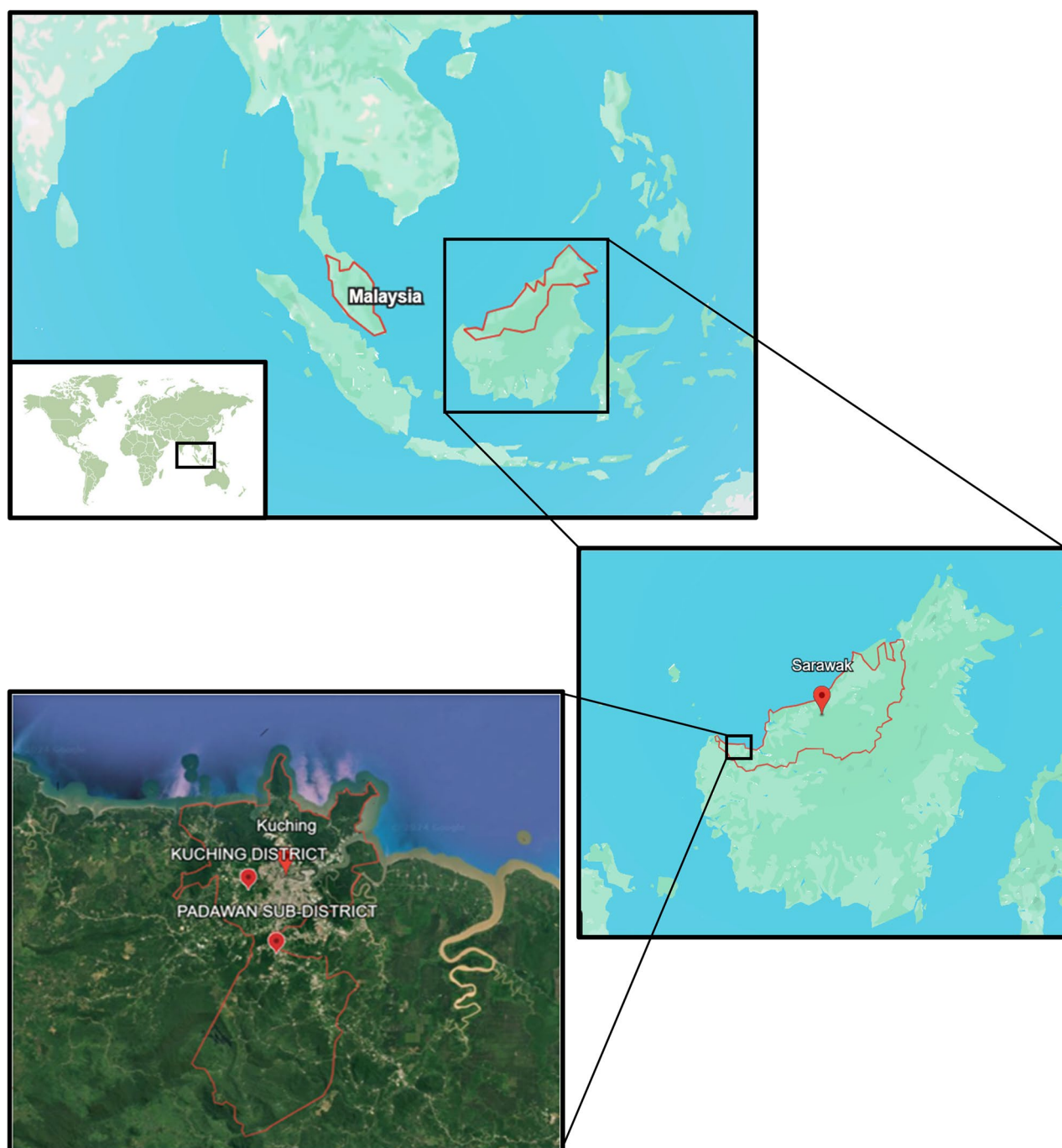
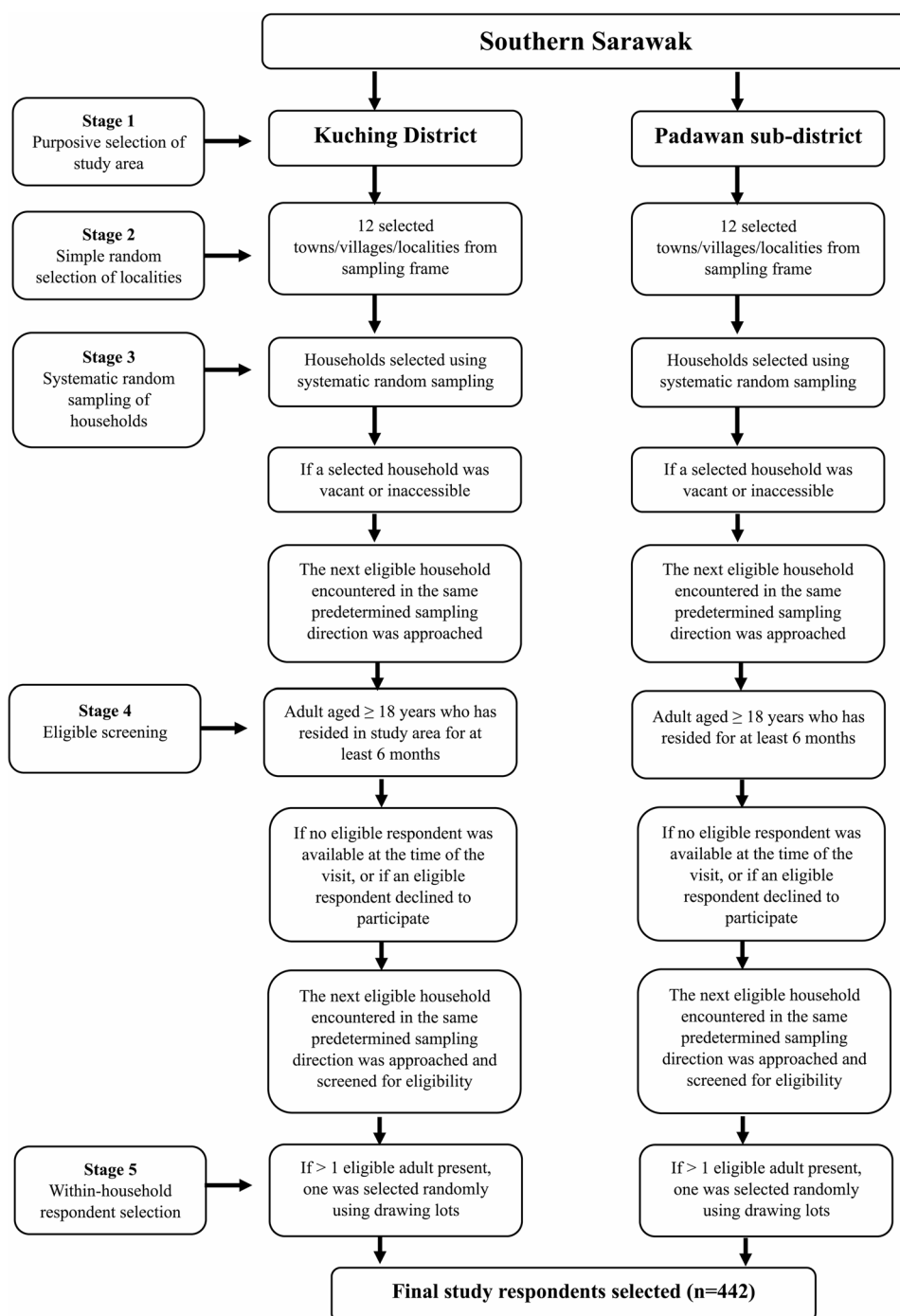


Fig. 1 Study area in Southern Sarawak, Malaysia, showing Kuching District and Padawan sub-district, the selected administrative areas for data collection

adjustment, the final target sample size was 442 respondents. While multistage sampling was applied in practice, the sample size was adjusted only for non-response, not for the design effect. This may have affected the precision of the estimates and is acknowledged as a limitation. The sampling frame consisted of selected residential localities within the Kuching District and the Padawan sub-district. Household enumeration was based on the available locality list and field mapping of residential areas within the selected localities. A multistage sampling approach was used to recruit adults from selected communities in Southern Sarawak (Fig. 2). In Stage 1, Kuching

Fig. 2 Sampling procedure for selecting households with eligible respondents in Southern Sarawak



District and Padawan sub-district were purposively selected because both are located within Southern Sarawak and together represent a travel-connected administrative centre and surrounding peri-urban and rural communities. Kuching District includes Kuching city, a major administrative, commercial, tourism, and travel hub in Sarawak, while Padawan sub-district includes communities with more varied peri-urban and rural characteristics. This purposive first-stage selection was aligned with the study objective of examining Mpox preventive practice in a travel-connected and socio-demographically diverse setting; however, it may limit the generalisability of the findings to other parts of Sarawak.

