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RESEARCH ARTICLE

Community participation in community-based surveillance of infectious diseases: A structural equation modeling approach based on the theory of reasoned action

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ABSTRACT

Background and Aim: Community-based surveillance (CBS) is a critical mechanism for early detection of infectious diseases. Understanding the behavioral drivers of CBS participation is essential to strengthening community engagement. This study employed structural equation modeling (SEM) based on the theory of reasoned action (TRA) to investigate the impact of knowledge, subjective norms (SN), and attitudes on the intention and behavioral likelihood (BL) of participating in CBS activities.

Materials and Methods: A cross-sectional survey was conducted among 470 schoolteachers selected through a multi-stage mixed sampling strategy across Kelantan, Malaysia. A structured questionnaire assessing sociodemographic factors, knowledge, attitudes, and perceptions toward CBS was developed and validated. Confirmatory factor analysis and SEM were employed with model parameters estimated using the robust maximum likelihood (MLR) approach. Model fit was assessed using comparative fit index (CFI), Tucker-Lewis index (TLI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR) indices.

Results: The final model demonstrated good fit (CFI = 0.923; TLI = 0.913; RMSEA = 0.045; SRMR = 0.070). Knowledge (β = 0.335) and SN (β = 0.296) positively influenced intention to participate in CBS, whereas negative attitudes (β = −0.313) showed a significant negative association. Intention significantly predicted BL (β = 0.633). The model explained 40% of the variance in intention and 43% in BL. Intention mediated the effects of knowledge, norms, and attitudes on behavioral engagement.

Conclusions: Knowledge, positive SN, and reduced negative attitudes are pivotal in fostering community participation in CBS initiatives. Intention emerged as a critical mediator linking cognitive and normative beliefs to actual behavioral engagement. These findings provide actionable insights for designing targeted interventions that enhance CBS participation and strengthen infectious disease surveillance at the community level.

Keywords: community participation, community-based surveillance, infectious diseases, structural equation modeling, theory of reasoned action.

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INTRODUCTION

Infectious diseases remain a major global public health challenge, encompassing both emerging and re-emerging illnesses such as human immunodeficiency virus/acquired immunodeficiency syndrome, severe acute respiratory syndrome, hemagglutinin type 1 and neuraminidase type 1 (H1N1) influenza, and coronavirus disease-19, all of which have exerted profound worldwide impacts [1]. Furthermore, the increasing prevalence of antibiotic resistance exacerbates this threat, complicating both treatment and control measures [2]. Without early detection, these infections have the potential to trigger outbreaks that may escalate into epidemics or pandemics [3]. Since infectious diseases often originate within communities, it is typically community members who first notice changes in health patterns. Prompt reporting of such events to health authorities facilitates timely interventions, thereby containing outbreaks before they escalate.

Community-based surveillance (CBS) is defined as the reporting of health events by community members to health authorities [4, 5]. According to the World Health Organization (WHO), CBS refers to "the systematic detection and reporting of events of public health significance within a community by the community members" [6]. Effective CBS systems are grounded in principles of participatory community engagement, characterized by high levels of acceptability, collaboration, communication, local ownership, and trust among community members [7]. Critical components for successful CBS implementation include adequate training, comprehensive knowledge, a sense of responsibility toward community health, and the use of straightforward, adaptable case definitions [7]. In addition, the integration of digital tools and real-time data analytics significantly improves the efficiency and impact of CBS systems [7]. CBS activities may be carried out by community health workers, community health volunteers, or local leaders and representatives, collectively referred to as key informants. Utilizing key informants as the primary source of surveillance signals, rather than depending on reports from the entire community, helps to reduce signal noise while maintaining system sensitivity [8]. These key informants are individuals with extensive community networks, including schoolteachers, village leaders, traditional healers, educators, and religious figures. In urban settings, the definition of "community" should be expanded to encompass high-risk groups such as sex workers, intravenous drug users, and specific ethnic or religious communities [8].

