



Transforming Coastal Household Sanitation: A Family-Centered PHAST Adaptation for Malnutrition and Environmentally Related Diseases-Vulnerable Communities

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Abstract

Poor environmental sanitation in coastal areas is closely associated with environmentally related diseases and malnutrition among under-five children, but participatory interventions are rarely evaluated at the household level. Therefore, this study aimed to implement and evaluate a family-centered adaptation of the Participatory Hygiene and Sanitation Transformation (PHAST) method in Medan Belawan District, Indonesia. A Participatory Action Research (PAR) design engaged 30 households with children under five years of age. Qualitative interview and observation data were triangulated with descriptive pre- and post-intervention sanitation indicators and anthropometric data to validate the thematic evidence. The results from the baseline assessment showed inadequate sanitation conditions, including unsafe toilets, open wastewater channels, as well as poor hygiene and waste management. Following the intervention, all families stored water and food in covered containers, 83.3% disposed of waste daily, and 50% performed actions such as closing toilet holes and cleaning up scattered waste. The intervention increased household environmental awareness, strengthened shared family responsibility for sanitation, and produced measurable improvements in sanitation practices. This reduced the risk of environmentally related diseases, and malnutrition remains a plausible, unmeasured downstream benefit. In conclusion, the adaptation appears feasible and acceptable for strengthening household sanitation ownership in low-resource coastal communities, warranting further evaluation of its longer-term health impact.

INTRODUCTION

Malnutrition is a persistent public health problem in Indonesia, contributing significantly to morbidity and mortality among children under five years of age. The relationship between malnutrition and infectious diseases is cyclical. Infection reduces appetite and nutrient absorption, while poor nutrition weakens immune function and increases susceptibility to pathogens (Wells dkk., 2020). This emphasizes the ecological triad of host, agent, and environment as a key determinant of child health (Purba dkk., 2025). Preventing malnutrition requires integrating nutrition-

specific and environmental health interventions within a holistic public health method rooted in family and community participation (Soma dkk., 2025).

Environmental sanitation serves as a proxy indicator of a community's welfare, correlating with the Sustainable Development Goals (SDGs), particularly Goal 3 (Good Health and Well-being), 6 (Clean Water and Sanitation), and 11 (Sustainable Cities and Communities), which require continuous access to safe drinking water, hygienic latrines, and proper waste management (WHO, 2021b). Poor sanitation encourages the

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transmission of pathogens that thrive in unhygienic conditions. This can lead to diarrhea, intestinal worm infections, and other environmentally related diseases that impair nutrient absorption and growth (Varela dkk., 2025). Therefore, improving sanitation is integral to achieving nutritional resilience in children.

Environmentally related diseases are a major health concern in low- and middle-income countries, where rapid urbanisation often exceeds sanitation capacity. Diarrhea remains among the top ten diseases treated in Indonesian primary health centres, while soil-transmitted helminth infections persist as an endemic burden (Petruzzi dkk., 2025). These contribute not only to acute morbidity but also to chronic malnutrition and developmental delays. Young children are particularly vulnerable due to behavioural patterns such as playing outdoors, limited hand hygiene, and frequent exposure to contaminated environments (Puteri & Fitria, 2025), reinforcing the need for preventive environmental health measures targeting households. Strengthening sanitation and hygiene at the family level could significantly reduce exposure risks and disease incidence. These focused efforts are more sustainable than curative health interventions alone (Susilawati dkk., 2022).

Coastal settlements in Indonesia face a distinct set of environmental and social challenges shaping health outcomes. The communities often face high population density, flooding, limited sanitation infrastructure, and constrained access to clean water (Masztalerz-Kozubek dkk., 2024). Medan city's coastal districts exemplify these conditions, with 3,408 diarrhea cases reported in Medan Marelan, 2,096 in Belawan, and 1,763 in Labuhan (Medan City Health Office, 2023). In addition to the burden of environmentally related diseases, malnutrition among children under five remains a public health concern in Medan City. The 2024 Medan City Health Profile reported 77 cases of severe malnutrition. These conditions are particularly concerning in Medan Belawan, a densely populated coastal area characterized by stilt-house settlements located in the tidal zone, where sanitation infrastructure remains inadequate. The area is marked by limited septic tank ownership, direct discharge of household wastewater into open drainage channels and coastal waters, insufficient solid waste management services, as well as frequent tidal flooding that worsens environmental contamination. These conditions increase the risk of diarrhea, intestinal infections, and other environmentally related diseases that may negatively affect children's nutritional status

and growth. Despite the implementation of various sanitation and nutrition programs, environmental health problems remain persistent in the coastal communities. This suggests the need for more participatory and family-centered methods to achieve sustainable behavioral change and improved health outcomes.

The Community-Based Total Sanitation implementation in coastal areas remains suboptimal due to limited community engagement (Fenita dkk., 2022). Strengthening participatory methods is essential to ensure long-term behavioural change. Family-oriented interventions can serve as a foundation for broader community sanitation improvements (Sofiyah dkk., 2025). Malnutrition among children under five remains a public health concern in Medan City, with the 2024 Health Profile reporting 77 cases of severe malnutrition citywide. The situation is specifically concerning in vulnerable coastal communities where inadequate sanitation and recurrent infections further compromise children's nutritional status. Despite various sanitation and nutrition programs, environmental health problems persist in Medan's coastal communities, with high diarrheal incidence, inadequate facilities, poor waste management, and continued malnutrition, signifying that existing efforts have not achieved sustainable improvement. This underscores the need for a broader intervention approach in Medan Belawan that combines infrastructure improvements and health education with greater household involvement in sanitation management and decision-making.

