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DEVELOPMENT OF A COMMUNITY PARTICIPATION INDEX AS AN ENVIRONMENTAL HEALTH EFFORT IN CONTROL DENGUE HEMORRHAGIC FEVER IN SURABAYA

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Abstract

Introduction: *Dengue haemorrhagic fever (DHF) remains a critical public health challenge in Surabaya, Indonesia. Despite intensive efforts, standardized measures for assessing community involvement in DHF control are lacking. This study addresses the gap by developing a Community Participation Index (CPI) that encompasses 3M Plus actions (drain, cover, recycle water containers plus other preventive actions), opportunities, and collective action at the household level, providing a comprehensive, quantitative tool to evaluate and guide intervention strategies.* ***Methods:*** *An analytical observational case-control design was conducted, involving 1,880 households, selected through stratified random sampling from 47 health centers across diverse epidemiological and demographic zones. Data collection included structured questionnaires, household interviews, and direct observation, with validity and reliability ensured by Cronbach alpha 0.74 and confirmatory factor analysis (CFA). The "One House One Jumantik" program, introduced nationally since 2016 and locally in Surabaya since 2017, served as a focal intervention to increase active community monitoring and participation.* ***Results and Discussion:*** *The CPI model demonstrated satisfactory fit (CFI 0.92, RMSEA 0.06), with opportunity and collective action recognized as the strongest contributors. The implementation of "One House One Jumantik" correlated with increased engagement and improved 3M Plus practices, resulting in lower DHF incidence. Biases related to sampling and self-reporting were mitigated through careful design and data triangulation.* ***Conclusion:*** *The CPI offers significant practical value for DHF surveillance, targeted interventions, and policy formulation. Strengthening ongoing education, improving access, and adapting programs to local contexts are essential for bridging gaps between awareness and sustainable action.*

INTRODUCTION

Dengue hemorrhagic fever (DHF) continues to pose a significant public health challenge in Indonesia, with case numbers consistently rising. The country is ranked second globally in terms of DHF cases among endemic nations (1). This trend is partly due to Indonesia's climate and ecology, which supports the spread of the DHF vector (2). Surabaya, one of the largest cities in Indonesia, is facing similar issues. Surabaya specifically reported 191 DHF cases in 2023, with a case fatality rate (CFR) of 0%. This marks a slight reduction compared to 2022, which saw 195 DHF cases and a CFR of 0.51%. Despite intensive interventions and ongoing efforts to curb the disease, challenges in DHF control persist, particularly in certain regions (3-4).

The 3M Plus is Indonesia's government-led initiative aimed at preventing Dengue Hemorrhagic Fever (DHF), focusing on three key actions: (a) Draining (cleaning water containers to eliminate mosquito breeding sites); (b) Closing (sealing water storage to

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prevent mosquito egg-laying); and (c) Burying (disposing of or burying items that could hold stagnant water). "The Plus" involves supplementary steps, including the use of mosquito repellents, clean-up weeks, surveillance, and continuous monitoring to eliminate mosquito breeding grounds (5). The program emphasizes active community involvement in maintaining cleanliness to help reduce the spread of DHF.

To support this, the government introduced the One House One Jumantik program nationally in 2016, which was subsequently implemented in Surabaya starting in 2017. This program designates one family member in each household as a mosquito larvae monitor, known as a jumantik. This initiative complements the 3M Plus as well as national and local dengue control guidelines, serving as a central element of community intervention (5-7). The goal is to enhance community engagement in regularly monitoring and preventing mosquito breeding at the household level, aiming for consistent and distributed prevention. With one family member taking responsibility as a jumantik, it is hoped that mosquito larvae monitoring and prevention can be conducted consistently and effectively (8-9).

To measure and enhance the effectiveness of community-based DHF prevention efforts, a Community Participation Index (CPI) has been developed (2,10). The importance of community empowerment is underscored by Ministry of Health strategies, which stress the importance of empowering communities in infectious disease control and ensuring the active participation of all societal elements in creating a healthy, vector-free environment (5-6,8-9). This approach is further validated by international evidence from Malaysia and Thailand showing the catalytic effect of community participation in significantly reducing DHF transmission.

METHODS

This study adopted an observational analytical approach with a case-control study design to develop the Community Participation Index as an environmental health effort in DHF control in Surabaya. The case-control design allows for a comparison of risk factors and their effects on participation rates in DHF prevention.

The study population consisted of Surabaya residents living within the service areas of health centers that reported DHF cases in 2022. The sample included families that met the inclusion criteria, namely families with DHF cases (case group) and without DHF cases (control group) during the research period. Exclusion criteria included households with incomplete responses or refusal to participate.