In Stage 2, residential localities within Kuching District and Padawan sub-district were identified using available locality lists and field mapping records. Twelve residential localities were selected from Kuching District and twelve from Padawan sub-district using simple random sampling, resulting in 24 localities in total. The target sample of 442 respondents was allocated equally between Kuching District and Padawan sub-district, with 221 respondents targeted from each study area. Within each study area, the target was distributed as evenly as possible across the 12 selected localities. As 221 could not be divided equally among 12 localities, five localities were allocated 19 respondents and seven localities were allocated 18 respondents, giving a total target of 221 respondents per study area. In Stage 3, households within each selected locality were selected using systematic random sampling. For each selected locality, the household sampling interval (k) was calculated as $k = N/n$, where N represented the estimated number of eligible households in that locality, and n represented the required number of households to be recruited. The first household was selected at random, after which every k -th household along residential lanes was selected according to the predetermined sampling direction. Households were approached during a single scheduled field visit. If the selected household was vacant or inaccessible, the next eligible household encountered in the same predetermined sampling direction was approached in accordance with the field replacement procedure.

In Stage 4, household members were screened for eligibility. Eligible respondents were adults aged 18 years and above who had resided in the study area for at least six months. Eligible individuals were invited to participate and provided informed consent before enrolment. If no eligible respondent was available at the time of the visit, or if an eligible respondent declined to participate, the household was considered unavailable for recruitment or recorded as non-response, as appropriate, and managed in accordance with the same field replacement procedure. In Stage 5, if more than one eligible adult was present in a household, one respondent was selected using a simple random method (drawing lots). The household replacement procedure was applied consistently during field recruitment but was not explicitly prespecified in the original sampling protocol. Replacement was conducted by proceeding to the next eligible household encountered along the same predetermined sampling direction to minimise discretionary household selection by the field team.

Outcome variable

The Mpox preventive practice measure in this study was adapted from Hashaam et al. (2023) [24]. It was operationalised using six Likert-type items, each scored on a five-point response scale ranging from “strongly disagree” to “strongly agree,” allowing respondents to indicate varying levels of agreement with statements reflecting Mpox-related preventive behaviours. A total preventive practice score was computed for each participant by summing item responses, yielding a possible range from 6 to 30. For analytical purposes, the total preventive practice score was dichotomised into good and poor preventive practice using the cut-off applied in the source study from which the items were adapted. Scores of ≥ 22 out of 30 were classified as good preventive practice, whereas scores of ≤ 21 were classified as poor preventive practice [24]. This threshold was retained to support comparability with previous Mpox KAP research and reflects generally favourable endorsement of preventive actions across the six items. In the present study, the adapted questionnaire was reviewed by public health specialists for content validity and cultural relevance, and pilot testing showed acceptable internal consistency for the preventive practice scale. The preventive practice scale demonstrated acceptable reliability, with a Cronbach’s alpha of 0.70, indicating adequate internal consistency among the items. Although dichotomisation facilitated interpretation and logistic regression modelling, it may reduce variability and statistical power. Future studies should consider analysing preventive practice as a continuous or ordinal outcome.

Explanatory variables

The explanatory variables in this study included a variety of sociodemographic factors and three key constructs: knowledge, attitude, and digital health literacy. The sociodemographic variables examined comprised age, gender

(male and female), marital status, place of residence, ethnicity, educational attainment, household income, and occupation sector. The knowledge and attitude components of the questionnaire were derived from a community study conducted by Hashaam et al. (2023) in Pakistan [24]. The cut-off points for knowledge and attitude were adapted from a previous study that used similar KAP scoring approaches. Respondents' scores were categorised using these established thresholds to facilitate interpretation and comparison with prior literature. Knowledge referred to the respondent's understanding of Mpox epidemiology, causative agent, natural history, laboratory confirmation, and vaccination uses. The knowledge component comprises 10 distinct items, with responses evaluated on a three-point scale: "yes," "no," or "I don't know." Correct responses were scored 1, while incorrect and 'I don't know' responses were scored 0. This system allowed for a maximum score of 10 points. Participants were classified into two groups: those with good knowledge (scoring 7 or higher out of 10) and those with poor knowledge (scoring 6 or below) based on the scoring approach used in this study. Attitudes toward Mpox refer to respondents' beliefs, perceptions, and feelings regarding the severity, susceptibility, and preventability of Mpox, as well as their acceptance of recommended control measures, and were assessed through a seven-item Likert-scale survey, with a maximum possible score of 35 points. Scores were categorised as either a positive attitude (26 or more out of 35) or a negative attitude (25 or below), in accordance with the scoring approach used in this study. Digital health literacy refers to the ability to search for, find, understand, and evaluate health information from electronic resources, and to use the knowledge gained to solve health-related problems. It was measured using a comprehensive set of 10 items derived from the HLS19-DIGI and HL-DIGI-INT framework, which assesses individuals' abilities to find, comprehend, and utilise digital health information effectively [25]. This framework also evaluates participants' proficiency in interacting with digital devices and health-related resources. For the HL-DIGI and HL-DIGI-INT components, responses were converted into a percentage (ranging from 0 to 100) of items rated as "very easy" or "easy" among valid responses. Higher scores indicated higher levels of digital health literacy. Scores were computed only for respondents who answered at least 80% of the items. In the present study, the results were classified as indicating either good or poor digital health literacy, based on thresholds established in this study and using a mean-based categorisation approach. The HL-DIGI-DD component was analysed descriptively to examine the frequency of using different digital sources for obtaining health-related information in a typical week. These items were not used to classify respondents as poor or good in digital health literacy. The frequency scale ranged from 1 to 5, where 1 denotes "less than once per week" or "not relevant," and 5 denotes "more than once per day".

Validations and statistical analyses

Before conducting fieldwork, the questionnaire (in Malay) was validated for content validity as a translated tool by three specialists in public health medicine with experience in epidemiology, communicable diseases, and health promotion to ensure that the wording was clear, relevant, and culturally appropriate. This was followed by a pilot test with 30 individuals outside the sample population to validate the instrument's performance. Reliability of internal consistency was found to be acceptable (knowledge Cronbach's alpha = 0.744; Attitudes Cronbach's alpha = 0.881; Digital Health Literacy Cronbach's alpha = 0.950; Preventive Practices Cronbach's alpha = 0.700), thus supporting the reliability of the composite measures that were used for analysis. All 442 questionnaires were complete for the variables included in the analysis; therefore, no imputation was performed. Data were analysed using SPSS version 29.0. Categorical variables were summarised as frequencies and percentages. Bivariate association analyses between Mpox preventive practice (good vs. poor) and candidate associated factor variables were performed using the Pearson Chi-Square Test and Fisher's Exact Test, where there was a small expected cell count. Logistic regression models were fitted to identify the factors associated with good Mpox preventive practices. Variables with $p < 0.25$ in bivariate analysis were considered for inclusion in the multivariable logistic regression model, along with variables deemed conceptually relevant based on the KAP framework and prior literature. This liberal screening threshold was used to reduce the risk of excluding potentially important associated factors or confounders at the preliminary stage. Backward stepwise logistic regression was subsequently used

to develop a parsimonious final model. Given the potential limitations of stepwise procedures, including model instability and data-driven variable selection, the final factors were interpreted cautiously. Statistical significance was set at $p < 0.05$, and adjusted odds ratios with 95% confidence intervals were reported. Multicollinearity was assessed using variance inflation factor/tolerance values. Model fit was assessed using the Hosmer-Lemeshow goodness-of-fit test and the overall model chi-square test.