The Participatory Hygiene and Sanitation Transformation (PHAST) model offers a structured participatory framework designed to enhance community capacity to manage sanitation and hygiene issues through engagement, analysis, planning, and monitoring (Almazan, 2024). Originally developed for water, sanitation, and hygiene (WASH) programmes, PHAST emphasises the 'software' (behaviour change) alongside the 'hardware' dimension (infrastructure). Its sequential steps of problem identification, problem analysis, planning for solution, behaviour change implementation, monitoring, and participatory evaluation are particularly suited to empower households and neighbourhood groups (Ikegulu dkk., 2024). Several international evaluations have shown the effectiveness of PHAST in improving hygiene practices when community participation is robust (McMichael & Vally, 2020). However, most evaluations have been implemented and assessed at the community level, and evidence on how the same principles can be

adapted to the household as the primary unit of engagement in complex coastal settings remains limited. Shifting the unit of engagement from the community to the family is the central adaptation examined in this study. Rather than proposing a new conceptual model, this study applied and evaluated the established PHAST framework through a family-centered implementation strategy to strengthen household ownership and support the sustainability of sanitation improvements (Barrington *et al.*, 2016). Through a participatory action study design, households with children under five were engaged to foster change in sanitation behaviour, household infrastructure, and environmental health awareness. The specific objectives include assessing baseline sanitation conditions and describing the nutritional status of participating children as contextual information, facilitating family-driven sanitation actions, as well as evaluating post-intervention changes in sanitation practices and hygiene behaviour. Potential downstream implications for children's health are discussed as plausible, literature-supported outcomes rather than directly measured effects (MacLeod *et al.*, 2025). By emphasising the role of the household as an agent of change, the model aims to strengthen family participation in safeguarding environmental health and nutrition (Mondal *et al.*, 2025).

METHOD

This study adopted a qualitative method using the Participatory Action Research (PAR) design, which emphasizes collaborative engagement with participants to enhance community awareness and foster sustainable behavioral change in household sanitation management (Hu & Stoecker, 2024). Qualitative data from in-depth interviews and household observations provided the main source of evidence, complemented by descriptive sanitation indicators and anthropometric measurements collected before and after the intervention. These three sources were not analyzed as separate parallel studies, but were triangulated during interpretation. The descriptive and anthropometric data were used to corroborate and contextualize the themes generated from the qualitative analysis. This study was conducted in the coastal area of Medan Belawan District, located in the northern part of Medan City, North Sumatera. The location was selected purposively because it represents a densely populated coastal region with limited sanitation infrastructure and high vulnerability to environmental diseases. Medan Belawan is also the largest district in the coastal zone of Medan City, where several residents

depend on informal sectors such as fishing and port labor (Dinas Kesehatan Medan, 2023). The study aimed to empower families in developing self-reliant capabilities to address public health challenges, particularly sanitation-related issues with systemic impacts on child nutrition and environmental health.

The population comprised households with at least one child under five, considering that this age group has a higher risk of infectious diseases due to immature immunity and low hygiene awareness (WHO, 2021). A total of 30 families were recruited using a purposive sampling method. The inclusion criteria were (1) complete members (father, mother, and child), (2) effective communication, (3) expressed willingness to participate, (4) at least six months of living together, (5) had at least one child under five, and (6) healthy and not undergoing medical treatment. The selection of households emphasized family engagement as a unit of health behavior transformation, consistent with participatory and empowerment-based study methods. A sample size of 30 was determined based on information richness rather than statistical representativeness. Recruitment continued until interviews and household observations began to yield recurring rather than new themes across the sanitation, disease, and nutrition domains of interest, consistent with the principle of thematic saturation commonly applied in participatory qualitative study of this scope.

Data were collected through multiple qualitative methods to capture the socio-environmental context and behavioral changes throughout the intervention. The in-depth interview guideline consisted of open-ended questions exploring perceptions of sanitation conditions, environmental health problems, community participation, child feeding practices, and existing health programs. Household observations were conducted using a structured checklist covering water sources, toilet facilities, wastewater disposal, solid waste management, handwashing facilities, and overall environmental sanitation conditions. Anthropometric measurements included body weight and height/length of children under five, which were assessed using calibrated digital scales and microtoise/length boards following standard WHO procedures, while nutritional status was interpreted using anthropometric indices appropriate for age. These measurements served as baseline contextual characterization of the study population, situating the sanitation intervention within the households' broader nutritional profile, rather than as a direct outcome measure of the

intervention. Post-intervention interviews were conducted to explore participants' experiences, perceived benefits, challenges, and changes in sanitation-related behaviors following the implementation of the PHAST intervention.

