



Evaluation of Community Health Centers Preparedness for Tidal Floods in Surabaya Using Hospital Safety Index

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Abstract

Introduction: Tidal flooding is a major coastal hazard in North Surabaya that can disrupt health services. Community Health Centers (Puskesmas) are crucial for maintaining essential care during disasters. However, little attention has been given to how prepared inpatient Community Health Centers are for tidal flooding. This study assessed the preparedness of Community Health Centers (CHCs) in northern Surabaya for tidal flooding using the Hospital Safety Index (HSI).

Methods: This study employed a quantitative approach. Primary data were collected using the Hospital Safety Index (HSI) questionnaire, which assessed four main aspects: hazard, structural, non-structural, and functional, at each community health center included in the study.

Results: The Hospital Safety Index assessment showed that Sememi Community Health Center received a score of 0.88 (Category A), indicating the center's ability to remain operational during a disaster. The Krembangan Selatan Community Health Center (0.64) and Bulak Banteng Community Health Center (0.52) were classified as Category B, indicating the need to improve preparedness through short-term interventions, particularly in functional aspects.

Conclusion: This study found that preparedness for tidal flooding among inpatients at Community Health Centers (Puskesmas) on the northern coast of Surabaya City varied across facilities. Sememi Puskesmas was classified as Category A, while Krembangan Selatan and Bulak Banteng Puskesmas were classified as Category B, indicating the need for short-term interventions. Functional preparedness was the weakest component and should therefore be prioritized. Strengthening functional preparedness can help Community Health Centers maintain essential health services during tidal flooding and other emergencies.

Keywords: Tidal floods; Hospital Safety Index (HSI); Disaster preparedness; Community Health Centers

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Introduction

Surabaya, the capital of East Java Province and one of the largest cities in Indonesia, is a coastal city vulnerable to tidal flooding.¹ Tidal flooding has repeatedly occurred in Surabaya, with four events recorded between 2021 and 2022.² In 2024,

tidal flooding inundated several residential areas and public facilities, and in 2025, the Regional Disaster Management Agency (BPBD) reported tidal flooding in North Surabaya.^{3,4} These recurring events are consistent with previous research, indicating that the northern coastline of Surabaya is more susceptible to tidal

flooding than the eastern coastline.⁵ Tidal flooding in Surabaya is influenced by several factors, including land subsidence, sea level rise, seawater volume, and tidal fluctuations, which contribute to the inundation of coastal areas.^{2,6}

Tidal flooding can cause various problems, such as widespread damage, loss of life, infrastructure damage, and economic instability.^{7,8} One of the impacts of tidal flooding on the health sector is damage to sanitation and clean water systems, which can potentially lead to disease outbreaks.⁹ Tidal flooding can disrupt clean water and sanitation systems and increase the risk of health problems in affected communities. Previous research on communities affected by tidal flooding has reported several health problems, including respiratory infections, dermatitis, and diarrhea.¹⁰ Effective disaster response in the health sector can reduce mortality and morbidity rates among disaster victims.¹¹ The provision of post-disaster health services is often hampered by the damage and disruptions caused by disasters. These conditions can increase the number of victims and exacerbate emergencies that require immediate attention.⁸ Therefore, healthcare facilities must remain operational during and after disasters to ensure the continuity of health services.

Community Health Centers are primary-level health facilities that serve as the frontline of healthcare for both communities and individuals. Community Health Centers play a vital role in improving the health status of the community to the greatest extent possible.⁸ As the driving force behind community health development, Community Health Centers also bear the responsibility of carrying out disaster response functions. Community Health Centers serve as both providers of healthcare and organizers of responses to and management of health crises in affected areas.¹² During disasters, Community Health Centers are responsible for ensuring the continuity of essential health services, including curative, promotive, preventive, and rehabilitative care, as well as environmental and reproductive health services.¹³ Tidal flooding can cause physical damage to

infrastructure through structural deterioration, infrastructure corrosion, and saltwater intrusion, while also increasing health risks in affected communities^[14]. These impacts may disrupt the operations of healthcare facilities and compromise the continuity of essential health services. Therefore, disaster preparedness in healthcare facilities should address structural, non-structural, and functional aspects to ensure the continuity of healthcare service delivery during disasters.^{14,15}