Results

Participants' characteristics

A total of 442 adults participated in the study. The median age was 37.5 years (IQR: 30–47), with an age range of 18–61 years. The sample was ethnically diverse, and Malay respondents formed the largest ethnic group. In terms of employment, the distribution was nearly balanced. Regarding monthly household income, 47.1% reported earnings between RM2,500 and RM5,000. Slightly more than half of the respondents were married (53.4%), while 40.5% were single and 6.1% were divorced or separated. Respondents were almost equally distributed by gender, predominantly tertiary educated, and mostly from urban areas. Detailed distributions are shown in Table 1.

Knowledge of the respondents about the Mpox disease

Overall, 286 respondents (64.7%) had poor Mpox knowledge, while 156 respondents (35.3%) had good knowledge. Table 2 presents the proportion of respondents who answered each knowledge item correctly, incorrectly, or were unsure. Knowledge was stronger for transmission and prevention items, including animal-to-human transmission, human-to-human transmission via skin-lesion contact, hand hygiene, common symptoms, and the need for laboratory confirmation. However, substantial knowledge gaps were observed for epidemiological and severity-related items, particularly the incubation period, historical case fatality ratio, disease history, and smallpox vaccine effectiveness.

Attitudes toward Mpox

According to Table 3, 421 respondents (95.2%) had a positive attitude, whereas 21 (4.8%) had a negative attitude. The data indicate a strong belief in the severity of Mpox and a high degree of support for preventive measures through restrictions, but there is a limited view on personal risk perceptions. Participants perceived Mpox as a serious public health threat and strongly supported restrictive prevention measures, but reported lower personal risk. Most viewed Mpox as fatal and potentially pandemic-like, and strongly endorsed lockdowns, travel restrictions, and heightened precautions during holidays. However, personal risk perception was mostly neutral, indicating a gap between concern about population-level threat and perceived individual vulnerability. Views on smallpox vaccine effectiveness were mixed: many agreed it is effective, but a large proportion remained neutral.

Digital health literacy

Digital health literacy, based on the HL-DIGI and HL-DIGI-INT components, was generally favourable for navigating, evaluating, and communicating health information online (Table 4). The mean digital health literacy score was 76.2 (25.9), with observed scores ranging from 0 to 100. Based on this mean cut-off, 193 respondents (43.7%) were classified as having poor digital health literacy, while 249 respondents (56.3%) were classified as having good digital health literacy. Respondents reported good perceived ability to judge reliability, understand information, find relevant information, apply online health information, use appropriate search terms, cross-check

Table 1 Sociodemographic characteristics of the respondents ($n = 442$)

Characteristics	Frequency (%)	Median (IQR)
Age (Years)		37.5(30–47)
18–29	100 (22.6%)	
30–39	149 (33.7%)	
40–49	97 (21.9%)	
50–59	87 (19.7%)	
≥ 60	9 (2.0%)	
Gender		
Male	223 (50.5%)	
Female	219 (49.5%)	
Ethnicity		
Malay	156 (35.3%)	
Chinese	94 (21.3%)	
Iban	91 (20.6%)	
Bidayuh	86 (19.5%)	
Others	15 (3.4%)	
Education level		
No formal education	15 (3.4%)	
Primary	30 (6.8%)	
Secondary	97 (21.9%)	
Tertiary	300 (67.9%)	
Occupation sector		
Government sector	124 (28.1%)	
Self-employed	123 (27.8%)	
Private sector	102 (23.1%)	
Unemployed	93 (21.0%)	
Monthly household income		
< RM2500	63 (14.3%)	
RM2500–RM5000	208 (47.1%)	
RM5001–RM10000	171 (38.7%)	
Place of residence		
Urban	273 (61.8%)	
Rural	169 (38.2%)	
Marital status		
Married	236 (53.4%)	
Single	179 (40.5%)	
Divorce/Separated	27 (6.1%)	

RM Ringgit Malaysia (Malaysian Currency), IQR Interquartile range

information across websites, and communicate through digital platforms. However, identifying whether information was offered with commercial interests remained a clear weakness.

Table 5 shows that health information was primarily accessed through websites and social media, whereas digital health devices, health apps, and formal online health-system interactions were rarely used or deemed irrelevant by most respondents. It describes patterns of digital health resource use but was not included in the digital health literacy score. This study assessed respondents' perceived ability to use and evaluate digital health information, but did not directly measure internet quality, device ownership, or availability of digital health platforms.

Mpox preventive practices

Participants showed a strong willingness to adopt Mpox precautions and supported population-level control measures, including quarantine, isolation, and routine preventive behaviours such as avoiding crowds, wearing masks, and handwashing. They also strongly endorsed greater public communication about Mpox risks.

Table 2 Knowledge of the respondents about Mpox disease (*N*=442)

Knowledge items	Correct <i>n</i> (%)	Incorrect <i>n</i> (%)	Not sure <i>n</i> (%)
Human Mpox disease was first isolated in the Democratic Republic of Congo (DRC)	150 (33.9%)	113 (25.6%)	179 (40.5%)
The causative factor of Mpox disease is bacteria	203 (45.9%)	230 (52.0%)	9 (2.0%)
One of the transmissions of Mpox disease can occur from animal to human	336 (76.0%)	53 (12.0%)	53 (12.0%)
Human-to-human transmission can occur by contact with the skin lesions of an infected person	361 (81.7%)	42 (9.5%)	39 (8.8%)
The incubation period (interval from infection to onset of symptoms) for Mpox infection is 1–21 days	29 (6.6%)	70 (15.8%)	343 (77.6%)
Practice good hand hygiene after contact with infected animals or humans is one of the ways to prevent the spread of Mpox	438 (99.1%)	0 (0.0%)	4 (0.9%)
Fever, headache, swelling of the lymph nodes, and muscle aches are common symptoms of Mpox disease	368 (83.3%)	5 (1.1%)	69 (15.6%)
The case fatality ratio of Mpox has historically ranged from 0–11%	57 (12.9%)	6 (1.4%)	379 (85.7%)
Mpox can be diagnosed clinically and need no laboratory confirmation	35 (7.9%)	400 (90.5%)	7 (1.6%)
Smallpox vaccine is also effective against Mpox	169 (38.2%)	115 (26.0%)	158 (35.7%)
Overall knowledge	<i>n</i>		%
Poor	286		64.7%
Good	156		35.3%

Correct responses were coded according to current scientific understanding of Mpox and the scoring key used in the questionnaire. For negatively worded items, such as bacterial causation and clinical diagnosis without laboratory confirmation, “No” was coded as the correct response. A total score of 0–6 was classified as poor knowledge, whereas a total score of 7–10 was classified as good knowledge

n=Frequency, %=Percentage

Table 3 Attitude of the respondents towards Mpox disease (*n*=442)