The intervention was structured using the PHAST model, which has been recognized globally as an effective method to improve hygiene and sanitation practices at the community level. The process consisted of six sequential stages: (1) Problem Identification, identifying household sanitation, nutrition, and environmental health issues; (2) Problem Analysis, differentiating between existing good practices and areas needing improvement; (3) Planning for Solutions, determining feasible sanitation and nutrition actions as well as assigning family roles; (4) Planning for Facilities and Behavior Change, implementing practical steps by family members; (5) Monitoring and Evaluation, assessing the progress and benefits of household sanitation management; and (6) Participatory Evaluation, measuring the proportion of tasks achieved and the sustainability of improved sanitation and nutrition behaviors. Furthermore, the intervention emphasized family role-sharing and decision-making, empowering each member to contribute to maintaining a clean and healthy household environment (Ikegulu dkk., 2024).

Data analysis followed a thematic qualitative method, integrating both deductive (based on the sanitation, disease, and nutrition domains guiding the interview protocol) and inductive codings (allowing themes to originate directly from participants' accounts) to extract themes related to sanitation practices, nutrition management, and environmental health behavior. The analysis included data organization, transcription, reduction, and categorization to identify patterns and relationships among key variables. Coding was performed independently by two members of the study team. Furthermore, differences in interpretation were resolved through discussion and consensus. The resulting coding framework was refined iteratively as new transcripts were reviewed. Changes in household sanitation management before and after the intervention were described descriptively. These descriptive indicators were examined alongside the qualitative themes to determine whether they corroborated, extended, or diverged from participants' narratives, forming the basis of the triangulated interpretation presented in the results. The credibility of the results was further strengthened through triangulation of multiple data sources, including interviews, household observations, and anthropometric assessments (Ahmed et al., 2025).

All participants were provided with informed consent forms explaining the study objectives, voluntary participation, and confidentiality measures. Ethical approval was obtained from the Health Research Ethics Committee, Faculty of Public Health, Universitas Sumatera Utara (No. 802/KEPK/ USU/2025). Data collection was conducted with full respect for participant privacy, and results were presented in aggregate form to ensure anonymity.

RESULT AND DISCUSSION

Four main categories were identified from the analysis of the data obtained from the study, namely action diagnosis phase, action planning, implementation, and action evaluation. A total of nine key informants were purposively selected to provide information on sanitation conditions, environmental health challenges, and child nutrition in the coastal area of Medan Belawan. The informants represented health authorities, public health center personnel, and mothers of under-five children.

Action Diagnosis Phase

The results of the in-depth interviews with nine key informants showed three major interrelated themes such as sanitation in coastal areas, environmentally related diseases, and child malnutrition. Seven key subthemes were identified to further explain the interactions among the issues. These include geographical conditions, health programs, socio-economic status, community participation, clean and healthy living behavior, parenting patterns, as well as dietary intake, as detailed in Figure 1.

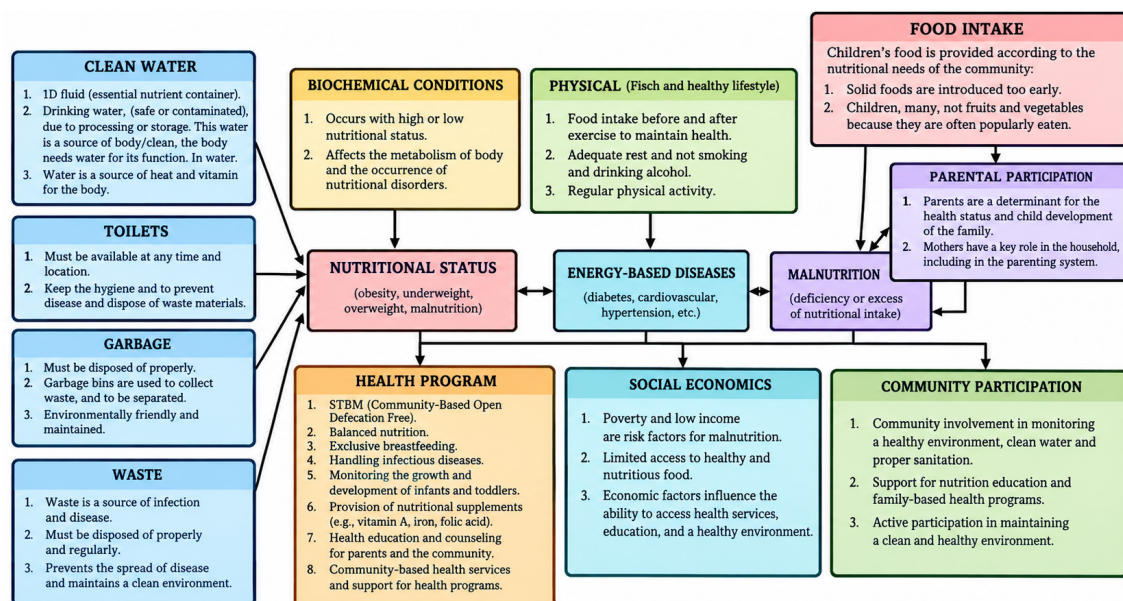
The thematic categories collectively describe how environmental, social, and behavioral determinants intertwine to influence health outcomes in coastal households of Medan City, Indonesia. Similar thematic interrelations have been observed in community-based environmental health studies in Southeast Asia, where sanitation, poverty, and nutritional factors were deeply interrelated (Muriithi dkk., 2024).