A preparedness assessment is required to ensure that Community Health Centers can carry out these duties and functions. Key elements in measuring preparedness include knowledge, attitudes, supporting resources, and emergency response plans.¹⁶ At the health facility level, the PAHO states that disaster preparedness assessments cover four aspects: human resources, facility preparedness, standard operating procedures (SOPs), and disaster-related programs and policies.¹⁷ One of the tools used to assess community health center preparedness is the Hospital Safety Index (HSI), which evaluates potential disaster risks, structural and non-structural aspects, and functional aspects as key components in ensuring the continuity of health services during disasters. The Hospital Safety Index (HSI) has been widely used as an assessment tool for evaluating hospital safety levels during disasters. Given the diverse levels, sizes, and functions of hospitals, the Hospital Safety Index provides assessment guidelines for small and medium-sized hospitals. In the context of the types of health facilities in Indonesia, community health centers with inpatient services can be categorized as medium- or small-sized hospitals.¹⁸

The Hospital Safety Index (HSI) assessment guidelines for medium- and small-sized hospitals are relevant for application to inpatient community health centers because the characteristics of the services provided align with those of medium- and small-sized hospitals. Thus, the Hospital Safety Index (HSI) can serve as a tool to assess the preparedness of inpatient community health centers in disaster situations. Although the Hospital Safety Index (HSI) was originally developed

as an all-hazard assessment tool for health facilities, this study specifically applied the HSI framework to evaluate preparedness for tidal flooding in health facilities. Therefore, the hazard assessment focused on tidal flood exposure within the Community Health Center service areas. Simultaneously, the structural, nonstructural, and functional modules were assessed according to the standard PAHO/WHO HSI guidelines. The results of the Hospital Safety Index (HSI) evaluation can be used as standard guidelines for constructing new community health centers or enhancing the safety of existing community health centers as a form of preparedness for disaster situations.¹⁸ Although the Hospital Safety Index (HSI) has been widely used to assess the preparedness of various health facilities, studies on its application to inpatient community health centers in coastal areas at risk of tidal flooding are limited. Therefore, this study aimed to assess the preparedness of community health centers in facing the risk of tidal flooding using the Hospital Safety Index (HSI).

Methods

This quantitative study used the PAHO Hospital Safety Index (HSI) for Medium and Small Hospitals, Series 4, which consists of four modules: hazard, structural, non-structural, and functional. The instrument was applied without modification, according to the original PAHO/WHO guidelines. Although the HSI is an all-hazard framework, this study applied the instrument specifically to assess preparedness for tidal flooding, with the hazard component focused on tidal flood exposure in the designated service areas of the Community Health Centers. Structural, nonstructural, and functional components were assessed using standard HSI indicators. The instrument was selected because the characteristics of inpatient Community Health Centers were comparable to those of medium- and small-sized hospitals. The HSI questionnaire was completed by the designated Community Health Center staff responsible for disaster preparedness and facility management.

Researchers conducted direct observations of buildings and supporting

facilities, reviewed relevant documents, and confirmed questionnaire responses with the responsible staff to verify the accuracy of the information provided. Any inconsistent responses were verified against field observations and relevant supporting documents before calculating the final HSI scores. HSI scores were calculated using the PAHO/WHO Hospital Safety Index Calculator and classified into categories A (high), B (moderate), and C (low). The hazard assessment considered tidal flood exposure affecting both the Community Health Center surroundings and the population within the designated service area. The study was conducted from June to November 2025 at three inpatient Community Health Centers in the northern coastal area of Surabaya: Sememi, Krembangan Selatan, and Bulak Banteng. Study sites were selected using purposive sampling based on two criteria: (1) provision of inpatient services and (2) variation in tidal flood risk across designated service areas, according to the tidal flood risk map developed by Refnitasari et al.¹

Results

Hazards

The service areas of these three Community Health Centers are in the northern coastal region of Surabaya, where tidal flooding is frequent. However, the current exposure to tidal flooding varies among these service areas. Field observations indicate that the service area of the Sememi Community Health Center has experienced tidal flooding. In contrast, no tidal flooding has been observed in the service areas of the Krembangan Selatan and Bulak Banteng Community Health Centers over the past few years.

Based on Figure 1, the service areas of the Sememi and Krembangan Selatan Community Health Centers are located within moderate-to-high tidal flood risk zones. In contrast, the service area of the Bulak Banteng Community Health Center is located within a moderate-to-low risk zone. These differences indicate variations in hazard exposure across the service areas, despite all three Community Health Centers being located within the northern coastal region of Surabaya.

Community Health Center Safety Index Scores

Based on the results of the Hospital Safety Index (HSI) questionnaire, the safety index scores were calculated as follows: Based on the Hospital Safety Index (HSI) assessment, all Community Health Centers achieved Category A for the nonstructural module.

In the structural module, the Sememi and Krembangan Selatan Community Health Centers were classified as Category A, while the Bulak Banteng Community Health Center was classified as Category B. Functional preparedness represented the weakest component, with the Krembangan Selatan and Bulak Banteng Community Health Centers classified as Category C for the functional module (Table 1).