Attitude items	SD <i>n</i> (%)	D <i>n</i> (%)	Neu <i>n</i> (%)	A <i>n</i> (%)	SA <i>n</i> (%)
I believe that Mpox is a fatal disease	8 (1.8%)	8 (1.8%)	1 (0.2%)	238 (53.8%)	187 (42.3%)
I believe that I am at risk of getting the disease.	6 (1.4%)	44 (10.0%)	225 (50.9%)	145 (32.8%)	22 (5.0%)
I believe that Mpox can cause a pandemic like COVID-19	2 (0.5%)	13 (2.9%)	2 (0.5%)	226 (51.1%)	199 (45.0%)
I believe that there should be a lockdown in areas reporting cases of Mpox disease.	2 (0.5%)	9 (2.0%)	3 (0.7%)	270 (61.1%)	158 (35.7%)
I believe that travelling from endemic areas (such as Africa, Nigeria, etc.) to non-endemic areas should be banned	1 (0.2%)	10 (2.3%)	16 (3.6%)	320 (72.4%)	95 (21.5%)
I believe that there is an increased risk of people getting the disease during festive seasons	1 (0.2%)	6 (1.4%)	3 (0.7%)	336 (76.0%)	96 (21.7%)
I believe that the smallpox vaccine is effective against Mpox	0 (0.0%)	17 (3.8%)	178 (40.3%)	218 (49.3%)	29 (6.6%)
Overall Attitude	<i>n</i>				%
Negative	21				4.8%
Positive	421				95.2%

A total score of 7–25 was regarded as a negative attitude, whereas a total score of 26–35 was regarded as a positive attitude

SD Strongly disagree, *D* Disagree, *Neu* Neutral, *A* Agree, *SA* Strongly agree

n=Frequency, %=Percentage

However, confidence in the adequacy of actions taken by local health authorities was lower, with nearly half of respondents remaining neutral, suggesting uncertainty regarding the perceived sufficiency of the local public health response. Details of respondents’ preventive practices were shown in Table 6.

Overall, this study found good preventive practice in 95.0%, positive attitude in 95.2%, poor knowledge in 64.7%, and good digital health literacy in 56.3% of respondents.

Table 4 Digital health literacy ($n=442$)

Items	VD <i>n</i> (%)	D <i>n</i> (%)	E <i>n</i> (%)	VE <i>n</i> (%)
Part A: dealing with digital health information (HL-DIGI)				
To judge whether the information is reliable?	0 (0.0%)	78 (17.6%)	288 (65.2%)	76 (17.2%)
To judge whether the information is offered with commercial interests?	1 (0.2%)	253 (57.2%)	178 (40.3%)	10 (2.3%)
To understand the information?	0 (0.0%)	66 (14.9%)	303 (68.6%)	73 (16.5%)
To use the information to help solve a health problem?	0 (0.0%)	135 (30.5%)	259 (58.6%)	48 (10.9%)
To judge whether the information is applicable to you?	0 (0.0%)	75 (17.0%)	286 (64.7%)	81 (18.3%)
To find the exact information you are searching for?	0 (0.0%)	89 (20.1%)	289 (65.4%)	64 (14.5%)
To visit different websites to check whether they provide similar information about a topic?	0 (0.0%)	76 (17.2%)	337 (76.2%)	29 (6.6%)
To use the proper words or search query to find the information you are looking for?	0 (0.0%)	69 (15.6%)	354 (80.1%)	19 (4.3%)
Part B Interaction with digital resources for health (HL-DIGI-INT):				
To express your opinion, thoughts, or feelings, ask a question in writing on social media including online forums?	0 (0.0%)	72 (16.3%)	316 (71.5%)	54 (12.2%)
Clearly formulate your written message when communicating with a health provider?	0 (0.0%)	69 (15.6%)	308 (69.7%)	65 (14.7%)
Digital health literacy	<i>n</i>			%
Poor	193			43.7%
Good	249			56.3%

Scores below the mean score of 76.19% was classified as poor digital health literacy, while scores of 76.19% and above was classified as good digital health literacy

VD Very difficult, D Difficult, E Easy, VE Very easy

n=Frequency, %=Percentage

Table 5 Health literacy-use of digital devices for health (HL-DIGI-DD) ($n=442$)

Variables	< 1/week <i>n</i> (%)	1–3 days/week <i>n</i> (%)	4–6 days/week <i>n</i> (%)	Once/day <i>n</i> (%)	> Once /day <i>n</i> (%)	Not relevant <i>n</i> (%)
Websites	196 (44.3%)	227 (51.4%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	19 (4.3%)
Social media, including online forums	147 (33.3%)	130 (29.4%)	54 (12.2%)	0 (0.0%)	0 (0.0%)	111 (25.1%)
A digital device related to health or health care	56 (12.7%)	47 (10.6%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	339 (76.7%)
Health app on your mobile phone	123 (27.8%)	19 (4.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	300 (67.9%)
Digital interaction with your health system	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	442 (100.0%)
Others	0 (0.0%)	10 (2.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	432 (97.7%)

n=Frequency, %=Percentage

Regression analysis: associated factors of good Mpox preventive practice

Simple logistic regression analyses were conducted to identify factors associated with Mpox preventive practice among the study participants ($n=442$). The outcome variable was the Mpox preventive practice, dichotomised as poor and good. The selection of variables for inclusion in the regression model was guided by preliminary univariate analyses, including Chi-square tests and Fisher's Exact test for categorical variables, and independent t-tests for continuous variables. Variables with p-values less than 0.25 in these preliminary analyses were included in the regression model (Table 7).

A binary logistic regression model was used to examine factors associated with preventive practices among participants. Model assumptions were assessed before proceeding to the binary logistic regression analysis. Diagnostic results showed that our logistic regression model fit the data adequately. Sociodemographic characteristics such as age, gender, educational level, occupation sectors, place of residence, and marital status were included in

Table 6 Mpox preventive practices of the respondents ($n=442$)

Practices items	SD <i>n</i> (%)	D <i>n</i> (%)	<i>N</i> <i>n</i> (%)	A <i>n</i> (%)	SA <i>n</i> (%)
I will take precautionary measures if Mpox disease becomes an epidemic in my area	3 (0.7%)	6(1.4%)	0(0.0%)	207(46.8%)	226(51.1%)
Quarantine is one way to prevent its spread at population levels just like COVID-19	5(1.1%)	8(1.8%)	0(0.0%)	269(60.9%)	160(36.2%)
Infected patients should be isolated from others	1(0.2%)	10(2.3%)	0(0.0%)	237(53.6%)	194(43.9%)
Avoiding crowds, using facemask and washing hands frequently will prevent its spread	1(0.2%)	16(3.6%)	1(0.2%)	264(59.7%)	160(36.2%)
I believe that there is a need for more awareness in the general public about Mpox	0 (0.0%)	17 (3.8%)	4 (0.9%)	261 (59.0%)	160 (36.2%)
I think local health authorities are taking sufficient steps to tackle Mpox	0 (0.0%)	77 (17.4%)	211 (47.7%)	154 (34.8%)	0 (0.0%)
Overall Practices	<i>n</i>				%
Poor	22				5.0%
Good	420				95.0%

A total score of 6–21 was classified as poor preventive practice, whereas a total score of 22–30 was classified as good preventive practice

SD Strongly disagree, D Disagree, N Neutral, A Agree, SA Strongly agree

n=Frequency, %=Percentage

Table 7 Result of the simple logistic regression of factors associating Mpox preventive practice ($n=442$)

Variables	β	SE	Wald χ^2	OR ^a	95% CI ^b
Age (Years)	-0.071	0.02	11.18	0.93**	(0.89,0.97)
Gender					
Male	Ref				
Female	-0.60	0.45	1.79	0.54	(0.22,1.33)
Education level					
No formal education	Ref				
Primary	1.50	1.27	1.39	4.46	(0.37,53.70)
Secondary	0.54	0.84	0.41	1.71	(0.33,8.96)
Tertiary	1.40	0.82	2.91	4.04	(0.81,20.14)
Occupation sector					
Government	Ref				
Self-employed	-0.98	0.61	2.60	0.38	(0.12,1.24)
Private sector	-0.63	0.66	0.91	0.53	(0.15,1.94)
Unemployed	0.42	0.87	0.23	1.52	(0.27,8.46)
Place of residence					
Urban	Ref				
Rural	-1.31	0.47	7.79	0.27*	(0.11,0.68)
Marital status					
Married	Ref				
Single	1.52	0.63	5.71	4.55*	(1.31,15.79)
Divorce/Separated	-0.03	0.78	0.002	0.97	(0.21,4.44)
Knowledge of Mpox					
Poor	Ref				
Good	0.65	0.52	1.55	1.91	(0.69,5.28)
Attitude towards Mpox					
Negative	Ref				
Positive	3.71	0.53	48.52	41.00**	(14.42,116.58)
Digital Health Literacy					
Poor	Ref				
Good	2.19	0.63	12.14	8.95**	(2.61,30.73)

^aOR = odds ratio, ^b95% CI = 95% Confidence interval for OR

p*-value <.05, *p*-value <.001

the regression model. Apart from that, knowledge of Mpox infection, attitude towards Mpox infection, and digital health literacy were also included. Stepwise logistic regression analysis was conducted for this purpose.