In Malaysia, consistent delays in reporting health events to authorities have been observed, with incidents often becoming known within communities or through media channels before being officially reported [9]. Such delays can impede timely responses and elevate the risk of small outbreaks developing into major public health emergencies. The absence of immediate communication between communities and health authorities suggests limited community engagement in health-related behaviors. The theory of reasoned action (TRA) was selected as the theoretical framework for this study by LaCaille [10] to investigate the influence of knowledge, attitudes, and subjective norms (SN) on the intention to participate in CBS, as well as how these factors affect the behavioral likelihood (BL) of engaging in CBS activities. TRA is widely employed to explain and predict various health behaviors [10–13].

While CBS has been recognized as a critical strategy for early detection and reporting of infectious disease outbreaks, there remains a limited understanding of the behavioral determinants that influence community members' willingness to participate in CBS activities, particularly in the Malaysian context. Although prior studies have examined the role of knowledge, attitudes, and SN in predicting health behaviors using the TRA, few have systematically applied structural equation modeling (SEM) to evaluate both the direct and indirect pathways influencing CBS participation. Moreover, existing research often overlooks the specific contributions of negative attitudes and the mediating role of behavioral intention in translating knowledge and normative influences into active engagement in surveillance activities. There is a need for a comprehensive analytical approach to elucidate these relationships and guide the development of evidence-based interventions aimed at strengthening CBS systems.

The present study aims to apply SEM based on the TRA to examine the causal relationships among knowledge of infectious diseases (KID), SN, negative attitudes, intention to participate, and the BL of engaging in CBS activities among schoolteachers in Malaysia. Specifically, the study seeks to quantify both the direct and indirect effects of cognitive and normative factors on behavioral outcomes and to identify key predictors that can inform the design of targeted strategies to enhance community engagement in infectious disease surveillance efforts.

MATERIALS AND METHODS

Ethical approval

Ethical approval was obtained from the Human Research Ethics Committee of Universiti Sains Malaysia (Reference No.: USM/JEPeM/22050317). Throughout the study, strict confidentiality protocols were maintained. All data were anonymized, and no personal identifiers were recorded. Participation was entirely voluntary, with participants informed of their right to withdraw at any stage without penalty. All research materials were securely stored in locked facilities and password-protected digital files accessible solely to authorized research personnel.

Study period and location

This study employed a cross-sectional survey design. Data collection was conducted over a 2-month period, from May to June 2024, involving both public and Islamic secondary schools located throughout Kelantan state, Malaysia.

Participants and sampling strategy

A total of 470 school teachers were recruited from four districts in Kelantan: Kota Bharu and Bachok (urban areas), and Kuala Krai and Pasir Puteh (rural areas). Teachers were selected due to their strategic role within communities, connecting students, families, and health authorities, and their capacity to observe health pattern changes. The sample size exceeded the minimum requirement of 463 participants, as determined using Arifin's web-based sample size calculator [14], and fulfilled the recommended thresholds for both confirmatory factor analysis (CFA) and SEM, according to Hair *et al.* [15] and Kline [16].

A multi-stage mixed sampling approach was applied:

1. First stage: Districts were purposively selected to represent both urban and rural areas.
2. Second stage: Schools within each selected district were randomly chosen using a computer-generated random number table.
3. Third stage: Teachers within the selected schools were recruited through convenience sampling based on their availability and willingness to participate.

Eligibility criteria included: (i) Minimum age of 18 years, (ii) Malaysian citizenship, (iii) ability to understand and respond in Malay, and (iv) provision of written informed consent.

Instrument development and validation

Questionnaire development

A customized questionnaire, termed the Knowledge, Attitude, and Perception toward Community-Based Surveillance of Infectious Diseases (KAP-CBS-ID), was developed based on the TRA. As no validated instrument specific to CBS-related knowledge and attitudes among community leaders existed, the creation of a novel tool was warranted. The questionnaire comprised three primary sections:

