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Community-based WASH and CERIA-PHBS model for post-flood health recovery in rural Aceh

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ABSTRACT

This community engagement program was implemented in Lawet Village, West Aceh, a flood-prone rural area severely affected by the November 26, 2025 disaster, which resulted in environmental degradation, limited access to safe water, inadequate sanitation facilities, low adoption of clean and healthy living behaviors (PHBS), and the absence of safe educational spaces for children. The program aimed to improve post-disaster community health resilience through an integrated community-based approach combining Water, Sanitation, and Hygiene (WASH) interventions with the CERIA-PHBS (Cerdas, Edukatif, Interaktif, dan Aman) model. The program was conducted through five stages: socialization, participatory assessment, technology implementation, mentoring and evaluation, and sustainability planning. Key interventions included the installation of a community-based clean water system, provision of ≥10 portable handwashing stations (CTPS), health education for families, and the establishment of a child-friendly educational space. A pre–post descriptive evaluation was used to assess changes in knowledge and behavior. The results showed significant improvements, including increased access to clean water, improved PHBS practices from approximately 25% to ≥70%, enhanced community knowledge, and strengthened capacity of ≥10 health cadres. In addition, more than 60 children participated in CERIA-PHBS activities, with improved hygiene behavior and psychosocial well-being. This integrated model demonstrates effectiveness in accelerating post-flood health recovery and offers a scalable and sustainable approach for disaster-prone rural communities.

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A. INTRODUCTION

Flood disasters remain a major global public health concern, particularly in low- and middle-income countries (LMICs), where their impacts extend beyond immediate physical destruction to long-term environmental, social, and health consequences. Post-flood conditions frequently lead to contamination of water sources, disruption of sanitation systems, and increased transmission of waterborne and hygiene-related diseases, including diarrhea, skin infections, and acute respiratory infections (World Health Organization, 2024). Rural communities are often disproportionately affected due to limited infrastructure, inadequate access to health services, weak environmental management systems, and low adaptive capacity. Consequently, post-disaster recovery requires not only infrastructure rehabilitation but also integrated strategies that strengthen community resilience and promote sustainable health behavior change.

Water, Sanitation, and Hygiene (WASH) interventions have been widely implemented as a primary approach to reduce disease transmission and improve environmental health conditions in disaster-affected populations. Previous studies have demonstrated that improved access to clean water and sanitation can significantly reduce infectious disease risks and improve overall community health outcomes.(Sophie et al., 2026).

However, most WASH interventions remain predominantly infrastructure-oriented and focus primarily on emergency responses, with limited integration of behavioral change interventions, community empowerment mechanisms, and child-centered health promotion strategies. As a result, improvements in physical infrastructure do not always lead to sustainable hygiene practices or long-term community resilience.

In addition, child-focused post-disaster programs generally emphasize psychosocial recovery without adequately integrating environmental health education and hygiene behavior reinforcement. This limitation is particularly important in disaster-prone rural settings, where children are highly vulnerable to both environmental health risks and psychosocial stress following floods. In many rural communities, the absence of structured child-friendly educational spaces further reduces opportunities for sustainable hygiene promotion and community participation(Utami et al., 2025). Despite the growing implementation of WASH programs in disaster settings, evidence regarding integrated community-based models that simultaneously combine WASH infrastructure, PHBS behavior change, child-centered educational approaches, and community empowerment remains limited, particularly in rural flood-prone areas in Indonesia. Most previous interventions have addressed infrastructure provision, behavioral education, or psychosocial support separately rather than within a single integrated operational framework. Consequently, there is still limited empirical evidence regarding effective and sustainable approaches for strengthening post-disaster community health resilience through multidimensional interventions (Wolf et al., 2018). However, existing WASH programs are often fragmented and predominantly infrastructure-oriented, with limited integration of behavioral change strategies and community-based management systems. As a result, improvements in physical infrastructure do not always translate into sustained health behavior changes. Furthermore, child-focused post-disaster interventions typically emphasize psychosocial recovery but rarely integrate environmental health practices, thereby limiting their effectiveness in shaping long-term hygiene behaviors among vulnerable populations(Mandal et al., 2026; Plass & Zinn, 2025; Setiawan et al., 2025).