Several variables were significantly associated with the prevalence of Mpox preventive practices. Age is statistically significant, with younger participants more likely to adopt preventive practices than older participants (OR=0.93, 95% CI [0.89, 0.97], $p < 0.001$). For every one-year increase, the odds of engaging in good preventive practices decrease by 6.9%. Rural residents were significantly less likely to engage in preventive practices than urban residents (OR=0.27, 95% CI [0.11–0.68], $p < 0.05$). Living in urban areas increased the likelihood of good preventive practices.

In terms of marital status, compared to married individuals, single participants were significantly more likely to engage in preventive practices (OR=4.55, 95% CI [1.31–15.79], $p < 0.05$). In contrast, divorced/separated participants had no significant difference in their preventive practices as compared to married individuals. Positive attitude was associated with increased odds of preventive practice (OR=41.00, 95% CI [14.42–116.58], $p < 0.001$), with participants with a positive attitude 41 times more likely to adopt preventive practices than those with negative attitudes. In addition, good digital health literacy was also significantly associated with increased odds of preventive practice (OR=8.95, 95% CI: 2.61–30.73, $p < 0.001$), with participants with good digital health literacy being nearly nine times more likely to engage in preventive practices compared to those with poor literacy.

Final multiple logistic regression

Variables selected through bivariate screening and conceptual relevance were entered into the multivariable binary logistic regression model using a stepwise procedure (Table 8). The final model identified five factors significantly associated with good Mpox preventive practice: age, gender, occupation sector, attitude towards Mpox infection, and digital health literacy. Age was significantly associated with good Mpox preventive practice. For each one-year increase in age, the odds of reporting good preventive practice decreased by 13% ($\beta = -0.14$, SE=0.06, Wald $\chi^2 = 6.28$, $p = 0.012$, AOR=0.87, 95% CI: 0.78–0.97). This indicates that younger respondents were more likely to report good preventive practices than older respondents.

Gender was also significantly associated with good Mpox preventive practice. Compared with male respondents, female respondents had significantly lower odds of reporting good preventive practice ($\beta = -4.41$, SE=1.29, Wald $\chi^2 = 11.76$, $p < 0.001$, AOR=0.01, 95% CI: 0.001–0.15). This finding suggests that male respondents were more likely than female respondents to report good preventive practice in the adjusted model. The occupation sector showed a significant association with good Mpox preventive practice. Compared with respondents employed in the government sector, self-employed respondents had higher odds of reporting good preventive practice ($\beta = 2.78$, SE=1.20, Wald $\chi^2 = 5.37$, $p = 0.020$, AOR=16.04, 95% CI: 1.54–167.62). Unemployed respondents also had significantly higher odds of reporting good preventive practice compared with government-sector respondents ($\beta = 5.45$, SE=1.84, Wald $\chi^2 = 8.79$, $p = 0.003$, AOR=232.80, 95% CI: 6.35–8541.77). However, the wide confidence intervals, particularly for unemployment, indicate considerable uncertainty about the magnitude of these estimates and should be interpreted with caution.

Attitude towards Mpox infection demonstrated the strongest association with good preventive practice. Respondents with a positive attitude towards Mpox had substantially higher odds of reporting good preventive practice compared with those with a negative attitude ($\beta = 7.46$, SE=1.47, Wald $\chi^2 = 25.88$, $p < 0.001$, AOR=1739.39, 95% CI: 98.18–308815.47). Although this association was statistically significant, the very wide confidence interval suggests imprecision, likely due to the small number of respondents with poor preventive practice or negative attitudes. Therefore, the strength of this association should be interpreted with caution.

Digital health literacy was independently associated with good Mpox preventive practice. Respondents with good digital health literacy had higher odds of reporting good preventive practice than those with poor digital health literacy ($\beta = 3.34$, SE=0.98, Wald $\chi^2 = 11.63$, $p < 0.001$, AOR=28.18, 95% CI: 4.14–192.00). This finding

Table 8 Result of the final multiple logistic regression of factors associated with Mpox preventive practice ($n=442$)

Variables	β	SE	Wald χ^2	Adj. OR ^a	95% CI ^b
Age (Years)	-0.14	0.06	6.28	0.87*	(0.78,0.97)
Gender					
Male	Ref				
Female	-4.41	1.29	11.76	0.01**	(0.001,0.15)
Occupation sector					
Government	Ref				
Self-employed	2.78	1.20	5.37	16.04*	(1.54,167.62)
Private sector	-1.68	0.92	3.35	0.19	(0.03,1.13)
Unemployed	5.45	1.84	8.79	232.80*	(6.35,8541.77)
Place of residence					
Urban	Ref				
Rural	-1.31	0.74	3.16	0.27	(0.06,1.14)
Marital status					
Married	Ref				
Single	1.98	1.03	3.72	7.22	(0.97,53.81)
Divorce/Separated	-0.77	1.14	0.46	0.46	(0.05,4.31)
Attitude towards Mpox					
Negative	Ref				
Positive	7.46	1.47	25.88	1739.39**	(98.18,308815.47)
Digital Health Literacy					
Poor	Ref				
Good	3.34	0.98	11.63	28.18**	(4.14,192.00)

Omnibus Test of Model Coefficients, $\chi^2(10) = 102.664$, $p < .001$

Model summary = -2 Log Likelihood value of 72.234, with Cox & Snell $R^2 = 0.207$ and Nagelkerke $R^2 = 0.634$

Hosmer and Lemeshow Test p -value = 0.346 (> 0.05)

^aAdj. OR = Adjusted odds ratio, ^b95% CI = 95% Confidence interval for OR

* p -value $< .05$, ** p -value $< .001$

suggests that the ability to access, understand, and appraise digital health information may play an important role in supporting preventive behaviour during emerging infectious disease threats.

Overall, the final model indicated that good Mpox preventive practices were associated with younger age, male gender, self-employment, unemployment, a positive attitude towards Mpox, and good digital health literacy. Place of residence and marital status were retained in the model but were not statistically significant after adjustment. The overall model was statistically significant ($\chi^2(10) = 102.664$, $p < 0.001$), and there was no evidence of a lack of fit (Hosmer-Lemeshow Goodness-of-Fit Test; $p = 0.346$). We also evaluated and confirmed that our model met all necessary assumptions, specifically by demonstrating the absence of multicollinearity before estimating the adjusted estimates. Multicollinearity was assessed using the variance inflation factor (VIF) and tolerance values. No serious multicollinearity was detected, with all VIF values below 5 and tolerance values above 0.20.