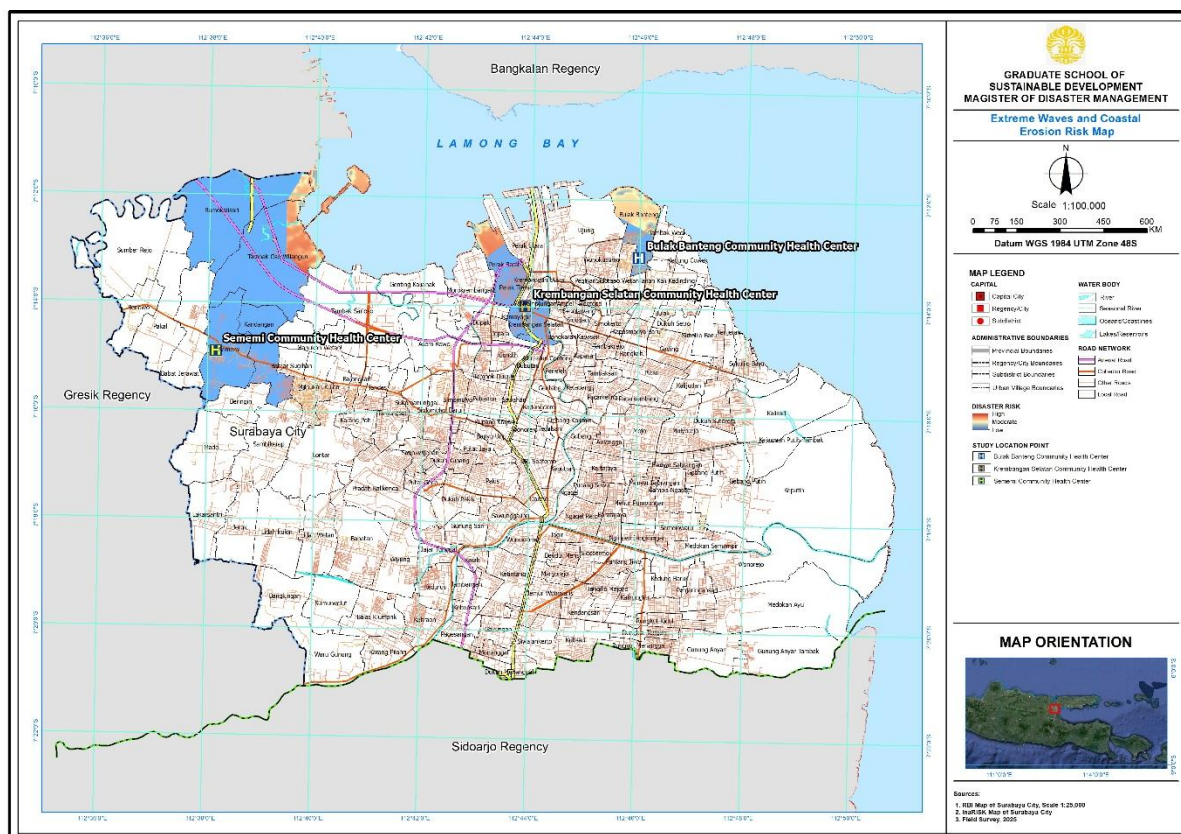


Figure 1. Tidal Flood Risk Map

Table 1. Community Health Center Safety Index Values

No	Safety Index	Sememi Community Health Center		Krembangan Selatan Community Health Center		Bulak Banteng Community Health Center	
		Score	Category	Score	Category	Score	Category
1	Structural	0.89	A	0.76	A	0.37	B
2	Non-structural	0.90	A	0.90	A	0.96	A
3	Functional	0.85	A	0.42	C	0.27	C
	Score	0.88	A	0.64	B	0.52	B

Discussion

Hazard

This study found differences in tidal flood exposure across the service areas of the three Community Health Centers. Based on field observations conducted during the Hospital Safety Index (HSI) assessment, the service area of the Sememi Community Health Center remains vulnerable to tidal flooding. In contrast, the service areas of the Krembangan Selatan and Bulak Banteng Community Health Centers currently experience reduced tidal flood exposure following the implementation of flood mitigation measures by the Surabaya Government. As primary healthcare providers, Community Health Centers are responsible for delivering health services within designated service areas. Therefore, the hazard assessment in this study focused on tidal flood exposure within each service area rather than solely on the geographical location of the Community Health Center building. This approach is consistent with the role of Community Health Centers in maintaining essential health services for populations within their service areas during disasters. These findings indicate that preparedness for tidal flooding should consider hazard exposure within the Community Health Center service area rather than solely the geographical location of the health facility.