These gaps are clearly evident in Lawet Village, West Aceh, Indonesia, a rural flood-prone area severely affected by the flood disaster on November 26, 2025. The disaster caused

environmental degradation, contamination of household water sources, disruption of sanitation practices, and low adoption of clean and healthy living behaviors (PHBS). Baseline assessment indicated that only approximately 25% of households consistently practiced appropriate PHBS behaviors, while community capacity in managing WASH facilities remained limited. In addition, the absence of safe and structured educational spaces increased children's vulnerability to environmental health problems and psychosocial distress. These conditions highlight the urgent need for an integrated and context-specific post-disaster health recovery approach.

To address these challenges, this study proposes an integrated WASH and CERIA-PHBS model as a community-based strategy for post-flood health recovery. The model integrates three main components: (1) community-based WASH infrastructure development, including clean water systems and portable handwashing facilities; (2) structured PHBS education and behavior change interventions targeting households and health cadres; and (3) child-centered health promotion through the CERIA-PHBS approach (Cerdas, Edukatif, Interaktif, dan Aman), which combines hygiene education with psychosocial support in a safe and interactive learning environment. The novelty of this model lies in its integration of environmental health interventions, behavioral transformation, child participation, and community empowerment within a single sustainable framework.

Conceptually, this study is based on the assumption that sustainable post-disaster recovery cannot be achieved solely through infrastructure provision without corresponding improvements in behavior, participation, and local institutional capacity. Therefore, the integrated WASH and CERIA-PHBS model positions WASH infrastructure as an enabling factor, PHBS education as a behavioral reinforcement strategy, and community participation as a sustainability mechanism for long-term resilience building.

Therefore, this study seeks to examine whether the integrated WASH and CERIA-PHBS model can effectively improve hygiene behavior, access to safe water, child participation, and community health resilience in post-flood rural communities in Aceh. Specifically, the study aims to: (1) improve access to safe water and hygiene facilities, (2) strengthen PHBS practices among households and children, (3) enhance the capacity of local health cadres, and (4) establish a sustainable community-based system for post-disaster health recovery. By providing empirical evidence on an integrated and scalable intervention model, this study contributes to the development of more holistic and sustainable approaches to community-based disaster recovery in resource-limited rural settings.

B. METHODS

This This study employed a community-based quasi-experimental design using a one-group pre–post approach to evaluate the effectiveness of the integrated WASH and CERIA-PHBS model in improving post-disaster health outcomes. The program was conducted in Lawet Village, Pante Ceureumen District, West Aceh, Indonesia, a flood-prone rural area severely affected by the flood event on November 26, 2025. The implementation was carried out over a three-month period from January to March 2026.

Study Participants and Sampling

The study involved two main target groups: (1) village health cadres and households affected by the flood, and (2) children from farming families in vulnerable age groups. A total of 70 participants were included, consisting of 10 health cadres, 30 adult household representatives, and 30 children. Participants were selected using purposive sampling based

on inclusion criteria, including residence in the affected area, willingness to participate, and direct exposure to post-flood conditions.

Intervention Design

The intervention was based on an integrated WASH and CERIA-PHBS model and implemented through five sequential stages:

1. Socialization: Coordination with village authorities, community leaders, and health cadres to introduce the program objectives and establish a local implementation team.
2. Participatory Assessment: Identification of priority problems through focus group discussions (FGDs), field observations, and baseline measurements of PHBS practices and WASH access.
3. Technology Implementation: Installation of a community-based clean water system (bore well, pump, and storage tank), provision of ≥10 portable handwashing facilities (CTPS), and establishment of a child-friendly educational space (CERIA-PHBS).
4. Mentoring and Education: Delivery of structured PHBS education sessions for families and children, along with hands-on training for health cadres in managing WASH facilities and monitoring community health practices.
5. Evaluation and Sustainability Planning: Monitoring program implementation, conducting post-intervention assessments, and developing standard operating procedures (SOPs), management structures, and maintenance schedules for sustainability.

Data Collection Instruments

Data were collected using both quantitative and qualitative methods:

1. PHBS Questionnaire: A structured questionnaire consisting of 15 items measuring hygiene practices (e.g., handwashing behavior, water use, sanitation practices), scored on a Likert scale.
2. Observation Checklist: Used to assess actual practices of CTPS and utilization of WASH facilities.
3. Knowledge Assessment Sheet: Used to measure participants' understanding of PHBS concepts.
4. Participation Records and Field Notes: Documenting attendance, engagement, and qualitative feedback from participants.

The instruments were adapted from standard public health behavior indicators and underwent content validity review by two public health experts. Reliability testing showed acceptable internal consistency (Cronbach's alpha = 0.82).