Discussion

Principal findings

This manuscript reports primary data from a community-based cross-sectional survey. Published literature was used to contextualise the empirical findings and was not intended to constitute a systematic or narrative review. The findings provide community-level evidence on Mpox preventive practice and associated factors among adults in Southern Sarawak, a travel-connected and socio-demographically diverse setting. Overall, 95.0% of respondents reported good Mpox preventive practice. However, this favourable self-reported practice should be

interpreted with caution, as it coexisted with substantial Mpox-specific knowledge gaps and uneven digital health literacy: 64.7% of respondents had poor Mpox-specific knowledge, and only 56.3% demonstrated good digital health literacy. In the final adjusted model, good preventive practice was significantly associated with younger age, male gender, occupation sector, positive attitude towards Mpox, and good digital health literacy. These findings suggest that community preventive practices in Southern Sarawak are uneven: behavioural willingness appears high, but important gaps remain in disease-specific knowledge and digital information capability.

Preventive practice despite knowledge gaps

The high proportion of respondents reporting good preventive practices may partly reflect the lingering influence of public health behaviours normalised during the COVID-19 pandemic, including hand hygiene, mask-wearing, self-isolation, quarantine, and avoidance of crowded places. Such behaviours may have become routine outbreak-control measures, even when disease-specific knowledge about Mpox remains limited. Similar findings were reported in Pakistan, where preventive practice was more favourable than knowledge or attitude, and the authors attributed this pattern in part to prior COVID-19 experience and public health warnings [24]. In that study, only 34.4% of respondents had good knowledge of Mpox, while 57.7% reported good preventive practice. The prevalence of good preventive practice in the present study was considerably higher than in the Pakistan study, which may reflect differences in setting, timing, scoring approach, prior exposure to public health campaigns, and communication context. The present study was conducted following sustained post-COVID-19 public health messaging and the reporting of confirmed Mpox cases in Malaysia, including Sarawak. These factors may have increased familiarity with general infectious disease prevention measures. Nevertheless, because preventive practice was self-reported, the finding may also be influenced by social desirability bias.

Therefore, the main interpretation is that respondents reported favourable Mpox preventive practice, but this should not be interpreted as evidence of comprehensive community readiness to manage potential Mpox exposure or importation. Effective prevention also requires accurate knowledge of the disease, early recognition of symptoms, timely care-seeking, confidence in credible information sources, and the ability to act appropriately during a real outbreak or importation event.

Despite the high reported rates of preventive practices, poor knowledge of Mpox remained common. This finding is consistent with other regional evidence. A community study in Southern Malaysia reported that only 25.8% of respondents had adequate knowledge of monkeypox and concluded that better community understanding was needed for outbreak response [26]. Similarly, the study in Pakistan found that 65.6% of respondents had inadequate knowledge of Mpox despite comparatively better preventive practices [24]. A systematic review and meta-analysis also reported that adequate knowledge and favourable attitudes towards Mpox were generally suboptimal among study populations [20]. In the present study, respondents recognised several basic aspects of transmission and prevention, including zoonotic transmission, skin-contact transmission, and hand hygiene. However, substantial uncertainty remained regarding the incubation period, case fatality ratio, and the effectiveness of the smallpox vaccine. These knowledge gaps are important because early clinical recognition and care-seeking depend on understanding symptoms, timing after exposure, and when medical assessment is required. For Southern Sarawak, risk communication should therefore move beyond broad messages such as maintaining hygiene or avoiding close contact. It should include clearer guidance on Mpox symptoms, incubation period, exposure risk, when to seek care, and what to do after possible exposure. Malaysian Ministry of Health guidance encourages individuals with symptoms such as rashes or sores to seek medical assessment and advises those at high risk of infection to avoid physical contact with infected persons [8].

Attitude and digital health literacy in relation to preventive practice

A positive attitude towards Mpox was significantly associated with good preventive practices in the final adjusted model. This finding is consistent with the knowledge-attitude-practice framework, in which favourable attitudes

and acceptance of preventive measures may facilitate protective health behaviour. Similar findings were reported in Vietnam and Ghana, where a positive attitude was associated with Mpox preventive behaviour among health-care workers and university students [16, 27]. The Ghana study used structural equation modelling and suggested that attitude may function as an important behavioural pathway linking knowledge with practice. However, the attitude finding in the present study requires careful interpretation, as a positive attitude does not necessarily imply high perceived susceptibility. Although many respondents perceived Mpox as serious and supported restrictive preventive measures, their perceived personal risk was largely neutral. This suggests a gap between perceived severity and perceived susceptibility. Based on the Health Belief Model, individuals are more likely to take protective action when they perceive both the disease and their own susceptibility as relevant threats [28]. In a non-endemic, low-prevalence setting such as Malaysia, respondents may view Mpox as serious at the population level yet not perceive it as personally immediate. This pattern has also been observed in other Mpox studies, where susceptibility, severity, knowledge, and contextual barriers influenced preventive behaviour differently across populations [28–30]. Hence, risk communication should not only stress seriousness but also explain how transmission occurs, which exposure situations increase risk, and what actions are appropriate, without creating stigma. Although many respondents supported restrictive measures, these views should be interpreted with caution because travel-related risk communication must remain proportionate, evidence-based, and non-stigmatising. Evidence from Pakistan and other non-endemic settings indicates that public adherence to Mpox prevention is shaped not only by awareness and attitude, but also by perceived relevance, trust, and the local risk context [31, 32]. The adjusted odds ratio for attitude was very large, with a wide confidence interval. Therefore, this finding should be interpreted as evidence of a positive association rather than a precise estimate of effect size. The imprecision may reflect the small number of respondents who hold negative attitudes or engage in poor preventive practices.

Digital health literacy was also independently associated with good Mpox preventive practice. This suggests that respondents who perceived online health information as easier to locate, understand, appraise, and use were more likely to report good preventive practice. This is important because outbreak information is now rapidly disseminated through official websites, social media, messaging applications, and other digital platforms. Evidence from infectious disease research supports the relevance of health literacy and digital health literacy to preventive behaviour. A Japanese study on COVID-19 found that preventive behaviours were associated with health literacy, information evaluation, and decision-making skills, highlighting the importance of evaluating information as evidence evolves [33]. A Korean study also found that e-health literacy was positively associated with preventive practices for infectious diseases and risk perception, with risk perception mediating the relationship between e-health literacy and practice [34]. These findings suggest that digital health literacy is not merely about accessing information, but also about shaping risk perception and translating information into action. Digital health literacy includes the ability to evaluate credibility, recognise persuasive or commercial intent, compare information across sources, and apply information appropriately to one's own situation [25, 35]. This is especially important during outbreaks, when misinformation, commercially driven content, and rapidly changing advice can spread faster than official clarifications and may affect risk perception, trust, and adherence to guidance [36, 37]. In the present study, respondents generally reported confidence in assessing reliability and cross-checking information, but many had difficulty identifying whether online information was offered with commercial interests in mind. Therefore, digital health literacy interventions should not only teach people how to search for information, but also how to verify sources, detect misleading claims, and recognise persuasive intent. Nevertheless, the digital health literacy estimate had a wide confidence interval and should be interpreted cautiously. Digital health literacy may also be related to education, occupation, language, internet access, and exposure to official health information. In addition, this study assessed perceived ease or difficulty in using digital health information but did not directly measure device ownership, internet quality, or availability of digital platforms.