Stratified random sampling was utilized to ensure balanced representation from areas with differing DHF incidence levels, stratified by epidemiological and demographic variability. The total sample size of this study comprised 1,880 households divided into two groups: the case group (940 respondents) and the control group (940 respondents). These respondents were selected from 47 out of the 63 health centers in Surabaya.

Primary data were gathered using a structured questionnaire aimed at evaluating community actions in the prevention of DHF. This questionnaire covered important aspects of 3M Plus practices, the implementation of mosquito nest eradication (PSN) activities within the neighborhoods, opportunities for involvement in DHF prevention programs, as well as a history of diseases in the family. The survey was carried out with the help of trained enumerators through direct interviews with respondents. Data was also obtained through direct observation of their homes and the surrounding environments. Data were collected and managed using the Kobo Toolbox application to facilitate real-time data recording and processing (11-13).

The dependent variable of this study was the Community Participation Index for DHF Prevention. The control variable was DHF history in the family and neighborhoods. Meanwhile, the independent variables of this study were sociodemographic factors (age and gender), individual factors (3M Plus in the household and opportunities for involvement in DHF prevention programs initiated by the community or government) and collective factors (joint activities within the neighborhood).

The instrument was validated with reliability testing (Cronbach alpha 0.74) and Confirmatory Factor Analysis (CFA), ensuring indicator accuracy. The collected data were processed using Microsoft Excel and JASP statistical software version 0.19.0 for descriptive and inferential analysis (14-16). Descriptive analysis was carried out to summarize the characteristics of the respondents. Confirmatory Factor Analysis (CFA) was employed to determine the key dimensions and indicators that define meaningful community participation in DHF prevention efforts (17-18). Logistic regression analysis was also conducted to assess relationships between variables.

This study received ethical approval from the Health Research Ethics Committee of Universitas Airlangga (No:71/EA/KEPK/2023). Research procedures adhered to ethical standards for health research. The respondents were provided with complete information regarding the purpose of the study and provided written informed consent prior to participation.

RESULTS

Characteristics of Respondents

Table 1 presents the characteristics of respondents from 47 out of the 63 health centers in Surabaya. The analysis of respondent characteristics revealed no statistically significant relationship between age or gender and the incidence of dengue hemorrhagic fever (DHF). Among respondents aged 18–41, 51.27% were in the control group and 48.73% in the case group, while those aged 42–65 comprised 48.60% of the control group and 51.40% of the case group (p = 0.24). Gender distribution was similarly balanced, with females accounting for 49.27% of the control group and 50.73% of the case group, and males making up 51.40% and 48.60%, respectively (p = 0.38). These results indicate that age and gender are not significantly associated with DHF incidence in this study population.

Table 1. Characteristics of Respondents

Characteristic	Control n(%)	Case n(%)	Total	p-value
Age				
18–41 years	505 (51.27)	480 (48.73)	985 (100.00)	0.24
42–65 years	435 (48.60)	460 (51.40)	895 (100.00)	
Total	940 (50.00)	940 (50.00)	1880 (100.00)	
Gender				
Female	610 (49.27)	628 (50.73)	1238 (100.00)	0.38
Male	330 (51.40)	312 (48.60)	642 (100.00)	
Total	940 (50.00)	940 (50.00)	1880 (100.00)	

CFA of Community Participation in DHF Control

In developing the Community Participation Index for DHF control, the CFA offers a framework to analyze the relationships between observed data and theoretical concepts linked to community involvement. The CFA utilized a third-order model to account for the complexity of the various community participation factors. At the first level, the 3M Plus (3MP) and Opportunity (KSP) factors were identified. These first-level factors were aggregated into second-level factors representing Family Actions (TKG) and Collective Actions (TKT). Ultimately, the two second-order factors were integrated to construct a third-order factor, representing overall community participation. The Confirmatory Factor Analysis (CFA) validated the Community Participation Index as a reliable and accurate representation of the intended construct.

CFA of Family Actions

Figure 1, which presents the Confirmatory Factor Analysis (CFA) of Family Actions, highlights several important relationships between constructs and indicators. The core factor, Family Action (S-O), is associated with two main components: the 3M Plus (3MP) and the Opportunity Factor (KSP). The analysis shows that the S-O construct corresponds to 3MP with a path weight of 0.56 and to KSP with a slightly stronger weight of 0.69, indicating that both factors are significant contributors, with KSP playing a slightly more dominant role.