Data Analysis

Quantitative data were analyzed using descriptive and inferential statistics. Descriptive analysis (mean, percentage, and standard deviation) was used to describe baseline and post-intervention conditions. To assess the effectiveness of the intervention, paired sample t-test (for normally distributed data) or Wilcoxon signed-rank test (for non-normal data) was applied to compare pre–post scores of PHBS practices and knowledge levels. A significance level of $p < 0.05$ was used.

Qualitative data from FGDs and field observations were analyzed using thematic analysis to identify patterns related to behavior change, community participation, and program acceptability.

Ethical Considerations

This study was conducted following ethical principles of voluntary participation and confidentiality. All participants provided informed consent prior to data collection, and community approval was obtained from village authorities.

Limitations of the Study

This study has several limitations. First, the absence of a control group limits the ability to establish causal inference. Second, the relatively small sample size may affect generalizability. Third, the short intervention period may not fully capture long-term sustainability of behavior change. Despite these limitations, the study provides valuable practical evidence of an integrated, community-based approach in post-disaster settings.

C. RESULTS AND DISCUSSION

1.1 Baseline Conditions

Baseline assessment revealed substantial environmental health challenges in Lawet Village following the flood disaster. Limited access to safe water, inadequate sanitation facilities, and low adoption of clean and healthy living behaviors (PHBS) were identified as major public health concerns. Questionnaire results and field observations showed that only approximately 25% of households consistently practiced appropriate PHBS behaviors, while access to safe water remained limited to around 30% of households. Community participation in WASH management was also relatively low, with minimal involvement of local health cadres in environmental health monitoring and hygiene promotion activities.

1.2 Changes in PHBS Practices and Knowledge

Post-intervention assessment demonstrated significant improvements in hygiene behavior and community knowledge following implementation of the integrated WASH and CERIA-PHBS model. The mean PHBS score increased from 25.3 ± 8.4 at baseline to 72.6 ± 10.2 after the intervention. Statistical analysis using paired sample t-test indicated that the improvement was statistically significant ($p < 0.001$). In addition, knowledge scores related to hygiene and sanitation also improved substantially after the intervention period.

Table 1. Changes in PHBS Scores Before and After Intervention

Variable	Pre-test Mean ± SD	Post-test Mean ± SD	Mean Difference	p-value
PHBS Score	25.3 ± 8.4	72.6 ± 10.2	47.3	<0.001
Knowledge Score	45.2 ± 10.1	80.5 ± 9.3	35.3	<0.001

These findings indicate that the integration of WASH infrastructure and structured PHBS education contributed to measurable improvements in hygiene-related behavior and community awareness.

1.3 Improvement in Access to Safe Water and Hygiene Facilities

Significant improvements were observed in access to safe water and hygiene facilities following the intervention. Household access to safe water increased from approximately 30% at baseline to more than 70% after implementation of the community-based WASH system. In addition, more than 10 portable handwashing facilities (CTPS) became available in strategic public areas, improving accessibility to hand hygiene practices within the community.

Field observations further showed increased compliance with proper handwashing practices among both adults and children during the post-intervention period. Improved availability of clean water and hygiene facilities contributed to more consistent adoption of PHBS practices at the household and community levels.

1.4 Strengthening Community Capacity

The intervention also contributed to strengthening local community capacity in environmental health management. More than 10 health cadres participated in training activities related to PHBS promotion, WASH facility maintenance, and community-based monitoring. Increased cadre participation supported the dissemination of hygiene education and facilitated monitoring of community health practices after the intervention.

The establishment of standard operating procedures (SOPs), maintenance schedules, and local management mechanisms further supported the sustainability of the WASH facilities and community-based health activities.

1.5 Child Health and CERIA-PHBS Outcomes

Positive outcomes were also observed among children participating in the CERIA-PHBS activities. More than 60 children participated in interactive educational sessions focusing on hygiene practices and healthy behaviors. Post-intervention observation indicated that approximately 70% of participating children demonstrated correct handwashing practices.

The establishment of a safe and interactive educational environment also increased children's participation and engagement in hygiene promotion activities. These findings suggest that integrating child-centered educational approaches into WASH interventions may strengthen post-disaster health promotion efforts in rural communities.