Sociodemographic and occupational factors associated with preventive practice

Younger age was associated with higher odds of good Mpox preventive practice in the final adjusted model. This may reflect differences in perceived relevance, mobility, social exposure, work environment, educational exposure, and responsiveness to information on emerging infectious diseases. Evidence from Mpox KAP studies suggests that age may shape awareness, attitudes, risk perception, and preventive behaviour. However, its influence appears to vary across epidemiological contexts, population groups, and information environments. For example, a survey among people living with HIV in Beijing identified age, location, sexual orientation, education, viral load, and coexisting sexually transmitted infections as factors related to Mpox KAP, suggesting that age may interact with other social and behavioural factors [38]. The present finding should therefore be interpreted cautiously. Younger respondents may have reported better preventive practices because Mpox prevention seemed more relevant to their social, occupational, travel, or community interactions. This does not mean that older adults are unwilling to practise prevention. In a non-endemic setting, older respondents may perceive Mpox as less personally relevant, particularly when there is no sustained local transmission. From a Health Belief Model perspective, preventive practice is influenced by perceived susceptibility and severity, perceived benefits and barriers, cues to action, and self-efficacy [28]. Age-specific communication may therefore be useful. For younger adults, messages may focus on social contact, travel, work, and close-contact settings. For older adults, communication should avoid implying low risk and should instead explain plausible exposure scenarios and appropriate care-seeking actions. This is important because age patterns in preventive behaviour are not uniform across infectious disease contexts; during COVID-19, for example, older adults often reported greater engagement in mitigation behaviours than younger adults [39].

Gender was significantly associated with good Mpox preventive practice, with male respondents more likely than female respondents to report good preventive practice in the adjusted model. This contrasts with some Mpox studies from Pakistan and Vietnam, where female respondents reported better preventive practices than male respondents [16, 24]. The opposite pattern in the present study may reflect local contextual differences rather than a universal gender effect. Several explanations are possible. First, men in this sample may have had greater exposure to workplace, travel-related, or public-facing outbreak messages. Second, men may have been more exposed to digital or occupational information channels relevant to Mpox alerts. Third, the high overall prevalence of good preventive practice may have produced sparse data in the poor-practice group, making the gender estimate less stable. Self-reported practice may also differ by gender due to differences in perceived expectations or in the interpretation of questionnaire items. Men may have perceived Mpox prevention information as more personally relevant because international discourse has often focused on adult transmission through close contact and sexual activity, particularly among gay, bisexual, and other men who have sex with men.

WHO reported that the 2022 global outbreak predominantly, although not exclusively, affected men who have sex with men, and CDC data showed that many men who have sex with men changed their behaviour after receiving related news [40]. However, this explanation is speculative because sexual orientation, sexual behaviour, and perceived sexually transmitted infection-related risk were not measured in this study. Thus, the gender finding should be interpreted as a study-specific association requiring further investigation, not as evidence that men are generally more preventive than women. Mpox communication should remain inclusive, factual, and non-stigmatising. However, gender-sensitive approaches may be useful if future studies confirm differences in risk perception, access to information, or the feasibility of prevention in Sarawak.

The occupation sector was independently associated with good Mpox preventive practice. Self-employed and unemployed respondents had higher odds of good preventive practice compared with government-sector employees. However, the very large odds ratios and wide confidence intervals indicate imprecision and should be interpreted cautiously. These findings should not be read as evidence that one occupational group is inherently more preventive than another. Instead, they suggest that occupation may shape the feasibility of practising prevention. Employment status and professional role have been identified as relevant socioeconomic and occupational factors in Mpox behavioural research, including studies of KAP, vaccination intention, and testing intention [16].

Preventive behaviours such as avoiding crowds, reducing close contact, isolating when symptomatic, reporting symptoms, and seeking care early are not purely individual choices. They are influenced by work routines, flexibility, leave availability, public-facing duties, workload, access to hygiene facilities, and the perceived consequences of being absent from work. Infection prevention research shows that adherence to preventive guidance is influenced by organisational and workplace factors, including training, communication, workplace culture, workload, physical space, and access to protective resources [41].

Self-employed respondents may have greater flexibility to modify schedules or reduce selected contacts, whereas unemployed respondents may face fewer workplace constraints, although these interpretations require further study. Conversely, government-sector employees may have fixed schedules, public-facing responsibilities, or essential service duties that make some preventive behaviours less flexible. This finding should not be interpreted as evidence that government employees are inherently less preventive; rather, it highlights the need to strengthen workplace environments through clear Mpox risk communication, feasible symptom-reporting pathways, hygiene support, non-stigmatising guidance, and timely access to care. Such support may include reliable information channels, symptom-reporting mechanisms, feasible leave arrangements, hygiene facilities, non-stigmatising guidance, and clear advice on when to seek care or reduce close contact. Labour conditions, work regulations, and limited paid leave may affect individuals' ability to follow prevention advice and access preventive health services [42]. Therefore, efforts to support Mpox preventive practice should extend beyond individual willingness and address the structural and occupational conditions that shape whether recommended preventive behaviours are feasible in real-world settings [42, 43].

Public health implications for Southern Sarawak and other travel-connected settings

Although income was not significantly associated with preventive practice in the present study, individual preventive behaviour should still be understood within a broader health systems context, as the ability to act on public health guidance is influenced by surveillance capacity, access to testing, risk communication, availability of vaccination, and service delivery arrangements. WHO's Mpox Global Strategic Plan emphasises surveillance, laboratory capacity, community protection, safe clinical care, and vaccination as core components of an effective and coordinated public health response to Mpox. These capacities are not equally distributed across settings. Low-income and resource-limited settings may face constraints in laboratory diagnosis, surveillance coverage, vaccine access, trained workforce, logistics, and medical countermeasures.

Recent literature on Mpox vaccine equity and outbreak response has also highlighted persistent gaps in equitable access to vaccines, diagnostics, surveillance, and supply chains in low- and middle-income countries and resource-poor settings [44–46]. Middle-income settings, including Malaysia, may have established public health infrastructure, clinical services, and national guidelines, yet still experience implementation gaps in coordination, risk communication, resource distribution, and geographic access. Malaysia's Mpox management guidance includes health education and interagency collaboration, reflecting existing preparedness mechanisms [47]. However, as an upper-middle-income country with a dual public–private health system and geographically diverse regions such as Sarawak, Malaysia's capacity to support Mpox prevention and control depends not only on national guidance, but also on effective local implementation. Although high-income settings may have stronger laboratory networks, vaccine procurement capacity, surveillance systems, and outbreak response resources, they may still face challenges related to stigma, misinformation, delayed care-seeking, and engagement with affected or marginalised populations [48].

The findings have practical implications for Mpox preparedness in Southern Sarawak, where Kuching functions as an important administrative and travel centre, and Padawan includes peri-urban and rural communities. Although the risk of imported Mpox cases remains low, preparedness should extend beyond surveillance and case management to include understanding community risk, credible communication, and practical support for preventive behaviour. Since Mpox has affected areas outside historically endemic countries following the 2022 multi-country outbreak, partly due to global travel, rapid community-based prevention guidance is needed

to complement surveillance and clinical preparedness [2, 4, 40]. The findings support a preparedness strategy that combines short-term and longer-term actions. First, surveillance and early detection should be supported by improving public recognition of symptoms, incubation period, exposure history, and indications for medical assessment. This directly addresses the limited Mpox-specific knowledge and uncertainty identified in the study. Second, clinical and community guidance should clearly explain isolation protocols, steps to take before medical assessment, and how family members or work colleagues should respond when symptoms occur. These messages should be practical, non-judgmental, and non-stigmatising [10, 11, 28]. Third, risk communication and community engagement should address the gap between high perceived seriousness and neutral perceived susceptibility. Public education should focus on understanding transmission, recognising symptoms that require medical evaluation, reducing close-contact risks, and identifying credible information. Communication should be timely, clear, action-oriented, and transparent about uncertainty, consistent with emergency risk communication guidance [49]. Because misinformation and commercially driven content may reduce trust during health alerts, communication materials should include message appraisal tools, such as consistent branding for official updates, fact-versus-myth formats, and prompts to help the public assess source credibility and persuasive intent [28, 35, 50]. Evidence from the 2022 multi-country outbreak indicates that Mpox presentation and risk communication needs may differ from general public assumptions, and ambiguous messaging about transmission, symptoms, and protection can contribute to misinformation and reduced confidence in health authorities [49, 51]. In Malaysia, intermittent case detection without sustained transmission suggests that public health strategies should prioritise rapid symptom recognition, early care-seeking, and prevention of onward spread. Implementation should consider workplace feasibility, travel-related settings, multilingual communication, and digital access. Given that occupation sector and digital health literacy were associated with good preventive practice, interventions should include workplace-based outreach, feasible symptom-reporting pathways, hygiene support, and clear guidance for employers. Information resources should also be placed in travel-related and community settings, including standardised frequently asked questions, scripted statements for community leaders and frontline workers, and multilingual social media content to reduce speculation, misinformation, and uncertainty. In Southern Sarawak, this combined approach is important because Kuching's role as a travel gateway and Padawan's peri-urban and rural context require communication strategies that are both digitally accessible and community-based.