Household Sanitation Conditions

The interviews showed persistent problems in four key components of sanitation, such as access to clean water, sanitation facilities, solid waste management, and household wastewater disposal. Although some households have access to municipal water supplies, many continue to rely on groundwater obtained from boreholes located near the coastline. Due to seawater intrusion, the water is often saline, turbid, foul-smelling, and oc-

Table 1. The characteristics of respondents

Informant	Position / Occupation	Highest Education	Age (Years)	Sex
Informant 1	Work Team for Communicable Disease Prevention and Control and Environmental Health	Master's Degree (S2)	47	Female
Informant 2	Work Team for Nutrition and Maternal and Child Health	Master's Degree (S2)	48	Female
Informant 3	Head of Medan Belawan Public Health Center	Master's Degree (S2)	50	Male
Informant 4	Person in Charge of the Nutrition Unit at Medan Belawan Public Health Center	Diploma III (D3)	47	Female
Informant 5	Person in Charge of the Sanitation Unit at Medan Belawan Public Health Center	Master's Degree (S2)	56	Male
Informant 6	Housewife	Junior High School	27	Female
Informant 7	Housewife	Senior High School	24	Female
Informant 8	Housewife	Senior High School	28	Female
Informant 9	Housewife	Senior High School	37	Female

**Figure 1.** Determinant factors

casionaly contains small worms. The following was the explanation of a community informant:

"Our wells are often cloudy with a fish-like smell, specifically after the tide rises" (Informant 6).

Sanitation facilities remain inadequate, as most households do not own septic tanks and continue to practice open defecation along rivers or coastal areas. This practice was closely related to the settlement pattern of stilt houses constructed

over tidal waters, where installing conventional sanitation systems was difficult. The following was the statement from an informant:

"People still defecate in the sea because of the difficulty of building a closed drainage system under these houses" (Informant 4).

Solid waste and wastewater management presented additional challenges. Household waste was frequently discarded into open drains or nearby water bodies, while waste collection servi-

ces covered only limited areas. Similarly, domestic wastewater was commonly discharged directly into drainage channels or coastal waters without prior treatment. These conditions contributed to environmental contamination and increased the risk of sanitation-related diseases.

Geographical conditions

Environmental factors further worsened sanitation problems in Medan Belawan. Frequent tidal flooding disrupted daily activities, contaminated water sources, and increased exposure to waterborne diseases. According to the statement from a sanitation officer:

"Flooding happens every day, specifically during high tides, and sometimes by 3 a.m., the water is already rising" (Informant 5).

The results are consistent with studies conducted in other coastal regions, where sea-level rise and inadequate drainage systems reduced sanitation resilience and increased environmental health risks (Gallego et al., 2025). Consequently, the geographical characteristics of low-lying coastal settlements contributed to the persistence of environmental health problems (Oscar et al., 2024).

Socioeconomic conditions and health programs

The socioeconomic circumstances of households were identified as important determinants of sanitation and nutritional outcomes. Most residents depended on informal occupations, including fishing, port labor, and small-scale trading, leading to unstable and limited incomes. These economic constraints affected households' ability to construct adequate sanitation facilities and provide nutritious foods for children. As noted by the head of the public health center:

"Families eat according to what they can afford, not based on nutritional needs" (Informant 2).

Similar patterns have been reported in other Indonesian coastal communities, where poverty and inadequate infrastructure jointly contribute to poor health outcomes (Chong et al., 2016). To address these challenges, several programs have been implemented, including Community-Based Total Sanitation and nutrition initiatives such as the One Day One Egg program. Health workers routinely monitored household sanitation facilities and water quality. One officer explained:

"We visit homes to test drinking water, and samples were often collected jointly with the Public Works Department" (Informant 3).

Despite the efforts, long-term sustainability remains challenging because community participation often depends on external incentives. There-

fore, strengthening collaboration among public health agencies, sanitation sectors, and corporate partners through Corporate Social Responsibility (CSR) initiatives is considered essential (Edwards et al., 2024).

Community participation

Community participation in environmental health programs was generally limited. Residents were more prone to attend activities when transportation allowances, food packages, or other incentives were provided. A nutrition officer explained:

"If we don't provide something, people won't come, saying they don't have money for transportation" (Informant 4).

This pattern suggests that participation has not been developed into a sustained sense of collective responsibility. Additional barriers, including childcare responsibilities and unfavorable weather conditions, further reduce community participation. Similar results were reported in participatory sanitation programs in other settings (Mketi et al., 2022; Dwipayanti et al., 2025).

In terms of clean and healthy living behavior, some households routinely boil water before consumption. However, proper handwashing and waste disposal practices remain inconsistent. The following was an observation from a health worker:

"Not everyone washes their hands before feeding the children, and the practice is significantly lacking" (Informant 4).

The results showed that awareness of hygiene does not always translate into daily practice. This is a challenge frequently encountered in WASH interventions worldwide (Babbar & Garikipati, 2025). Sustaining healthy practices requires continuous behavior change communication alongside supportive environmental infrastructure (MacLeod et al., 2025).

Parenting pattern and malnutrition

Childcare responsibilities were largely borne by mothers, but caregiving was often shared with grandmothers or older siblings. This arrangement sometimes contributed to inconsistent feeding practices and childcare routines. The following was an observation from a health informant:

"Sometimes the grandmother feeds the child differently when the mother is away working" (Informant 3).