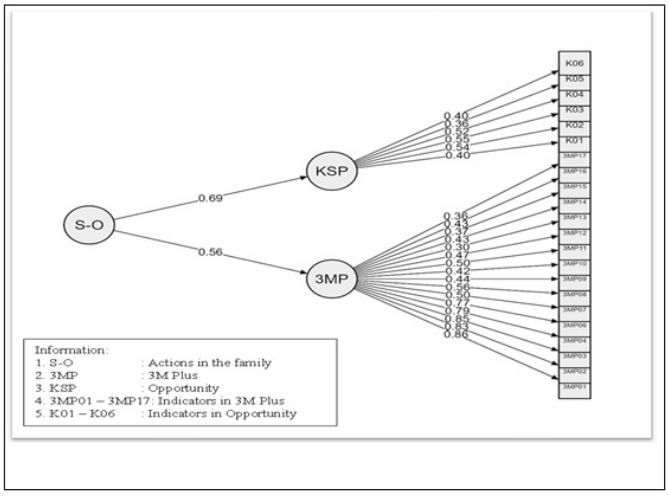

Figure 1. CFA of Family Actions

The 3M Plus factor itself is linked to a series of indicators labeled 3MP01 through 3MP17. However, one indicator, 3MP05, was excluded from the model due to its extremely low factor loading, suggesting it did not significantly represent the construct. The remaining indicators varied in their degree of correlation with the 3MP factor. Some demonstrated a strong connection, supporting the robustness of the 3MP construct, while others showed weaker associations, highlighting variability in how effectively each indicator captured aspects of 3M Plus behavior.

In parallel, the Opportunity Factor (KSP) is associated with indicators K01 through K06. The indicators demonstrated strong factor loadings, ranging from 0.69 to 0.84, indicating a consistent and significant contribution to the KSP construct. This variation among the Opportunity indicators underscores the multidimensional nature of the "Opportunity" concept as it relates to Family Action within the broader framework of Community Participation. Overall, the figure illustrates how both 3MP and KSP are essential components of Family Action, with each contributing uniquely through their respective sets of indicators. The exclusion of weak indicators like 3MP05 further strengthens the model

by ensuring that only the most relevant and reliable measures are included.

The CFA fit indices provide insight into how well the proposed model aligns with the observed data. Table 2 presents the fit indices for the CFA model of family actions. The model exhibits excellent fit, with CFI, TLI, and IFI values all exceeding 0.90. Similarly, the NFI and RFI values—both above 0.90—indicate a strong model fit. The PNFI score of 0.870 suggests that the model is parsimonious and appropriately fits the data. The approximation error metrics, RMSEA (0.046) and SRMR (0.052), also support a good fit, as RMSEA values below 0.05 and SRMR values below 0.08 are considered acceptable. Lastly, the GFI value of 0.977 further confirms the model's excellent alignment with the observed data, approaching the ideal threshold of 1.

Table 2. Fit Indices for CFA of Family Actions

Index	Value
Comparative Fit Index (CFI)	0.972
Tucker-Lewis Index (TLI)	0.969
Bentler-Bonett Non-normed Fit Index (NNFI)	0.969
Bentler-Bonett Normed Fit Index (NFI)	0.965
Parsimony Normed Fit Index (PNFI)	0.870
Bollen's Relative Fit Index (RFI)	0.961
Bollen's Incremental Fit Index (IFI)	0.972
Relative Noncentrality Index (RNI)	0.972
Root Mean Square Error of Approximation (RMSEA)	0.046
RMSEA 90% CI lower bound	0.043
RMSEA 90% CI upper bound	0.049
Standardized Root Mean Square Residual (SRMR)	0.052
Goodness of Fit Index (GFI)	0.977

CFA of Community Participation

Figure 2 on the Confirmatory Factor Analysis (CFA) of Community Participation illustrates several key components in a narrative framework. At the core of the analysis is S-O, a second-level construct representing the latent factor "Community Participation," which is measured through two primary indicators: TKG and TKT. TKG functions as one of the two first-order factors contributing to the overarching concept of Community Participation. It is linked to S-O through a path with a weight of 0.51, suggesting that "Family Action" plays a moderately balanced role in shaping community involvement. Within TKG, two specific indicators, 3M Plus (3MP) and the Opportunity Indicator (KSP) serve as measurable components. The factor loading for 3MP is 0.41, indicating a significant contribution to TKG, while KSP shows a higher factor loading of 0.68, highlighting a stronger influence on the same construct. Similar to TKG, the TKT construct, which represents "Collective Actions," is also linked to the S-O construct, with a path weight of 0.51. This equal path suggests that both Family Actions and Collective Actions make an equal contribution to the broader concept of Community Participation.