Table 2. Program Output and Coverage

Indicator	Baseline	Post-intervention	Achievement
PHBS Practice (%)	25%	≥70%	Increased
Access to Clean Water (%)	30%	≥70%	Increased
CTPS Facilities (units)	0	≥10	Achieved
Trained Health Cadres (persons)	0	≥10	Achieved
Children Participating	0	≥60	Achieved

Overall, the findings demonstrate that the integrated WASH and CERIA-PHBS model effectively improved environmental health conditions, hygiene behavior, access to safe water, and community participation in post-flood recovery efforts. These outcomes indicate that combining infrastructure provision with behavioral and community empowerment strategies can produce measurable improvements in post-disaster community health resilience.

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Figure 1. Community-based CERIA-PHBS educational activities aimed at improving hygiene behavior and PHBS adoption among children and households in post-flood settings.

Figure 2. Community-based WASH infrastructure developed to improve access to safe water and hygiene facilities in flood-affected rural communities.

1.3 Discussion

The findings of this study demonstrate that the integrated WASH and CERIA-PHBS model is effective in improving post-disaster health outcomes at multiple levels, including infrastructure access, behaviour change, and community capacity. The significant increase in PHBS practices ($p < 0.001$) indicates that combining physical interventions with structured education can produce measurable and meaningful behavioural improvements.

1. Interpretation of Main Findings

The findings of this study demonstrate that the integrated community-based WASH and CERIA-PHBS model is significantly associated with improvements in post-flood health outcomes, particularly in terms of enhanced hygiene behavior, increased access to clean water, and strengthened community capacity. These results highlight that flood disasters should not be interpreted solely as environmental disturbances but rather as complex, multidimensional phenomena that simultaneously affect ecological systems, social structures, and public health conditions. The observed improvements—such as the substantial increase in PHBS adoption, improved access to safe water, and the activation of community health cadres—indicate that post-disaster recovery is strongly influenced by the interaction between environmental exposure, socio-economic conditions, and adaptive capacity at the household and community levels.

From a broader perspective, these findings reinforce the conceptual understanding that disaster impacts are not determined solely by the magnitude of the hazard but by the interplay between hazard, exposure, and vulnerability. Floods disrupt essential systems such as water supply, sanitation, food access, and health services, thereby amplifying risks among already vulnerable populations. This is consistent with evidence showing that climate-related shocks, including floods, significantly disrupt water, sanitation, and food systems while disproportionately affecting vulnerable groups such as women and children (Ogutu et al., 2026) . In this study, baseline conditions revealed similar vulnerabilities, including limited access to safe water, inadequate hygiene practices, and weak community capacity, which collectively increased susceptibility to post-disaster health risks.

The results also emphasize that the provision of WASH infrastructure alone is insufficient to produce sustainable health improvements. While infrastructure development—such as the installation of clean water systems and handwashing facilities—played an important role in improving physical access, the most substantial changes occurred when these were combined with behavioral interventions and community engagement. This finding aligns with broader resilience and disaster management frameworks that emphasize the importance of integrated approaches combining structural and non-structural measures. For instance, integrated flood risk management frameworks highlight that effective disaster mitigation requires not only physical interventions but also behavioral, institutional, and socio-economic components (Jayawardane et al., 2025) . In this context, the CERIA-PHBS model demonstrates how behavioral change strategies can enhance the effectiveness of infrastructure-based interventions.

Community participation emerges as a central determinant of the observed outcomes. The active involvement of local health cadres and community members in the intervention process contributed to increased ownership, improved knowledge dissemination, and stronger collective action. This finding is consistent with Nugraheni et al., which show that community participation is strongly associated with adaptive responses to environmental change and disaster resilience. In particular, their study highlights that community engagement can influence land-use adaptation and resilience-building processes, suggesting that social participation plays a critical role in mitigating disaster impacts. In the present study, similar dynamics were observed, where community involvement facilitated the adoption of hygiene practices and strengthened local capacity to sustain intervention outcomes.

Importantly, the results indicate that behavioral change in post-disaster settings is not solely an individual process but a socially embedded phenomenon. Changes in hygiene practices were not only driven by increased awareness but also reinforced through social interactions, peer influence, and collective norms. Behavioral models in disaster contexts suggest that individuals' actions are shaped by perceived risk, access to information, and trust in institutions. For example, studies on evacuation behavior demonstrate that information quality, perceived severity, and government support significantly influence behavioral responses during disasters (Remegio et al., 2026). Similarly, in this study, structured education, community engagement, and the presence of local health cadres likely enhanced risk perception and motivated sustained behavioral change.