1. Demographic information: Including age, gender, education level, teaching experience, and sources of infectious disease information.
2. Knowledge domain: Contained 31 items, subdivided as follows:
    - *KID1*: Eighteen items assessing understanding of transmission, prevention, and control measures.
    - *Knowledge of CBS (KID2)*: Three items evaluating familiarity with the CBS concept.
    - *Community-level case definition (KID3)*: Ten items assessing ability to recognize reportable signs and symptoms, referencing International Federation of Red Cross and Red Crescent Societies (IFRC) (2017, 2019) and WHO (2018) guidelines.
    - All knowledge items were dichotomously scored (0 = Incorrect; 1 = Correct).
3. Attitude domain: Structured according to TRA, consisting of four factors measured on a 5-point Likert scale (1 = Strongly disagree to 5 = Strongly agree):
    - *Negative attitudes (ATT)*: Six items assessing unfavorable perceptions toward CBS.
    - *SN*: Four items evaluating perceived social pressure to participate.
    - *Intention to participate in CBS (INT)*: Six items assessing willingness to engage.
    - *BL*: Seven items measuring the likelihood of performing CBS-related activities.

Validation process

A comprehensive, sequential validation process was undertaken:

1. Expert validation: Eleven public health and infectious disease professionals from Universiti Sains Malaysia, the Malaysian Ministry of Health, and local Kelantan public health offices evaluated the content validity for relevance, clarity, and comprehensiveness.
2. Face validation: A small sample of teachers reviewed the instrument for clarity, readability, and cultural appropriateness, with revisions made based on feedback.
3. Pilot testing: The revised questionnaire was administered to 30 non-sample participants to identify any residual comprehension or response issues.
4. Psychometric validation: Advanced statistical techniques were employed, including:
    - Item response theory analysis for knowledge items.
    - Exploratory factor analysis for attitude constructs.
    - CFA for all constructs.

This rigorous approach ensured the instrument's reliability and validity for assessing CBS-related knowledge and attitudes among schoolteachers.

Data collection procedure

Before administration, participants received both written and verbal explanations of the study objectives, confidentiality measures, and their voluntary rights. Written informed consent was obtained. Completing the self-administered questionnaire required approximately 20–25 min. Research assistants were present to address any participant queries.

Confidentiality was maintained by assigning unique identification codes and removing personal identifiers from all datasets. Data were stored securely

in password-protected files accessible exclusively to the research team.

Statistical analysis

SEM was used to estimate direct and indirect effects among latent variables, conducted using Mplus version 7.4. CFA was performed using RStudio (version 4.4.2) with the lavaan package. Multivariate normality was assessed through Mardia's test; due to non-normal distribution, the robust maximum likelihood estimator (MLR) was utilized.

Model fit was evaluated using standard indices: Comparative fit index (CFI), Tucker-Lewis index (TLI), root mean square error of approximation (RMSEA), and standardized root mean square residual (SRMR), adhering to the recommended thresholds (CFI and TLI ≥ 0.92; RMSEA ≤ 0.08; SRMR ≤ 0.08) [15, 16].

Item parceling was employed to reduce model complexity and enhance parameter stability. Items within the KID1, KID2, and KID3 domains were grouped into three parcels based on unidimensional subsets, following the guidelines of Little *et al*. [17], which recognizes that parceled items better approximate multivariate normality [15].

RESULTS

Participants

Table 1 presents the demographic and background characteristics of the study population. Participants had a mean age of 43.3 years (SD = 9.5). A majority were female (59.6%) and predominantly of Malay ethnicity (99.4%). Most participants were married (79.4%), and a considerable proportion (64.7%) were employed in government service. Regarding educational attainment, 87.2% of participants held a university degree or higher, reflecting the teacher-based composition of the sample. Concerning their professional roles, 52.8% were Islamic schoolteachers, while 47.2% were public schoolteachers. In addition, 64% of the participants resided in urban areas, whereas 36% were from rural settings.

Table-1: Sociodemographic characteristics of community representatives (n = 470).