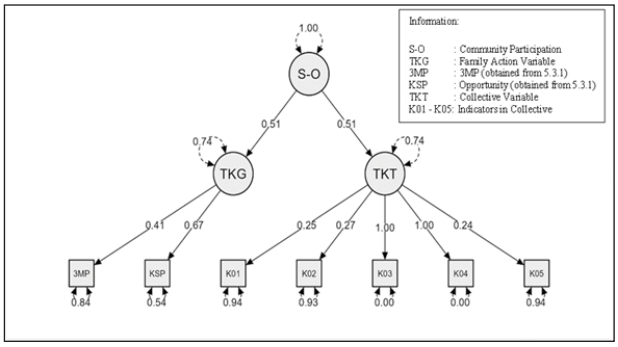

Figure 2. CFA Community Participation

When analyzing the specific indicators of Collective Actions, labeled K01 through K05, their contributions differ significantly. K03 and K04 exhibit the strongest influence, both with a factor loading of 1.00, highlighting their critical role in shaping Collective Actions. In contrast, K01 and K02 have lower factor loadings of 0.25 and 0.27, respectively, suggesting that their contributions are relatively weaker. K05 also contributes to the construct, though modestly, with a factor loading of 0.24. The reliability of both TKG and TKT is considered high. This is visually illustrated in the figure by a dotted circle labeled with a value of 0.75, indicating strong reliability in terms of the variance accounted for by each factor within the model.

As shown in Table 3, 'Community Participation' emerged as a multifaceted concept shaped by the interplay of multiple factors and indicators. "Family Action" and "Collective Action" are very important for measuring this construct. The CFA analysis of "Community Participation" revealed excellent model fit, as evidenced by the fit indices in Table 3. Indices that achieved perfect values of 1.000 such as CFI, TLI, and IFI, indicated a near-perfect fit between the model and the analyzed data. These indices have traditionally been considered important indicators of the quality of a model fit in the CFA, with values close to or equal to 1 indicating excellent fit.

Table 3. Fit Indices for CFA of Community Participation

Index	Value
Comparative Fit Index (CFI)	1.000
Tucker-Lewis Index (TLI)	1.000
Bentler-Bonett's Non-normed Fit Index (NNFI)	1.000
Bentler-Bonett's Normed Fit Index (NFI)	1.000
Parsimony Normed Fit Index (PNFI)	0.571
Bollen's Relative Fit Index (RFI)	1.000
Bollen's Incremental Fit Index (IFI)	1.000
Relative Noncentrality Index (RNI)	1.000

RMSEA and PNFI values indicate another aspect of the model fit. An RMSEA value of 0.094, with a 90% confidence interval ranging from 0.083 to 0.105 and below the 0.10 threshold, suggests an acceptable model fit. However, the PNFI value of 0.571 reflects a moderate level of model parsimony, implying that the model may still contain some unnecessary complexity. Conversely, the SRMR value of 0.069—being under the acceptable limit of 0.08—further supports a good model fit.

The combination of the near-perfect fit indices and slightly different RMSEA and PNFI values provides insight for future model improvements. First, the excellent performance of most fit indices indicates that the overall CFA model for Community Participation had an excellent fit with the data collected. Second, the less-than-perfect RMSEA and PNFI values suggest areas for further evaluation. Possible solutions include simplifying the model or re-examining the measured constructs to ensure that all relevant factors have been considered to enhance both parsimony and precision.

The development and validation of the Community Participation Index (CPI) utilized Confirmatory Factor Analysis (CFA) to ensure the theoretical model matched observed data from Surabaya households. The CFA revealed a satisfactory model fit for the index, with key indicators showing robust values (CFI 0.92, RMSEA 0.06). Within the model, opportunity indicators demonstrated high factor loadings, reflecting their strong and consistent contribution to the overall construct. Likewise, collective action emerged as a principal contributor, as shown by its substantial path weight. This analysis confirms that both opportunity and collective action are the most influential factors in improving community participation, and they play equally critical roles in effective dengue prevention. The CFA results thus support the reliability and validity of the CPI as a tool for evaluating involvement in DHF control.

Formula for the Community Participation Index for DHF Control

The development of the Community Participation Index for DHF control followed a structured and empirical methodology. The process began with thorough validation of the selected indicators based on the CFA model. Indicators such as KSP, 3MP, K01 to K05, were identified as significant contributors to Community Participation. Following validation, separate indices for the latent factors “TKG” and “TKT” were computed and then combined using a method that guarantees equal contribution from both, based on their factor loadings for “S-O”. To maintain consistency, the final index was produced through a normalization process.

This formula reflects a data-driven method to more accurately assess genuine community participation, thereby informing the development of more effective policies and interventions. When effectively implemented, the Community Participation Index can significantly enhance both the theoretical framework and practical strategies for community engagement in DHF control, providing deeper insights into its underlying dynamics. The construction of the index necessitates a rigorous, methodical approach within an academic framework. The foundation for the index was the second-order Confirmatory Factor Analysis (CFA) model. Statistical modeling was used in this study to assign relative weights to each indicator, represented through the estimated additive factor.

The initial step is essential as it guarantees that the index is grounded in validated measurements, involving precise calculation of indicators directly linked to the first-order latent factors. This process provides valuable insights into how these variables shape the broader framework of community participation in DHF control. After confirming the stability and relevance of the first-order factors, the model progressed to a second-order Confirmatory Factor Analysis (CFA). In the later stages, the model integrates the calibrated first order indicator into larger latent factors, such as “TKG” and “TKT”. Using this method, the formula not only quantifies participation but also captures its essence a more abstract and multidimensional constructin a more structured and comprehensive way.