Several mothers showed limited knowledge regarding child nutrition and feeding recom-

mendations. Early introduction of complementary foods before six months of age was commonly reported, increasing the risk of digestive diseases and nutrient malabsorption. Similar observations were reported by Zelalem et al. (2020), who stated that inappropriate infant feeding practices contribute to infection and stunting risk (Tafese et al., 2020).

Children's dietary patterns reflect limited dietary diversity. Parents frequently described their children as selective eaters who avoided fruits and vegetables. The following was an explanation from a mother:

"My child will only eat food with soup, and she doesn't like fruits or vegetables" (Informant 6).

Another stated:

"He's a picky eater; sometimes he won't eat unless it's his favorite food" (Informant 8).

Economic limitations further restricted access to protein-rich foods, leading families to rely on less nutritious staples. These circumstances emphasized the continuing need for nutrition education and community-based interventions (Smith et al., 2022).

Interrelationship between sanitation, disease, and malnutrition

The results showed a cyclical relationship between poor sanitation, environmentally related diseases, and malnutrition. Unsafe water sources, inadequate waste management, and poor hygiene practices created conditions that facilitate the transmission of diarrheal diseases, respiratory infections, and skin diseases. Recurrent infections subsequently impair nutrient absorption and weaken immune function, reinforcing the cycle of undernutrition (Aguayo & Menon, 2016).

At the same time, limited household income, inadequate nutrition knowledge, and low community participation reduce the effectiveness of health interventions. Breaking this cycle requires a family-centered and participatory method that strengthens local capacity for sustainable sanitation and nutrition improvement.

The PHAST model implemented in this study provided a practical framework for empowering households through collective decision-making and shared responsibility. By engaging families directly in problem identification, planning, and implementation, the intervention encouraged meaningful behavioral change. The integration of environmental sanitation, health education, and community participation suggests that the PHAST-based family model may serve as a promising strategy for improving health outcomes in other coastal and resource-constrained

settings (Ikegulu et al., 2024).

Action Planning Phase

Based on the results of the action diagnosis phase, which identified key issues related to sanitation, environmentally related diseases, and child malnutrition in the coastal areas of Medan City, a plan was developed focusing on family-based sanitation transformation through the PHAST method. Furthermore, this method emphasizes active community participation in identifying local health problems, formulating feasible solutions, as well as independently implementing behavioral changes toward clean and healthy living. The participatory nature of PHAST correlated with sustainable community empowerment principles, which encourage shared responsibility and local ownership of environmental health improvements (Ikegulu dkk., 2024).

During the planning phase, the study team collaboratively identified the participants, comprising households, community health cadres, and local community leaders. These actors were considered essential for promoting behavior change at both the household and neighborhood levels. The planning process also comprised strategic step formulation to ensure that the PHAST intervention was context-specific, culturally sensitive, and correlated with the daily realities of coastal families. A public health officer emphasized the importance of collaboration, stating:

"The community should be part of the solution; otherwise, the program will not last" (Informant 2).

Sustainable sanitation transformation required strengthening the capacity of coastal communities to manage their own environmental health systems (Voronkova dkk., 2025).

The action plan included a series of participatory sessions designed to stimulate critical reflection and shared learning among families. Activities were tailored to help households visualize the relationship between sanitation behaviors, disease risks, and children's nutritional status. This step was essential to translate abstract health messages into concrete household actions, such as safe waste disposal, handwashing routines, and improved food hygiene. Similar participatory action frameworks have been successfully implemented in Southeast Asia and Africa, where PHAST-based programs significantly enhanced community awareness and sanitation practices. Therefore, the planning phase served not only as preparation for intervention but also as a catalyst for building a sense of empowerment and collective responsibility among the target population

(Bose dkk., 2024).

Action Implementation

The implementation of the family empowerment intervention was conducted using the PHAST method, which prioritized the active participation of mothers with children under the age of five as primary agents of change within the household. This method recognized mothers as key influencers in shaping daily hygiene practices, food safety behaviors, and household sanitation management. The intervention aimed not only to improve sanitation facilities but also to enhance behavioral practices that directly affect the health and nutrition of children. Implementation was conducted across 30 participating households, with each meeting the inclusion criteria of having at least one child under the age of five.

The initial identification process was conducted through home visits, during which facilitators interviewed mothers and observed household sanitation facilities. Participants were encouraged to describe their daily hygiene routines, water management practices, and waste disposal methods. Field notes and photographs were used to document the condition of sanitation facilities. The results showed that most sanitation activities were predominantly managed by mothers, while other family members, such as fathers and older children, only assisted when demanded. The following was a statement from a participant:

"I usually clean the bathroom and take out the garbage; my husband only helps when I remind him" (Informant 9).

Despite strong motivation among mothers, several unhygienic practices were still observed. Several participants had not consistently practiced handwashing at five critical times. Water containers were rarely cleaned, and open waste bins remained common. However, mothers expressed enthusiasm and openness during this phase, with the feeling that the everyday struggles with sanitation were finally being acknowledged (Wolf dkk., 2022). Constraints such as lack of time, financial limitations, and insufficient support from other family members were identified. These were factors commonly reported in sanitation-related behavioral studies in low-income coastal settings (Sinharoy dkk., 2023).

