



Research Article

Current situation and challenge of maritime patient transfer system in archipelagic province

Lakkana Thaikruea^{1,*}, Jackrit Suwantap² and Massayu Engkapisakorn¹

¹Samui Comprehensive Maritime Safety Center, Royal Thai Ministry of Public Health, Surat Thani 84140, Thailand
²Samui Hospital, Samui District, Surat Thani 84140, Thailand

*Corresponding author's e-mail address: lakkana.t@cmu.ac.th

Article information	Abstract
Received: November 19, 2025 Revision: March 14, 2026 Accepted: March 20, 2026	The demand for maritime patient transfer (MPT) has recently increased in Samui District, Thailand; however, no formal documentation maritime patient transfer system (MPTS) currently exists. This study aimed to assess the existing MPT operations and provide recommendations for system development. A cross-sectional study was conducted from January to November 2025 across all 15 organizations involved in MPT. Researchers collected data, observed the transfer procedure, and surveyed the ports and vessels. Of 140 personnel from district hospitals, 121 participated (86.43 %), alongside all 42 representatives from other organizations. MPT is currently conducted independently by hospitals, with Samui Hospital serving as the primary transfer facility. None of the participating organizations reported having formal MPT protocols or standardized ambulance boats. Awareness of core MPTS components was limited. At Samui Hospital, respondents showed general awareness, but limited understanding, of the MPTS. Prior transfer experience was associated with higher knowledge of procedures, guidelines, systems, and safety equipment (all $p \leq 0.008$), yet lower confidence in on-board emergency patient evacuation ($p < 0.001$). Among involved organizations, experienced representatives were more likely to recognize their organizational role in the district MPT system ($p < 0.001$) and to understand the organizational MPT concept than those without experience ($p \leq 0.031$). Key challenges included the absence of an integrated system, unclear organizational responsibilities, and workforce and training limitations. The study recommends establishing a district-wide MPTS with a dedicated Operation Center to provide consultation, operational support, transfer monitoring, and rescue coordination. A preliminary MPTS model was collaboratively developed with key organizational representatives and presented during stakeholder consultations in Samui District. Subsequent engagement with Koh Phangan Hospital expanded the model's application to both Samui and Phangan Districts. Feedback from both districts was consolidated, refined, and endorsed by stakeholders. Sustainable MPT in island settings requires standardized ambulance boats, regulatory frameworks for operator training and certification, and structured educational programs. The proposed system is feasible and scalable due to reliance on existing budgets and personnel. It may be applicable to other archipelagic provinces, given their comparable healthcare infrastructure and maritime patient transferring.
Keywords Maritime; Patient; Transfer; System; Ambulance boat; Model; Regulation	

1. Introduction

In many developing countries, healthcare access remains a persistent challenge, particularly in remote, rural, and maritime regions (Handayani et al., 2018). Thailand and Indonesia has no exceptions, facing significant disparities in healthcare infrastructure across their vast archipelagic and tourism-driven geographies (Handayani et al., 2018; Institute for Population and Social Research, Mahidol University, 2019; Aryani et al., 2022). As a response to these challenges, water ambulances have emerged as a promising solution to bridge critical gaps in emergency medical services (Battineni et al., 2022; Messelink et al., 2023). However, the effective implementation of such systems necessitates compliance with international maritime regulations and a comprehensive understanding of local healthcare access challenges (Handayani et al., 2018; Kjaervoll et al., 2024). The demand for emergency medical response capabilities in maritime environments has intensified due to population growth, expanding tourism, and geographic isolation (Institute for Population and Social Research, Mahidol University, 2019; Willcox-Pidgeon et al., 2019). Islands such as Nusa Penida (Indonesia) and Samui (Thailand) illustrate these challenges (Institute for Population and Social Research, Mahidol University, 2019; Aryani et al., 2022; Lodde et al., 2019; Rut et al., 2017). In Thailand, similar issues have been observed in island provinces known for marine tourism. High-profile incidents, such as the 2018 Phuket boat tragedy and a 2024 patient-transfer vessel collision, highlight the urgent need for dedicated maritime medical transfer systems. The absence of such systems continues to contribute to preventable deaths and adverse patient outcomes (Institute for Population and Social Research, Mahidol University, 2019). The experience of Pacific Island nations offers pertinent models for designing resilient MPTS in resource-constrained archipelagic environments (Casey et al., 2025). Several Small Island Developing States (SIDS), including the Solomon Islands, Tonga, Samoa, and Palau, have established national Emergency Medical Teams (EMT) (Casey et al., 2025). The Republic of Palau's EMT serves as a powerful example of how a small island nation (population 17,614) can successfully institutionalize a global standard. (Ferguson et al., 2023) It developed its Standard Operating Procedures by specifically adapting the World Health Organization's EMT Classification and Minimum Standards to suit its local, large-ocean context (Ferguson et al., 2023). This model emphasizes formalized governance, relying on a Technical Working Group comprising key governmental and disaster response stakeholders to manage resources, mobilize teams, and integrate clinical preparedness into the National Risk Disaster Management Framework (Ferguson et al., 2023). The availability of specialized equipment (EMT cache) procured for all Pacific EMTs further supports their deployment readiness (Ferguson et al., 2023). Even in high-income settings such as Norway and the state of Maine (USA), professionalized maritime patient transport entails substantial financial investment, with purpose-built ambulance vessels (Kjaervoll et al., 2024). These experiences demonstrate that safe and effective MPT cannot rely on informal or non-medical transport assets (Kjaervoll et al., 2024; World Health Organization, 2020). In many island settings, inadequate vessels, insufficient safety equipment, and weak maritime safety standards expose patients and personnel to avoidable risk. Resilient MPTS therefore require integrated design across vessel standards, safety equipment, operational protocols, training, and governance, as failures in any component increase the likelihood of adverse events (Mišković & Wang, 2025). At the national level, MPT design should align with World Health Organization pre-hospital guidance emphasizing governance, operational standards, emergency communication and dispatch, and medical oversight (Casey et al., 2025; World Health Organization, 2020). In Thailand, fragmented inter-agency coordination undermines interoperability and exacerbates transfer delays (Sittichanbuncha et al., 2014; Qiao et al., 2022).