The main purpose of balancing the second-order latent factors was to develop a comprehensive psychometric index based on the conceptual validity and statistical significance of the CFA model. The index provides a powerful tool for research and practice in the field, indicating the level of community participation in DHF control efforts. Therefore, this iterative process demonstrates the scientific rigor and commitment to creating reliable instruments to measure and increase public participation in public health.

The formula for the Community Participation Index in DHF Control are as follows:

3M Plus Score = [(0.86×3MP01) + (0.83×3MP02) + (0.85×3MP03) + (0.79×3MP04) + (0.77×3MP06) + (0.50×3MP07) + (0.56×3MP08) + (0.44×3MP09) + (0.42×3MP10) + (0.50×3MP11) + (0.47×3MP12) + (0.30×3MP13) + (0.43×3MP14) + (0.37×3MP15) + (0.43×3MP16) + (0.36×3MP17)] / 16

Opportunity Score = (0.4×KS01) + (0.54×KS02) + (0.55×KS03) + (0.52×KS04) + (0.36×KS05) + (0.4×KS06)] / 6

Family Action Score	=	[(3M Plus Score×0.41) + (Opportunity Score×0.68)] / 2
Collective Action Score	=	[(0.25×K01) + (0.27×K02) + (1×K03) + (1×K04) + (0.24×K05)] / 5
Community Participation Score	=	Family Action Score + Collective Action Score
Community Participation Index	=	Community Participation Score

Description of Indicators:

3M Plus score	=	3M Plus implementation score in the family (16 indicators)
Opportunity Score	=	the availability and accessibility of individual and family time to participate in DHF control activities
Family Action Score	=	3M Plus implementation and opportunities scores in the family
Collective Action Score	=	joint activities involving all community members in DHF control
Community Participation Score	=	combination of family and collective actions scores
3MP01	=	draining and scrubbing the water reservoir once a week
3MP02	=	tightly closing the water reservoir
3MP03	=	reusing or recycling waste materials
3MP04	=	replace the water in plant vases and bird's drinking bowl, dispose of water in the wastewater dispenser reservoir, and other containers once a week
3MP06	=	sealing holes in bamboo, trees, or soil
3MP07	=	sprinkling larvicide powder
3MP08	=	maintaining fish that feed on larvae in ponds or water storage areas
3MP09	=	installing wire mesh on windows
3MP10	=	installing wire mesh on ventilations
3MP11	=	installing wire mesh on doors
3MP12	=	storing used clothes in closed containers
3MP13	=	not hanging used clothes
3MP14	=	ensuring adequate lighting and ventilation of the room
3MP15	=	using mosquito nets
3MP16	=	applying chemicals/herbs to prevent mosquito bites
3MP17	=	planting mosquito-repellent plants
KS01	=	attending guidance and counselling sessions
KS02	=	reporting DHF cases at home to jumantik (health workers)
KS03	=	self-checking larvae at home
KS04	=	allowing officers (jumantik) to inspect inside the house
KS05	=	participating as a member of larvae monitoring teams in DHF prevention program
KS06	=	providing DHF-related counselling
K01	=	attending invitations for DHF counselling sessions
K02	=	organizing or participating in mosquito nest eradication activities
K03	=	creating and disseminating DHF related materials
K04	=	participating in the mosquito nest eradication competition
K05	=	contributing to joint fundraising for DHF prevention activities related to mosquito nest eradication at the neighborhood level

The final formula is:

Community Participation Index	=	Family Action Score + Collective Action Score

The index scores, as presented in Table 4, are categorized into three groups based on predefined cut-off points:

Table 4 Community Participation Index Score in DHF Control

Index Score	Category
2.47 – 3.29	Good participation
1.65 – 2.47	Sufficient participation
0.82 – 1.65	Lack of participation

Analysis of Community Participation Index Family Actions Related to 3M Plus

Table 5 examines the implementation of the 3M Plus actions within families and compares their application across control and case groups. In the "Good" category, 33.3% of families in the control group implemented 3M Plus effectively, compared to 24.57% in the case group. The analysis produced an estimate of -0.153, an Odds Ratio (OR) of 0.858, and a p-value of 0.026, indicating a statistically significant association between good 3M Plus practices and a reduced risk of being in the case group.

In the "Moderate" category, 55.32% of families in the control group and 49.68% in the case group practiced 3M Plus adequately. However, with an estimate of 0.107, an OR of 0.849, and a p-value of 0.128, the association was not statistically significant. In contrast, in the "Poor" category, 11.38% of families in the control group and 25.75% in the case group showed weak implementation

of 3M Plus. This category had a statistically significant estimate of 0.126, an OR of 2.599, and a p-value < 0.001, highlighting a strong correlation between inadequate 3M Plus practices and an increased risk of belonging to the case group.