Participatory tools were integrated into this stage to enhance engagement and self-reflection. Facilitators used sticky notes as a visual medium for participants to express sanitation challenges specific to the households. Each identified problem, such as standing water from household wastewater, open waste bins, and uncovered toilets,

was recorded on a sticky note and placed on a discussion board. This technique enabled families to collectively visualize the sanitation problems and place priority for subsequent action planning. The use of simple participatory visual tools is particularly effective in encouraging communication and problem-solving in PHAST-based interventions (Ikegulu dkk., 2024).

The study developed a baseline sanitation profile, as summarized in Table 2, which described household sanitation facilities, hygiene behaviors, water supply systems, and waste management practices. This information served as the foundation for assessing the level of clean and healthy living behavior (PHBS) within each household and for tracking changes over time. Previous results showed limited access to safe water, open defecation practices in several households, and poor waste disposal behaviors. These conditions have been strongly associated with the persistence of diarrhea and malnutrition among children in coastal environments (WHO, 2021a) (Vilcins dkk., 2018).

Environmental conditions surrounding the homes showed potential health hazards. All households discharged greywater into open channels, and none had covered septic tanks, leaving fecal matter directly accessible to insects. Furthermore, 63.3% of houses had visible scattered waste, and 40% experienced stagnant water around the homes, particularly during high tides. These unsanitary conditions increase exposure to vectors such as flies and mosquitoes, contributing to recurring episodes of diarrhea and skin infections (Kesumawati dkk., 2025).

The baseline sanitation characteristics emphasized the systemic vulnerability of coastal households in Medan Belawan. Although most families possessed basic facilities, poor infrastructure, limited hygiene awareness, and environmental constraints hindered the realization of safe sanitation. These results justify the application of the PHAST participatory method, which aimed to enhance both behavior and infrastructure through family empowerment and community-driven sanitation management (Ejemot-Nwadiaro dkk., 2021).

Implementation of Family Sanitation Actions

The problems identified during the participatory assessment were analyzed collaboratively between the households and facilitators to determine underlying causes and consequences. Based on this analysis, families and facilitators jointly developed a set of actionable strategies to improve household sanitation conditions. During

Table 2. Environmental Sanitation Characteristics Among Households at Initial Visit

Sanitation Indicator	Condition	n	%
Defecation site	Own latrine	27	90
	Direct pit	3	10
Final fecal disposal	Septic tank	11	36.7
	Drainage channel	13	43.3
	Discharged into water	6	20
Handwashing at critical times	None	1	3.3
	One correct time	6	20
	Two correct times	19	63.3
	Three correct times	4	13.3
Frequency of cleaning drinking water container	Every 2-3 days	13	43.3
	Daily	9	30
	Irregular (when dirty)	8	26.7
Food storage condition	Covered container	30	100
Frequency of solid waste disposal	Everyday	25	83.3
	Not daily	5	16.7
Type of waste bin	Open	26	86.7
	Covered	4	13.3
Final solid waste disposal	Burned	1	3.3
	Scattered around	16	53.3
	Collected	13	43.3
Household wastewater disposal	Trough open channel	30	100
Toilet or septic cover to prevent insect contact	Open	30	100
Use of septic tank	Yes	11	36.7
	No	19	63.3
Presence of human faces near the house	Yes	1	3.3
	No	29	96.7
Scattered garbage around the house	Yes	19	63.3
	No	11	36.7
Standing water around the house	Yes	12	40
	No	18	60

this stage, each family formulated a shared commitment outlining specific activities to be implemented and the responsibilities of each member. Facilitators documented these agreements on the discussion board to ensure mutual understanding and accountability. The following was the explanation from a participant:

"After the discussion, we knew more clearly what each family member had to do because the tasks were written down and agreed upon together at home" (Informant 7)

Each household agreed to undertake sanitation improvements through role-based par-

ticipation. Fathers were responsible for physical facility maintenance, such as repairing or sealing toilet holes, providing covered waste bins, and improving wastewater drainage. The following was the statement from another participant:

"My husband helped with the parts that needed more physical work, such as fixing the toilet area, preparing the waste bin, and checking the water flow around the house" (Informant 8)

Mothers were tasked with ensuring food hygiene, maintaining soap availability, and monitoring children's handwashing habits. Children were encouraged to practice handwashing with

Table 3. Types of Sanitation Actions Implemented by Participating Families

Sanitation Action	Families committed (n)	Families Implemented (n)	Implementation (%)
Mothers wash hands at the five critical times (CTPS)	9	1	11.1
Children (under-five) wash hands at five critical times	9	1	11.1
Clean drinking water containers daily	7	0	0.0
Dispose of household waste daily	1	0	0.0
Collect waste in a covered waste bin	22	8	36.4
Dispose of waste through public collection (TPS)	2	0	0.0
Close toilet holes or cover latrine openings	18	9	50.0
Clean scattered waste around the house	14	7	50.0
Eliminate standing water from household wastewater	12	6	50.0

soap and to help maintain household cleanliness. The following was the explanation from a participant :

“The children were also reminded to wash their hands with soap and help keep the house clean, specifically by not leaving waste scattered around” (Informant 9)

The roles were visually recorded on sticky notes, where each family member wrote their commitments and assigned responsibilities. The process strengthened the sense of collective responsibility and improved intra-family communication in maintaining a clean and healthy living environment. This stage represented the practical implementation of the previously designed action plan. Families conducted the activities according to the respective roles, with continuous guidance from facilitators. The intervention encouraged families to select sanitation actions based on readiness, motivation, and available resources. The actions included individual hygiene behaviors, solid waste management, toilet sanitation, and household environmental control. Families were provided with a sanitation checklist to monitor progress and reinforce behavioral consistency.