Variable	Mean (SD)	Frequency	Percentage
Age (years)	43.3 (9.5)		
Gender			
Male		190	40.4
Female		280	59.6
Ethnicity			
Malay		467	99.4
Others		3	0.6
Marital status			
Single		73	15.5
Married		373	79.4
Divorced		6	1.3
Widowed		18	3.8
Occupation			
Government servant		402	64.7
Private sector		60	12.8
Pensioner		3	0.6
Other		5	1.1
Level of education			
Primary school		3	0.6
Secondary school (PMR/SRP)		2	0.4
Secondary school (SPM)		16	3.4
Religious school (pondok)		2	0.4
Diploma		37	7.9
University and higher education		410	87.2
Role of community leaders			
Public school teacher		222	47.2
Islamic school teachers		248	52.8
Residency			
Rural		169	36
Urban		301	64

SD=Standard deviation

Structural equation model

Table 2 illustrates the progression of model refinement from the initial baseline model to the final optimized structure. The initial model (M0) exhibited a moderate fit to the data (RMSEA = 0.058, CFI = 0.869, TLI = 0.835, SRMR = 0.073). Model M1 incorporated a covariance path between Q46f1 and Q46f1 (modification index [MI] = 127.8), resulting in an improved fit (RMSEA = 0.047, CFI = 0.916, TLI = 0.904, SRMR = 0.071). Further refinement in model M2, by adding a covariance between Q42f1 and Q41f1 (MI = 29.5), achieved optimal fit indices (RMSEA = 0.045, CFI = 0.923, TLI = 0.913, SRMR = 0.070), indicating substantial improvements as suggested by the modification indices.

Table 3 summarizes the final model's path relationships, including standardized regression coefficients (β), confidence intervals (CI), critical ratios (CR), standard errors (SE), and corresponding p-values. KID demonstrated a significant positive effect on intention to participate (INT) (β = 0.335, 95% CI: 0.225–0.445, CR = 5.026, p < 0.001). Similarly, SN had a positive influence on intention (β = 0.296, 95% CI: 0.163–0.429, CR = 3.663, p < 0.001). Conversely, negative attitudes (ATT) had a significant negative association with intention (β = −0.313, 95% CI: −0.447–−0.179, CR = −3.844, p < 0.001). Finally, intention emerged as a strong predictor of BL (β = 0.633, 95% CI: 0.557–0.709, CR = 13.725, p < 0.001). All path estimates were statistically significant (p < 0.001), underscoring the robustness of the model. Figure 1 illustrates the finalized SEM, showing standardized path coefficients and their corresponding p-values.

DISCUSSION

The TRA served as the conceptual framework for investigating the behavioral determinants of community participation in CBS. The findings indicated that the structural model demonstrated an excellent fit to the data. Knowledge and SN exhibited significant positive effects on participants' intentions to engage in CBS activities, whereas negative attitudes were inversely associated with intention. In turn, intention exerted the most substantial direct influence on the BL of engaging in CBS activities.