Table 5. Family Actions Related to 3M Plus

3M Plus Category	Control (n, %)	Case (n, %)	*p-value*	*Odds ratio*
Good	313 (33.3)	231 (24.57)	*Reference*	
Moderate	520 (55.32)	467 (49.68)	0.128	0.849
Poor	107 (11.38)	242 (25.75)	< 0.001	2.599
Total	940 (100.00)	940 (100.00)		

Opportunity

Table 6 presents a significant relationship between opportunity categories and the distribution of individuals within the control and case groups, with all p-values < 0.001. In the "Good" category, 33.09% of individuals in the control group had good opportunities, compared to 15.75% in the case group. For the "Moderate" category, 40.21% of individuals were in the control group, while 39.90% were in the case group. An OR of 1.995 indicates that individuals with moderate opportunities are twice as likely to belong to the case group compared to the control group. In the "Poor" category, 26.70% of individuals in the control group increased to 44.36% in the case group. An OR of 3.244 suggests that individuals with poor opportunities are 3.24 times more likely to be in the case group. These findings underscore a strong statistical association between opportunity categories and the increased likelihood of being in the case group.

Table 6. Opportunity

Opportunity	Control (n,%)	Case (n,%)	*p-value*	*Odds ratio*
Good	311 (33.09)	148 (15.75)	*Reference*	
Moderate	378 (40.21)	375 (39.90)	< 0.001	1.995
Poor	251 (26.70)	417 (44.36)	< 0.001	3.244
Total	940 (100.00)	940 (100.00)		

Family Actions

Table 7 analyzes the relationship between total family actions (categorized as good, moderate, or poor) and the status of control and case groups, accompanied by OR and p-value calculations. In the "Good" category, 30.21% of families in the control group performed good actions, compared to 14.04% in the case group. For the "Moderate" category, 59.68% of families were in the control group and 62.55% in the case group, with an OR of 2.296, indicating that families with moderate actions were 2.3 times more likely to belong to the case group. Meanwhile, in the "Poor" category, 10.11% of families in the control group increased to 23.40% in the case group, with an OR of 5.316 (p-value < 0.001), indicating that poor actions significantly increased the risk of being in the case group by 5.32 times.

Table 7. Total Actions in the Family

Family	Control (n,%)	Case (n,%)	*p-value*	*Odds ratio*
Good	284 (30.21)	132 (14.04)	*Reference*	
Moderate	561 (59.68)	588 (62.55)	< 0.001	2.296
Poor	95 (10.11)	220 (23.40)	< 0.001	5.316
Total	940 (100.00)	940 (100.00)		

Collective Action

The analysis of Table 8 reveals a significant relationship between collective actions and the status of the control and case groups. In the "Good" category, the control group (28.51%) had a higher proportion than the case group (11.28%). In the "Moderate" category, the likelihood of an individual being in the case group increased 3.1 times (OR = 3.095), while in the "Poor" category, the likelihood increased 3.18 times (OR = 3.184, p-value < 0.001). These results suggest that collective actions rated as moderate or poor are strongly associated with an increased likelihood of being part of the case group.

Table 8. Collective Actions

Collective Action	Control (n,%)	Case (n,%)	*p-value*	*Odds Ratio*
Good	268 (28.51)	106 (11.28)	*Reference*	
Moderate	348 (37.02)	426 (45.32)	< 0.001	3.095
Poor	324 (34.47)	408 (43.40)	< 0.001	3.184
Total	940 (100.00)	940 (100.00)		

Community Participation

The data from Table 9 show a significant difference in community participation between the control and case groups. In the control group, 44.15% of respondents exhibited "Good" participation, while only 29.89% in the case group did the same. This difference

is significant, with a p-value < 0.001. The Odds Ratio analysis indicates that individuals with "Moderate" participation are 1.67 times more likely to be in the case group, while those with "Poor" participation have more than four times the likelihood compared to those with "Good" participation. These findings highlight that the case group tends to have lower levels of participation.

Table 9. Cross-tabulation of community participation

Community Participation	Control (n,%)	Case (n,%)	*p-value*	*Odds Ratio*
Good	415 (44,15)	281 (29,89)	*Reference*	
Moderate	489 (52.02)	554 (58.94)	< 0.001	1.673
Poor	36 (3.83)	105 (11.17)	< 0.001	4.308
Total	940 (100.00)	940 (100.00)		

Correlation of Characteristics with Community Participation Index

Table 10 presents the correlation between age, gender, and the Community Participation Index. In the age groups, individuals aged 18-41 years tend to have lower participation (classified as "Poor"), while those aged 42-65 years are more prevalent in the "Good" category. The Contingency Coefficient of 0.053 indicates a weak correlation between age and community participation, suggesting that other factors have a greater influence. Regarding gender, women have a higher percentage across all categories, particularly in the "Poor" category (71.5%), with a Contingency Coefficient of 0.078, indicating a weak correlation between gender and participation. These findings suggest that while age and gender influence participation, other factors are more significant in determining the level of community involvement.