Implementing Mpox preparedness in Southern Sarawak may face several practical challenges. First, preparedness activities may be constrained by funding, workforce capacity, competing public health priorities, and the need for coordination across health offices, local authorities, employers, airport authorities, healthcare facilities, and community leaders. Second, global and national guidance must be adapted to the local context. WHO guidance on Mpox preparedness for points of entry emphasises risk communication customised for travellers, point-of-entry workers, and community partners. In contrast, Malaysian Mpox management guidance includes screening and management of travellers and flight crew from affected countries at international entry points [44, 47, 52]. This is relevant to Southern Sarawak because Kuching International Airport is a major point of entry, and Sarawak continues to experience substantial air traffic through its airports. Third, communication and accessibility barriers must be considered. Research in Sarawak indicates that although information and communication technology can support rural development, access barriers persist in remote areas. Recent studies of rural Sarawak have identified inequalities related to poor internet access, limited device ownership, digital illiteracy, and socioeconomic disparities [53, 54]. Consequently, Mpox communication should not depend solely on digital media, but should also include clinic-based counselling, community discussions, printed materials, radio broadcasts, and engagement with community leaders. Fourth, Sarawak's multicultural context means that health messages may need to be translated into Malay, English, and locally appropriate languages or dialects to improve comprehension and acceptability [55]. Finally, local preparedness should consider occupational variation in the feasibility of prevention. Workers in transport, healthcare, tourism, or public-facing service sectors may face different exposure levels and practical barriers to distancing or isolation when symptomatic [47, 52]. Therefore, Mpox preparedness in Southern Sarawak should include workplace-sensitive guidance, symptom-reporting

pathways, de-stigmatised messaging, sanitation support, and coordination with relevant agencies, including airports and healthcare institutions.

Strengths and limitations

This study has several strengths. It provides community-level evidence from the general adult population in a non-endemic but travel-connected setting. In contrast, much of the existing Mpox literature has focused on healthcare workers, students, or specific high-risk populations. Community evidence is important because early recognition, care-seeking, stigma reduction, and adherence to prevention guidance depend partly on public understanding and cooperation. The use of a structured questionnaire, content validation of the translated tool, and pilot testing strengthened the measurement of key constructs. The inclusion of digital health literacy is another strength, given the increasing role of online information in shaping outbreak-related behaviour.

Several limitations should be acknowledged. The cross-sectional design limits causal inference, and the associations observed should not be interpreted as evidence of causality [21]. Self-reported responses may be affected by recall and social desirability biases, particularly regarding preventive practices. The findings from Kuching District and Padawan may not be generalisable to more remote communities in Sarawak, where digital access, language, health service reach, and information environments may differ.

The first stage of sampling involved purposive selection of Kuching District and Padawan sub-district. Although this was appropriate for examining Mpox preventive practice in a travel-connected and socio-demographically diverse setting, it limits statistical generalisability to the wider Sarawak population. The findings should therefore be interpreted as evidence from selected communities within Southern Sarawak rather than as population-representative estimates for the entire state. In addition, vacant or inaccessible households, households without an eligible respondent available during the scheduled visit, and households in which an eligible respondent declined to participate were replaced with the next eligible household encountered along the predetermined sampling direction. Although this procedure was applied consistently within each locality, household replacement may have altered the original probability of selection and introduced some selection bias, particularly by favouring households with eligible respondents who were available at the time of data collection.

Dichotomising knowledge, attitude, digital health literacy, and preventive practice may have reduced variability and statistical power. Construct validity was not assessed using exploratory or confirmatory factor analysis; future studies should further validate the adapted instrument in the Sarawak context. In addition, although the ≥ 22 cut-off for good preventive practice was adopted from the source study and retained for comparability, it has not been locally criterion-validated among adults in Sarawak. Future studies should consider validating this threshold using local psychometric assessment, criterion-based approaches, or sensitivity analyses using continuous or ordinal preventive practice scores.

The digital health literacy measure assessed perceived ease or difficulty in using digital health information but did not directly measure internet quality, device ownership, or availability of formal digital platforms. Finally, Mpox evidence and public health guidance continue to evolve, and future studies should reassess community preparedness as recommendations change. Qualitative or mixed-methods research could further explain why preventive readiness varies across groups and how trust, perceived feasibility, and digital information appraisal influence the adoption of preventive measures. Future intervention studies should also evaluate risk communication strategies that integrate verification cues, culturally tailored messages, and digital health literacy support rooted in established digital health literacy frameworks [10–12].

Conclusion

This community-based cross-sectional study found that adults in Southern Sarawak, specifically the Kuching District and the Padawan sub-district, reported high levels of Mpox preventive practices. However, this favourable practice coexisted with poor Mpox-specific knowledge and uneven digital health literacy, indicating that preventive practice alone should not be interpreted as evidence of comprehensive community readiness. Good preventive practice was independently associated with younger age, male gender, occupation sector, positive attitude towards Mpox, and good digital health literacy.

These findings highlight the importance of strengthening community-level risk communication and digital health literacy to support sustained Mpox preventive practice in travel-connected settings. Public health messages should clearly address Mpox transmission, symptom recognition, exposure risk, isolation guidance, and early care-seeking. In Southern Sarawak, locally adapted communication should consider workplace settings, multilingual needs, and non-digital outreach to ensure rural and lower-literacy communities are not excluded from accurate, actionable Mpox information.

Abbreviations

AOR	Adjusted odds ratio
CI	Confidence interval
HL-DIGI	Digital health literacy
HL-DIGI-DD	Use of digital devices for health
HL-DIGI-INT	Interaction with digital resources for health
KAP	Knowledge, attitude and practice
MOH	Ministry of Health
RCCE	Risk Communication and Community Engagement
SD	Standard deviation
SPSS	Statistical Package for the Social Sciences
STROBE	Strengthening the Reporting of Observational Studies in Epidemiology
VIF	Variance inflation factor
WHO	World Health Organisation

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Authors' contributions FM conceived the study idea and led the initial development of the research objectives and field implementation plan. The study was conceptualised and supervised by SFJ, with co-supervision and methodological input from RN and SHL, including guidance on study design, instrument adaptation, and analytical strategy. FM and MCHL coordinated and led field activities, including team briefings, participant recruitment logistics, and the supervision of data-collection procedures, with operational support from FL. FM was primarily responsible for data entry, data cleaning, coding, and statistical analyses, with all co-authors contributing to data verification, interpretation of findings, and refinement of the analytic outputs. SFJ led the overall manuscript drafting and write-up, with all authors providing critical revisions for important intellectual content. All authors read and approved the final version of the manuscript for submission.

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Data availability The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate Ethical approval for this study was obtained from the Medical Research Ethics Committee (MREC), Universiti Malaysia Sarawak (UNIMAS) (Ethics Reference Number: FME/25/36). The study was conducted in accordance with the principles of the Declaration of Helsinki. All study records and data were handled confidentially and used solely for this research, in accordance with the ethics approval conditions. Permission from relevant authorities at the study sites was obtained before data collection. All participants provided informed consent before enrolment. Participation was voluntary, and respondents were informed about the study objectives, procedures, confidentiality protections, and their right to decline participation or withdraw from the study at any time without penalty.

Consent for publication Not applicable.

Competing interests The authors declare no competing interests.

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