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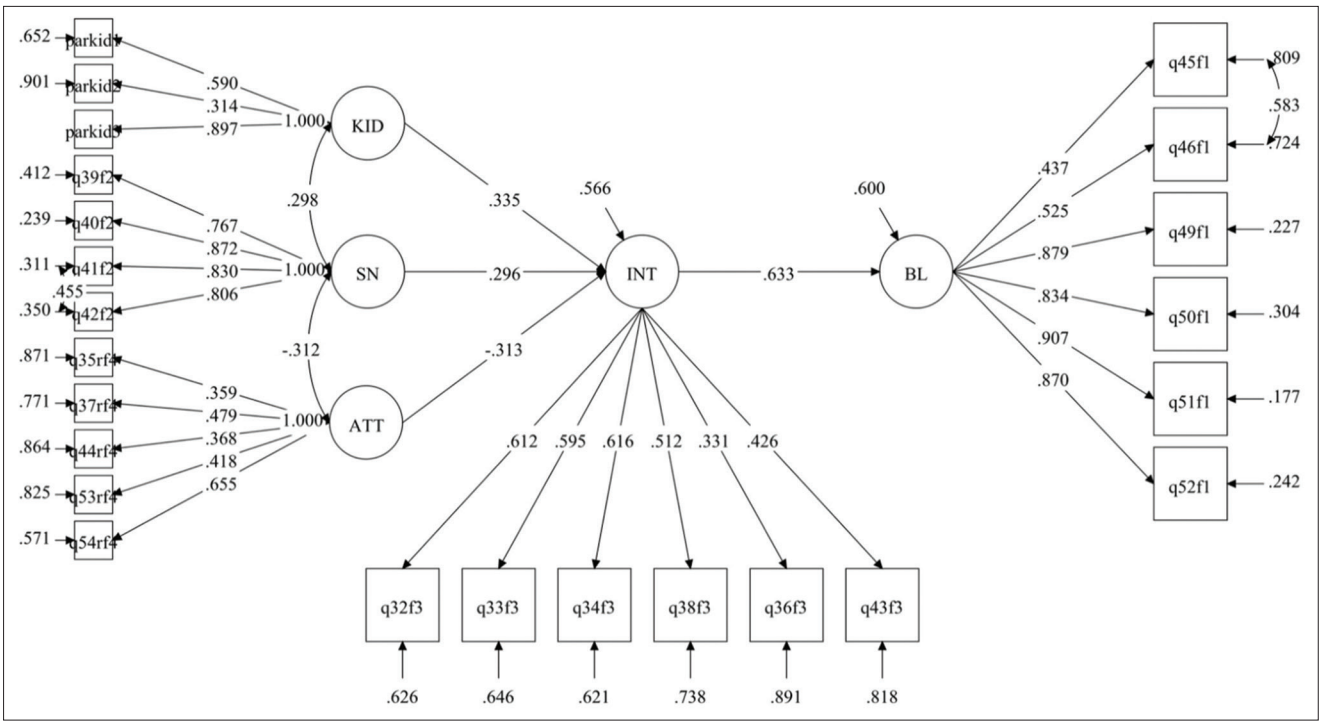

Figure 1: Final structural equation model illustrating standardized path coefficients and their corresponding p-values. β=Standardized path regression coefficient, CBS=Community-based surveillance, KID=Knowledge of infectious diseases, SN=Subjective norms, ATT=Negative attitudes toward in CBS, INT=Intention to participate in CBS, BL=Behavioral likelihood to engage in CBS activities.

Table-2: Summary of the findings of the fitness test for models 1–4 (n = 470).

Model	Modification	RMSEA (90% CI)	RMSEA p-value	CFI	TLI	SRMR
M0: Initial model	-	0.058 (0.053-0.064)	0.007	0.869	0.835	0.073
M1	Q46f1 with Q46f1 (MI=127.8)	0.047 (0.041-0.053)	0.789	0.916	0.904	0.071
M2	Q42f1 with Q41f1 (MI=29.5)	0.045 (0.039-0.051)	0.915	0.923	0.913	0.070

RMSEA=Root mean square error of approximation, CFI=Comparative fit index, TLI=Tucker-Lewis index, SRMR=Standardized root mean square residual

Table-3: Path relationships of the final model (n = 470).

Relationship	β (95% CI)	CR	SE	p-value
KID→INT	0.335 (0.225, 0.445)	5.026	0.067	<0.001
SN→INT	0.296 (0.163, 0.429)	3.663	0.081	<0.001
ATT→INT	−0.313 (−0.447, −0.179)	−3.844	0.082	<0.001
INT→BL	0.633 (0.557, 0.709)	13.725	0.046	<0.001

β (95% CI)=Standardized regression coefficient with confidence intervals, CR=Critical ratio, SE=Standard error, p-value indicates statistical significance (p < 0.05). KID=Knowledge of infectious diseases, INT=Intention to Participate in CBS, SN=Subjective norms, ATT=Negative attitudes toward, BL=Behavioral likelihood

Initially, the knowledge domain was introduced into the SEM model as three distinct subdomains. However, due to issues related to model complexity and convergence, the knowledge variables were parceled into three groups, treated as observed variables, and subsequently reintroduced into the model. This strategy, endorsed by Little *et al.* [17], effectively addressed the analytical challenges and enabled successful SEM analysis.

The results confirmed that knowledge is a crucial predictor of engagement intention, underscoring the importance of informed community representatives in promoting participation in CBS activities. These findings are consistent with prior studies by Chen *et al*. [18] and Bayır *et al*. [19], which highlight the pivotal role of knowledge in enhancing public health engagement. Educational initiatives aimed at increasing disease awareness and communicating the benefits of CBS are recommended to reinforce this relationship [20, 21].