Table 10. Correlation of Respondent Characteristics with Community Participation Index (using Contingency Coefficient)

Characteristics Respondent	Community Participation Index			Total (%)	Contingency Coefficient	*p-value*
	Good (n,%)	Moderate (n,%)	Poor (n,%)			
Age						
18-41 years	209 (21.2)	452 (45.9)	324 (32.9)	985 (100.0)		
42-65 years	227 (25.4)	405 (45.3)	263 (29.4)	895 (100.0)	0.053	0.068
Total (%)	436 (23.2)	857 (45.6)	587 (31.2)	1880 (100.0)		
Gender						
Female	278 (22.5)	541 (43.7)	419 (33.9)	1238 (100.0)		
Male	158 (24.6)	316 (49.2)	168 (26.2)	642 (100.0)	0.078	0.003
Total (%)	436 (23.2)	857 (45.6)	587 (31.2)	1880 (100.0)		

Bias and Limitations

Potential bias includes selective participation, recall error, and indicator measurement error. Efforts to reduce bias included comprehensive sampling and triangulation with official health surveillance data.

DISCUSSION

Characteristics of the Respondents

The analysis revealed no significant relationship between age and gender with DHF incidence in Surabaya. However, age and gender showed influences on participation patterns, with the prevalence of higher CPI among older and female respondents suggesting socio-cultural, not biological, influence. While age and gender do influence participation in public health programs, their effects tend to be less significant. However, the social and cultural dimensions tied to these demographics can shape how individuals engage with and contribute to health initiatives (19–22). Gaining a thorough understanding of social and gender dynamics is critical for crafting inclusive and effective strategies for community involvement. To foster broad and meaningful participation, it is vital to adopt an approach that integrates diverse demographic and socio-cultural factors, promoting a holistic and sustainable strategy for DHF prevention and control (23).

Indicators of 3M Plus Implementation

Studies on the application of 3M Plus practices within households have demonstrated a notable reduction in DHF risk. These measures, designed to eliminate mosquito breeding sites, have proven effective in controlling disease vectors. Households that consistently implement 3M Plus are at a significantly lower risk of DHF compared to those with minimal or inconsistent practice (24-25). However, moderate implementation did not produce significant differences between control and case groups, highlighting the necessity for thorough and consistent application. Inconsistent adherence to vector control strategies has contributed to rising DHF cases, underscoring the importance of comprehensive and sustained implementation (26-27).

The success of 3M Plus interventions is not solely dependent on individual behavior but also hinges

on collective community engagement. Community-based Mosquito Nest Eradication initiatives have been shown to greatly reduce DHF incidence (2). Thus, promoting widespread awareness and education about 3M Plus at both household and community levels is essential for effective DHF prevention (10,22,28-29).

Indicators of Opportunity

The link between "Opportunity" and DHF risk underscores the critical role of access to preventive resources, health education, and mosquito control measures in reducing disease transmission. The strong effect of opportunity aligns with the Health Belief Model, where perceived opportunity acts as a cue to action, catalyzing preventive behavior. Enhanced access to these elements is directly associated with a lower risk of contracting DHF by strengthening public health infrastructure and individual preventive capabilities (27). Nonetheless, even when opportunities appear sufficient, a disconnect often persists between theoretical access and practical implementation, with many individuals struggling to adopt preventive behaviors effectively.

Insufficient access to health resources can heighten vulnerability to DHF (10,30), highlighting the urgency of ensuring more inclusive access to public health education and services. Evidence indicates that improved knowledge, heightened risk awareness, and strong community participation are key to minimizing DHF exposure and fostering more effective, sustainable prevention strategies (31). Supporting this, studies in Malaysia reveal that active community engagement in initiatives such as environmental clean-up and health education significantly lowers DHF transmission. Notably, the use of Community-Based Participatory Research (CBPR) has proven effective, as collaboration between local communities and health authorities plays a vital role in eradicating Aedes mosquito breeding sites, the primary vector of DHF (32).

Indicators of Collective Actions

The discourse on the role of collective action in addressing DHF highlights that communities with high levels of participation are markedly more effective in lowering DHF risk. Cooperative community efforts are pivotal in DHF prevention, with evidence showing that strong collective engagement leads to a significant decrease in cases (20,33). The prominence of collective action is further explained by the Theory of Reasoned Action, where social norms and joint commitment play crucial roles in public health success. In contrast, communities exhibiting only moderate participation did not experience meaningful reductions in DHF incidence, suggesting that partial efforts are insufficient for effective prevention. This aligns with findings from various studies that underscore the necessity of robust, coordinated efforts among stakeholders, including government and private sectors for successful DHF control (32,34).