Regular monitoring and evaluation were conducted to assess the extent of action implementation within each household. Facilitators visited homes weekly to observe behavioral changes and document improvements. Table 2 summarizes the types of sanitation actions that were selected and implemented by participating families.

The data showed that several sanitation actions were successfully implemented by participating families, particularly related to physi-

cal environmental improvements. The most successfully executed actions included closing toilet holes or latrine openings (50%), cleaning scattered waste (50%), and eliminating stagnant water around the house (50%). These results showed that families prioritized visible and practical sanitation improvements that directly impacted the surroundings. The participation of male household members in these activities, particularly in tasks requiring physical effort, contributed significantly to the successful implementation of the environmental actions (Osuafor & Akokuwebe, 2023). Meanwhile, hygiene behaviors such as handwashing at critical times and daily cleaning of water containers had much lower implementation rates ($\leq 11\%$). Despite being frequently discussed during participatory sessions, these behaviors proved more challenging to sustain in daily routines. The low implementation of hygiene-related actions suggests that behavioral change requires longer reinforcement and habitual adaptation, specifically in communities with limited access to water and sanitation supplies (Nuraeni dkk., 2024). The use of covered waste bins showed moderate success. It is implemented by 36.4% of households, signifying an improvement in domestic waste management. However, coordination with external services, such as municipal waste collection, was not adopted, possibly due to limited service coverage and irregular collection schedules in coastal areas. Similar challenges were documented by (Pradeilles dkk. 2021), who stated that household sanitation improvements in low-resource communities were often constrained by infrastructure limitations beyond control (Behera dkk., 2024). The evalua-

tion shows that households' concrete, visible, and within immediate control actions are more prone to be adopted, while behavioral hygiene practices that depend on sustained motivation and resource availability were less consistently implemented.

Facilitators conducted household monitoring visits to observe the progress of agreed sanitation actions. The monitoring focused on four key indicators such as latrine cleanliness, handwashing with soap at critical times, safe drinking water management, and solid waste disposal. The results of the visits showed that most mothers had begun to practice regular handwashing. Furthermore, drinking water was stored in covered containers, and several families had started disposing of waste daily. These improvements reflect the early stages of behavioral internalization resulting from the participatory method.

Several households continued to face challenges in maintaining physical infrastructure, particularly closing toilet openings and repairing wastewater channels. These difficulties were largely attributed to limited resources and inadequate sanitation facilities, which are common constraints in low-income coastal areas (Haqekkk., 2025). The facilitators observed that some houses built above tidal water or with minimal drainage infrastructure required external support to achieve structural sanitation improvements.

Most families are committed to implementing three to four sanitation actions, comprising 15 and seven households, respectively. This result reflects a high level of enthusiasm and readiness among families to adopt multiple behavioral changes simultaneously. The willingness to engage in several sanitation-related practices also shows improved understanding of the relationship between sanitation, hygiene, and disease prevention.

The following was the statement of a participant:

"Now we try to do more than one thing at once, such as wash hands, cover the waste, and make sure there's no stagnant water" (Informant 8)

Six families chose to implement only two sanitation actions. This variation may be related to differences in time availability, household workload, or perception of added domestic responsibilities. Similar results have been observed in other participatory sanitation studies, where families with higher economic or caregiving burdens showed slower adoption of hygiene behaviors (Nuraeni dkk., 2024). These results emphasize the importance of continuous facilitation and motivational reinforcement to sustain participation and encourage gradual expansion

of hygiene practices.

The final stage included a participatory evaluation conducted jointly between facilitators and participating families. During this phase, families were invited to reflect on behavioral changes, perceived benefits, and challenges encountered throughout the implementation process. Participants acknowledged that the intervention increased awareness that sanitation is a shared responsibility rather than an individual task. Most families expressed commitment to continuing these positive practices and chose to retain the visual media (sticky notes) presented in the homes as daily reminders of sanitation commitments.

Significant improvements were observed in two primary indicators, such as the use of covered waste bins and environmental cleanliness around the household (Yuliana, 2020). The proportion of families using covered waste bins increased from 13.3% to 40.0%, reflecting a 26.7% improvement. This change signifies growing community awareness regarding the importance of hygienic waste management to prevent environmental contamination and the spread of disease vectors (Abdulloh dkk., 2024). Similarly, the proportion of households reporting scattered waste in the surroundings decreased from 63.3% to 36.7%. This signified that 26.6% of families adopted better environmental cleanliness practices after the intervention.

Despite the improvements, several sanitation challenges remain, particularly in wastewater management, septic tank coverage, and final waste disposal, requiring further intervention to achieve a healthy and sustainable environment. These results are in line with previous studies showing that participatory sanitation interventions effectively modify behavior, but structural sanitation improvements demand continuous support and local government participation (MacLeod dkk., 2025).