SN also demonstrated a positive influence on intention, suggesting that perceived social expectations and encouragement from peers and authorities are important drivers of CBS participation. This observation is in accordance with the theoretical propositions of both TRA and the theory of planned behavior (TPB), which emphasizes the significance of SN in shaping behavioral intentions [10, 22]. Intervention strategies should therefore focus on harnessing normative social influences through targeted campaigns and endorsements to foster greater engagement [23–25]. Several studies utilizing TRA and TPB frameworks have reported positive associations between SN and intention across various health behaviors [12, 13, 19, 26].

Negative attitudes were incorporated into the model to capture community representatives'

unfavorable perceptions toward CBS, a factor previously reported by Ratnayake *et al*. [27] and Metuge *et al*. [28] to hinder public health initiatives. Addressing and mitigating negative perceptions is essential to improving participation rates. This finding also resonates with previous research by Nezakati *et al*. [29], Tuan *et al*. [30], and Alhamad and Donyai [31] employing TRA and TPB, which highlighted the impact of attitudes on health behavior intentions.

Moreover, BL was strongly and directly predicted by intention, which emerged as the most influential mediator within the model. This result aligns with the TRA framework, which posits intention as the primary determinant of actual behavior [32].

Despite the contributions of this study, several limitations must be acknowledged. First, the cross-sectional design precludes the inference of causal relationships between variables, necessitating longitudinal research to validate the causal pathways identified. In addition, the recruitment of schoolteachers as proxies for community representatives may restrict the generalizability of the findings. Although their inclusion aligns with WHO and IFRC recommendations [3, 33], future studies should consider validating the model across diverse community leader groups, including village leaders, traditional healers, religious figures, and educators.

CONCLUSION

This study applied SEM grounded in the TRA to elucidate the behavioral determinants influencing community participation in CBS of infectious diseases. The findings demonstrated that KID and SN significantly and positively predicted the intention to participate in CBS activities, while negative attitudes were inversely associated with intention. BL to engage in CBS was most strongly and directly influenced by intention, with the model explaining 40% of the variance in intention and 43% in BL.

The practical implications of these findings are considerable. Targeted educational initiatives that enhance community representatives' KID and CBS processes are likely to strengthen engagement. In addition, leveraging positive normative pressures through community leaders and peer influences can further encourage participation. Addressing and mitigating negative attitudes is also essential to optimize CBS involvement and improve early detection and reporting of infectious disease events.

A notable strength of this study is the rigorous methodological framework, combining a validated instrument with advanced psychometric evaluations and robust SEM analyses. The multi-stage mixed sampling approach across urban and rural settings enhances the representativeness of the findings within the Malaysian context. Furthermore, the use of intention as a mediator offers deeper insights into the mechanisms linking cognitive and social determinants to behavioral outcomes.

However, certain limitations should guide future research. The cross-sectional design precludes causal inference; therefore, longitudinal studies are needed to confirm temporal relationships and validate the predictive pathways identified. In addition, expanding the research to include other types of community leaders, such as village heads, religious figures, and traditional healers would enhance the generalizability of the findings beyond schoolteachers.

This study provides empirical evidence supporting the pivotal roles of knowledge, SN, and attitudes in shaping CBS participation. These insights provide a valuable foundation for designing community-centered interventions that promote proactive surveillance behaviors, ultimately contributing to the strengthening of public health systems and more effective outbreak prevention and response.

AUTHORS' CONTRIBUTIONS

AAH, AKG, NMY, NB, and SMH: Conceptualization. AAH and AKG: Methodology. AAH, NAMN, and FMS: Data collection. AAH, AKG, NMY, and NB: Validation. AAH and AKG: Formal analysis. AAH: Data curation. AAH: Writing–original draft preparation. AKG, NMY, NB, and SMH: Supervision. All authors have read and approved the final manuscript.

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COMPETING INTERESTS

The authors declare that they have no competing interests.

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