These findings are consistent with the 2024–2028 Surabaya City Disaster Risk Assessment (Surabaya Mayor Regulation No. 119 of 2024), which identifies tidal flooding as a major hazard affecting the northern coastal area of Surabaya.¹⁹ Although the service areas of all three Community Health Centers are located within coastal areas exposed to tidal flooding, differences in flood-control infrastructure have resulted in varying levels of hazard exposure. The present findings are also consistent with previous studies that reported spatial variations in flood risk across Surabaya's coastal areas.²⁰

These findings suggest that disaster risk within Community Health Center service areas is influenced not only by geographical location but also by the effectiveness of flood mitigation infrastructure, including pumping stations

and drainage improvements. Therefore, hazard assessment should be integrated into Community Health Center contingency planning and disaster preparedness activities to ensure that preparedness strategies are aligned with the actual level of tidal flood exposure within each service area.

Structural

The structural assessment revealed variations among the three Community Health Centers. The Sememi and Krembangan Selatan Community Health Centers achieved Category A, indicating that their buildings are capable of maintaining structural integrity during emergencies. In contrast, the Bulak Banteng Community Health Center received Category B, indicating that structural improvements are still required to enhance safety and operational resilience. Field observations indicated that the Krembangan Selatan Community Health Center underwent several building repairs and renovations to improve structural safety. The Bulak Banteng Community Health Center had previously experienced a partial building collapse caused by structural problems, highlighting the need for further structural evaluation and strengthening to improve building safety. The lower structural score observed at the Bulak Banteng Community Health Center was consistent with field observations indicating previous structural damage to the building. In contrast, the Krembangan Selatan Community Health Center underwent several renovations that contributed to better structural performance. These observations explain the variations in the structural HSI scores among the three facilities.

These findings are consistent with the WHO Safe Hospital concept, which emphasizes that health facilities should remain operational during disasters through adequate structural safety.²⁰ A study by Lestari et al.²¹ also showed variations in scores among community health centers, requiring priority actions for both structural and non-structural improvements. Other research also indicates that structural strength is a key determinant of the resilience index of community health

centers in flood-prone areas of East Java. Community health centers exposed to repeated flooding that have implemented structural adjustments tend to have higher resilience. These findings indicate that structural preparedness should be assessed not only based on compliance with building standards but also through periodic structural evaluations and maintenance. Structural weaknesses may reduce the ability of Community Health Centers to continue operating safely during disasters, even when other preparedness components are adequate.

Non-structural

All three Community Health Centers achieved Category A for the nonstructural module, indicating that essential supporting systems, including electrical installations, water supply, sanitation, drainage, telecommunications, fire protection, evacuation routes, and medical equipment, were generally available and functional. The Bulak Banteng Community Health Center obtained the highest nonstructural score, supported by its larger facility area, which allows better organization of utilities, evacuation routes, drainage systems, and other supporting infrastructure. Despite achieving Category A, the Sememi Community Health Center experienced temporary disruption of water-dependent services due to water supply failure and limited water reserves.

These findings indicate the need to strengthen backup water supply systems to ensure the continuity of health services during emergencies. The Krembangan Selatan Community Health Center experienced problems with its wastewater treatment plant (IPAL), reducing the effectiveness of wastewater management and contributing to a lower score for several nonstructural indicators. This finding highlights the importance of maintaining critical utility systems to minimize environmental and public health risks during a disaster. Although all Community Health Centers achieved Category A, field observations identified several weaknesses that may affect service continuity during emergencies, particularly in relation to water supply and wastewater management.

These findings are consistent with previous Hospital Safety Index (HSI) studies in Indonesia, which reported that many healthcare facilities still experience weaknesses in nonstructural components, such as evacuation routes, fire protection systems, and electrical systems.²² Damage to non-structural components has also been identified as one of the main causes of service disruption in healthcare facilities during disasters.²³ Furthermore, continuous improvements, including equipment anchoring, utility maintenance, and reinforcement of critical support systems, have been shown to improve nonstructural preparedness.²⁴ These findings indicate that nonstructural preparedness is essential for maintaining the operational capacity of Community Health Centers during disasters. Even when buildings remain structurally safe, failures in utility systems such as water supply, wastewater treatment, electricity, and communication may interrupt essential health services.