Communities with low engagement levels were linked to elevated DHF risk, reinforcing the need for structured interventions such as health education and environmental management to disrupt mosquito breeding grounds (35-37). Effective DHF prevention fundamentally depends on the active participation of all community members, supported by public health strategies that foster and sustain collective action (38). Global evidence supports that active communal interventions, such as those in Malaysia and Thailand, lead to significant reductions in DHF transmission, validating CPI's multidimensional and international relevance.

Effectiveness of One House One Jumantik

The One House One Jumantik program correlated with increased household participation, with 33.3% good 3M Plus practices in control group versus 24.57% in case group (OR = 0.858, p = 0.026). This demonstrates the program's positive impact on community engagement in DHF prevention efforts. Opportunity equity and collective neighborhood actions further reduced risk, reinforcing the role of social support networks and community norms in effective disease control.

Theoretical Implications

The creation of this index holds significant theoretical value for public health research, particularly in advancing the understanding and management of vector-borne infectious disease prevention and control:

Health Belief Model

This study reinforces the core concepts of the Health Belief Model (HBM) while deepening the understanding of its application in DHF control efforts in Surabaya. A comprehensive approach was employed to analyze the diverse factors influencing community participation. Moreover, the research explores dynamic interactions across individual, family, and community levels, each playing a role in shaping DHF prevention efforts. The resulting model supports the development of evidence-based strategies and interventions tailored to local conditions, offering a meaningful and practical contribution to public health.

Theory of Reasoned Action

This study also applied the Theory of Reasoned Action to explain and optimize DHF control efforts in

Surabaya. The focus was on the relationship between knowledge, attitudes, perceptions, collective action, and the implementation of effective public health strategies. This study identifies that knowledge of DHF is an important foundation for driving behavioral change, supporting the principle that accurate information is the first step to behavioral transformation (39). Positive attitudes towards DHF control efforts have been proven to influence active community participation, consistent with the theory that attitudes shape intentions and behaviors. At the community level, this study highlights the importance of collective action and social participation in strengthening DHF control efforts through coordination and cooperation (40-41).

Practical Implications

This index carries significant practical implications in the context of public health interventions (11,42). Continuous evaluation can guide smarter resource allocation, which has been recommended by studies related to DHF control (25). Community education, being a milestone in improving communal health, can be built on the data and analysis provided by the index (43). Community engagement and empowerment become more strategic due to clear participation mapping (22). In the realm of policymaking, the index provides a strong scientific basis for responsive, evidence-based decision-making, aligning with previously proposed public health intervention policies (44). This Community Participation index-based supervision and monitoring are expected to help the government anticipate and manage DHF incidents more proactively (45).

CONCLUSION

Analysis of respondent characteristics in Surabaya did not find a significant relationship between age and gender with DHF incidents. The analysis revealed that a history of DHF in the family or neighborhoods increased the risk of DHF, emphasizing the need to include this factor in prevention and control strategies. This supports a more personalized and community prevention approach to public health interventions to address DHF vector habitats and prevent sthe spread of the disease.

CPI is proposed as a robust, evidence-based metric for evaluating and guiding community participation in DHF prevention. Effective 3M Plus practices at home are associated with a lower risk of DHF, suggesting that families who consistently implement them tend to have fewer incidences. This confirms the need for a comprehensive implementation of 3M Plus and community support to prevent the habitat of Aedes aegypti mosquitoes. There is a significant relationship between high “Opportunity Indicator” which is associated with low risk of dengue fever transmission.

Community-based DHF prevention, through collective action, is a key strategy to reduce DHF cases. It emphasizes the need for active community participation as part of DHF control efforts. The formula of the Community Participation Index in DHF Control is as follows: “Community Participation Index = Family Action Score + Collective Action Score”

The Community Participation Index serves as an effective instrument for evaluating community involvement in DHF prevention and can guide policymakers in tailoring more targeted and sustainable public health strategies. The index provides practical insights for surveillance, targeted interventions, and resource allocation for policymakers. Enhancing education, accessibility, opportunity equity, and continuous adaptation of community-based programs are essential to improve the effectiveness of DHF prevention efforts and to bridge the gap between awareness and actual action for achieving sustainable impact.

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AUTHORS’ CONTRIBUTION

SZ: methodology, software, writing- original draft preparation, visualization and investigation. MFDL: conceptualization, data curation, software, validation, writing- reviewing, and editing. RY: conceptualization and

reviewing. HBN and RD: statistical model, visualization, and reviewing. MRHF: writing and editing. AFF: writing and visualization.

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