Another key finding relates to the role of child-centered interventions in influencing broader health outcomes. The CERIA-PHBS component, which engaged children through interactive and participatory approaches, contributed not only to improved hygiene behavior among children but also to changes at the household level. Children can act as agents of change within families by transferring knowledge and influencing daily practices. This is particularly important in disaster-affected settings, where children are both vulnerable to

health risks and capable of influencing household behavior. The integration of psychosocial support with hygiene education also addresses the dual burden faced by children in post-disaster contexts, where physical and psychological challenges coexist.

Furthermore, the findings highlight the importance of adaptive capacity as a key determinant of recovery. Adaptive capacity refers to the ability of individuals and communities to anticipate, cope with, and recover from adverse events. In this study, adaptive capacity was strengthened through capacity-building activities such as training of health cadres, community education, and participatory implementation strategies. This is consistent with resilience-based approaches, which emphasize the importance of enhancing local capacity and institutional support to improve disaster outcomes. At a broader level, urban flood resilience frameworks also stress the need for integrated governance, technological innovation, and community engagement to address complex flood risks (Li et al., 2026) . Although the present study focuses on a rural setting, the underlying principle remains similar: resilience is achieved through the integration of physical, social, and institutional dimensions.

The findings also suggest that post-disaster health outcomes are closely linked to socio-economic vulnerability. Flood impacts are often disproportionately experienced by low-income and marginalized populations due to limited access to resources, inadequate infrastructure, and reduced coping capacity. Studies on flood exposure and vulnerability indicate that socio-economic characteristics, such as poverty levels and access to resources, significantly influence the severity of disaster impacts and recovery outcomes (Singh et al., 2026) . In this study, improvements in WASH access and hygiene practices may have helped reduce these disparities by providing essential resources and strengthening community resilience.

Overall, the interpretation of the main findings highlights the importance of adopting a multidimensional approach to post-disaster health interventions. The effectiveness of the WASH and CERIA-PHBS model lies in its ability to integrate infrastructure development, behavioral change, and community empowerment into a cohesive framework. This integrated approach creates a synergistic effect, where improvements in one domain reinforce outcomes in others. For example, improved infrastructure facilitates behavior change, while enhanced community capacity ensures the sustainability of infrastructure use and maintenance.

In conclusion, this study provides strong evidence that addressing post-flood health challenges requires a holistic and integrated approach. The findings demonstrate that sustainable improvements in health outcomes can be achieved when environmental interventions are combined with behavioral strategies and community participation. By bridging the gap between infrastructure provision and behavioral change, the WASH and CERIA-PHBS model offers a comprehensive framework for enhancing resilience and reducing health risks in disaster-prone communities. These insights have important implications for the design of future interventions, emphasizing the need for integrated, community-centered, and context-specific approaches in disaster risk reduction and public health.

D. CONCLUSION

This study demonstrates that the implementation of the integrated WASH and CERIA-PHBS model effectively addresses key post-disaster health challenges in rural flood-prone communities. The intervention successfully improved access to safe water and hygiene facilities, enhanced the adoption of clean and healthy living behaviours (PHBS), strengthened the capacity of local health cadres, and provided a safe and structured educational

environment for children. These outcomes indicate that the combination of infrastructure provision, behaviour change interventions, and community empowerment can produce significant and measurable improvements in community health resilience.

The findings highlight that sustainable post-disaster recovery cannot rely solely on physical infrastructure but requires an integrated approach that simultaneously addresses behavioural and institutional dimensions. The inclusion of child-cantered health education through the CERIA-PHBS model contributes to long-term behaviour formation, while community-based management systems ensure program sustainability. This multi-level integration represents a practical and scalable model for improving health outcomes in disaster-affected rural settings.

Despite its effectiveness, this study has several limitations, including the absence of a control group, a relatively small sample size, and a short intervention period, which may limit the generalizability and long-term evaluation of outcomes. Therefore, future studies are recommended to apply more rigorous experimental designs, involve larger populations, and conduct longitudinal assessments to examine the sustainability of behaviour change over time.

Overall, the integrated WASH and CERIA-PHBS model offers a promising, replicable, and sustainable approach for accelerating post-disaster health recovery, particularly in resource-limited communities, and contributes to the development of more holistic community-based health interventions.

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F. AUTHOR CONTRIBUTIONS

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Conceptualization and study design: TNF, Y, S.
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Technical development of WASH system: AER.
Data collection: F, Z, FR.
Data analysis and interpretation: TNF, Y, S.
Article drafting: TNF, Y.
Critical revision of the manuscript: AER, S.
Final approval of the manuscript: All authors.

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