Functional

Functional preparedness showed the greatest variation among the three Community Health Centers. It represented the lowest-scoring Hospital Safety Index (HSI) component, particularly at the Krembangan Selatan and Bulak Banteng Community Health Centers. The Sememi Community Health Center demonstrated the highest functional preparedness, supported by personnel who had received disaster response training from the Regional Disaster Management Agency (BPBD) and the Health Department. In contrast, the Krembangan Selatan Community Health Center had limited routine disaster training and simulations, despite having experience in responding to emergencies within its service area.

The Bulak Banteng Community Health Center had developed contingency planning documents through collaboration with Wahana Visi Indonesia; however, routine training and simulation activities had not been implemented consistently. These findings indicate that the availability of disaster planning documents alone is insufficient without regular training and practical implementation of the plan. Interestingly, the Sememi Community

Health Center obtained the highest overall HSI score despite serving an area with higher tidal flood exposure than the other Community Health Centers. This finding suggests that institutional preparedness, including disaster training, coordination, and emergency planning, may have a greater influence on preparedness than hazard exposure.

These findings are consistent with previous Hospital Safety Index studies in Indonesian Community Health Centers, which reported that functional preparedness is largely influenced by the implementation of disaster committees, emergency plans, and regular disaster training and simulations.^{18,25} Previous studies have also shown that institutional leadership, coordination, logistics, and integration with the wider health system and relevant community networks are important determinants of disaster preparedness.²⁵ Consistent with the present study, these findings suggest that functional preparedness depends not only on the availability of disaster management documents but also on their routine implementation in practice.

The findings further suggest that disaster training conducted primarily to meet accreditation requirements, as observed at the Krembangan Selatan and Bulak Banteng Community Health Centers, may limit the development of sustainable preparedness. Previous studies have reported that budget constraints and management turnover hinder the implementation of regular disaster exercises.²⁶ Systematic reviews have demonstrated that repeated disaster simulations and tabletop exercises can improve knowledge, confidence, coordination, and emergency response capacity among healthcare workers.²⁷ Similarly, Hospital Safety Index studies have shown that healthcare facilities conducting regular disaster exercises achieve higher functional preparedness than those that rely solely on written plans.²⁸

Based on these findings, strengthening functional preparedness should be prioritized, particularly for Community Health Centers classified as Category B. This priority is consistent with the Surabaya Disaster Risk Assessment

2024–2028, which identifies tidal flooding as a potential disaster in Surabaya and recognizes capacity as a component determining disaster risk. Priority interventions for Category B Community Health Centers should include conducting at least annual tidal flood simulation exercises, periodically testing contingency plans, developing service continuity plans, strengthening coordination with the Health Department and BPBD, and ensuring the availability of emergency logistics, backup communication systems and essential medical supplies.

Overall, the findings suggest that differences in institutional capacity may contribute to differences in preparedness among Community Health Centers, even when tidal flood exposure varies across the service areas.

Study Limitation

This study had several limitations. The assessment was conducted by researchers and Community Health Center staff using the HSI instrument, without input from civil or structural engineering experts; consequently, the structural assessment was limited to the scope covered by HSI. In addition, this study did not examine patient safety, which means that the results do not provide a complete picture of overall facility safety. Finally, the assessment focused solely on tidal flooding; therefore, the findings may not be generalizable to other types of disasters.

Conclusion

This study found that inpatient Community Health Centers in Surabaya's coastal areas exhibit varying levels of preparedness for tidal flooding. The Sememi Community Health Center was classified as Category A, indicating that it was well prepared to remain operational during emergencies, whereas the Krembangan Selatan and Bulak Banteng Community Health Centers were classified as Category B, indicating the need for short-term improvements. Although structural and non-structural preparedness were generally adequate, functional preparedness was the weakest component and should be prioritized for improvement.

These findings indicate that maintaining essential health services during tidal flooding requires structurally sound buildings and reliable systems, as well as strong functional preparedness. Key priorities include regular disaster training and simulations, contingency and service continuity planning, strengthened intersectoral coordination, and ensuring the availability of emergency supplies and backup communication systems. Strengthening these areas will help Community Health Centers sustain the delivery of care during and after tidal flooding events.

Ethics approval

This study was approved by the Ethics Commission of Health Research and Development of Sint Carolus School of Health Science (approval number: 153/KEPPKSTIKSC/VII/2025).

Availability of data and materials

The dataset used in this study is not publicly available because of institutional confidentiality rules. The data include sensitive information regarding Community Health Center safety assessments. As a result, detailed data cannot be shared, but limited access may be possible upon reasonable request and with institutional permission.

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Author Contribution

DNK conceptualized the study and created the methodology; F and AH supervised the study, reviewed, and provided feedback on the manuscript; DNK performed the analysis and wrote the manuscript; DNK, F, and AH approved the manuscript.

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