Beyond behavioral changes, the intervention led to a redistribution of household roles, reflecting enhanced collective environmental health awareness. For instance, several families reported that waste management tasks previously performed solely by mothers were now shared with fathers, while older siblings began assisting in cleaning water containers. This shift signifies that the intervention not only improved sanitation knowledge but also strengthened intra-family participation and gender-balanced engagement in maintaining a healthy home environment (Chirgwin dkk., 2021).

Action Evaluation

The implementation of household sanitation transformation through the PHAST method showed a substantial improvement in family awareness and collective responsibility for maintaining domestic cleanliness. Post-intervention monitoring confirmed that all family members had consistent commitment and willingness to adopt daily sanitation management practices. Household cleanliness was no longer perceived as the sole responsibility of mothers. Additionally, it became a shared obligation comprising fathers, mothers, and children. The following was the statement of a participant,

"Before, most of the cleaning was done by me, but after the program my husband and children also understood their roles in keeping the house and toilet area clean" (Informant 7)

Each member actively participated in maintaining household hygiene and ensuring that sanitation facilities were functioning properly (Ikegulu dkk., 2024).

Positive changes were evident in the overall environmental quality of participating households. The changes occurred because families began to implement the agreed sanitation tasks more consistently. This was supported by visual reminders, family role-sharing, and regular monitoring by facilitators. The following was the statement from a participant:

"The notes displayed at home reminded us of what had to be done. My husband and children also helped, and the facilitators' visits encouraged us to keep cleaning the toilet area, covering the waste, and checking stagnant water around the house" (Informant 8)

Homes appeared cleaner, healthier, and more comfortable to inhabit. The surrounding environment became more organized, and water sources were visibly clearer. Additionally, the domestic areas were tidier and more aesthetically pleasing.

Improvements were observed in latrine hygiene and wastewater channel maintenance. Based on the broader literature, these improvements are plausibly associated with a reduced risk of environmentally related diseases and undernutrition among children under the age of five. However, the present study did not directly measure disease incidence or nutritional outcomes following the intervention (Nuraeni dkk., 2024). Families reported a sense of renewed motivation and wellbeing in their daily routines, describing the clean environment as a source of psychological comfort and family pride. The following was the statement from another participant:

"The house feels more comfortable now. When the waste is covered, and there is no stagnant water, I feel calmer about the children playing around the house" (Informant 8)

The household transformation fostered a more positive and health-conscious atmosphere that encouraged sustainable hygiene practices. This result reinforces that family-centered, participatory sanitation interventions can effectively promote both behavioral and psychosocial change (Arsénio dkk., 2018).

The results confirm that the PHAST-based educational and mentoring activities were effective in improving the physical condition of household environments and developing collective consciousness as well as self-reliance among families in managing sanitation. The outcomes show a shift from dependence on external health programs toward sustainable, community-driven environmental management. This empowerment is essential to achieving long-term improvements in public and environmental health within low-resource coastal settings (Voronkova dkk., 2025).

Study limitation

There are several limitations that should be considered when interpreting the results. First, the study was conducted in a single coastal district, Medan Belawan, which may limit the transferability of the results to other coastal settings with different environmental and socio-cultural characteristics. Second, the number of informants was relatively limited, but participants were purposively selected based on direct participation in sanitation, environmental health, nutrition, and community activities. The informants represented key stakeholders who possessed in-depth knowledge and experience relevant to the study objectives, allowing the collection of rich and context-specific information. Third, the evaluation focused on changes observed during the intervention period and was therefore unable to assess the long-term sustainability of behavioral and environmental improvements. Future studies across multiple coastal communities and with longer follow-up periods are recommended to further examine the sustainability and broader applicability of the family-centered PHAST adaptation.

CONCLUSION

In conclusion, the family-centered adaptation of the PHAST method successfully increased household awareness and behavioral change in maintaining environmental cleanliness. Families became more active and responsible in managing

sanitation facilities, ensuring clean water, as well as maintaining hygienic food and waste management practices. Sanitation was no longer viewed as the mother's duty alone but a shared commitment among all family members.

The participatory process encouraged cooperation, strengthened family cohesion, and improved the overall physical and social environment of coastal households. The transformation led to cleaner, healthier, and more organized living conditions while fostering a sustainable habit of collective responsibility for sanitation. These behavioral and environmental improvements are, in the authors' view, the most compelling contribution of the study. Reduced risk of environmentally related diseases and malnutrition among children remained a plausible downstream benefit supported by the broader literature. However, longer-term evaluations focusing on health outcomes are needed to confirm the sustainability of the effects.

Local health institutions should continue this participatory model by integrating PHAST-based education into community programs. Continuous mentoring, infrastructure support, and cross-sector collaboration are essential to sustain behavioral changes and ensure long-term improvements in environmental health. The empowerment of families as the core unit of change remains a key strategy in achieving healthier and more resilient coastal communities.

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DECLARATION OF GENERATIVE AI

This manuscript received limited assistance from an AI-based language tool (Quillbot and ChatGPT) for language refinement and grammar checking. The authors critically reviewed and finalized all content and accept full responsibility for the published work. No AI tools were used

in data analysis or the interpretation of findings.

DECLARATION OF COMPETING INTEREST

The authors declare no conflicts of interest related to the research activities or the publication of the study findings.

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