In life-threatening or severe medical emergencies occurring at sea, shipboard healthcare personnel face considerable challenges. Maritime medical responders often operate with limited training, minimal equipment, and restricted medical supplies, making effective treatment in remote

marine environments exceedingly difficult (Lodde et al., 2019; Rut et al., 2017). These limitations highlight the critical need for a reliable, rapid, and coordinated maritime patient transfer system (MPTS) to ensure timely access to advanced medical care (Aryani et al., 2022; Lodde et al., 2019; Rut et al., 2017). The growing annual demand for emergency medical services further underscores the urgency of establishing such systems. Patients presenting with sudden or critical conditions require accurate, timely, and safe 24-hour transportation to higher-level healthcare facilities. Addressing this need involves not only the development of standardized protocols, but also the deployment of appropriate vehicles and medical equipment specifically designed for maritime settings (Aryani et al., 2022; Kjaervoll et al., 2024; Lodde et al., 2019). An effective MPTS is especially crucial in coastal and island regions, where high tourism activity and limited on-site medical infrastructure create vulnerabilities in emergency response (Institute for Population and Social Research, Mahidol University, 2019; Kjaervoll et al., 2024).

Thailand's southern islands- Koh Samui, Koh Phangan, and Koh Tao in Surat Thani Province- are internationally recognized destinations for marine-based tourism, offering activities such as swimming, diving, and water sports (**Figure 1**) (Institute for Population and Social Research, 2019). Administratively, Koh Samui belongs to Samui District, while Koh Phangan and Koh Tao fall under Phangan District. Located in the Gulf of Thailand, these islands face inherent risks associated with marine environments, including accidents, water-related injuries, and drowning incidents. The demand for emergency care has increased in recent years. The number of accidents reported at Samui Hospital rose from 2,911 cases in 2023 to 3,161 in 2024 and 3,213 in 2025. Samui hospital currently serves as the primary facility responsible for MPT. Due to limited healthcare capacity and infrastructure in the surrounding islands, healthcare facilities in Phangan District frequently transfer patients to Samui island for advanced medical care. Inter-island patient transfers have also increased over the same period. Samui Hospital referred 1,832, 2,186, and 2,792 patients to higher-level hospitals on the mainland in 2023, 2024, and 2025, respectively. In addition, the hospital received 2,170, 1,716, and 1,867 patient transfers from healthcare facilities in Phangan District (Koh Phangan and Koh Tao) during the same period. This highlights the need to examine the factors influencing maritime patient transfer safety in order to strengthen emergency medical services and improve patient outcomes in island communities.

Managing such emergencies in maritime environments presents unique challenges distinct from those encountered in land-based healthcare systems (Casey et al., 2025). Escalating demand for emergency medical services, combined with constrained healthcare infrastructure and limited resources in remote island settings, underscores the necessity for an effective and well-coordinated maritime patient transfer system (MPTS) (Handayani et al., 2018; Battineni et al., 2022; Kjaervoll et al., 2024; Ferguson et al., 2023). Despite the increasing burden of emergencies in coastal and island regions, no formal reports or systematic evaluations of maritime patient transfer (MPT) currently exist for Surat Thani Province. Critical gaps in evidence persist, including deficiencies in stakeholder knowledge and awareness of MPT, system organization and infrastructure, workforce training and preparedness, availability and appropriateness of transport vessels, operational and safety challenges, and resource and finance. Generating empirical data to address these gaps is essential for informing system optimization, enhancing inter-agency coordination, and improving emergency care outcomes in maritime and island contexts. This study aims to assess the current situation of MPT and provide recommendations for MPTS development. The findings will be used to inform the development of a prototype MPT model and contribute to the establishment of a standardized national framework for MPT in Thailand.



Figure 1 Archipelago map of Samui, Phangan, and Tao islands of Surat Thani Province, Thailand.

2. Materials and methods

2.1 Study design

A cross-sectional study was conducted in Samui District of Surat Thani Province, Thailand, between January and November 2025.

2.2 Sampling procedure and data collection

The study population was the maritime patient transfer operation in Samui District. Therefore, all fifteen organizations involved in sea-based patient transport were included. These comprised of Samui Hospital, the Tourism Authority of Thailand: Koh Samui Office, the Koh Samui Tourist Police, the Marine Police, the Koh Samui City Municipality, the Samui Rescue Foundation, Wattanapat Hospital Samui, Bangkok Hospital Samui, the Samui Naval Station (Songkhla Naval Base, Naval Area Command 2), the Royal Thai Navy, the Koh Samui Meteorological Station, the Koh Samui District Public Health Office, the Marine Department, the Department of Disaster Prevention and Mitigation, and the Office of Koh Samui District. An initial stakeholder meeting on MPT was convened by the research team to engage relevant organizations and provide an opportunity for discussion, information exchange, and structure and content of questionnaires. For quantitative

questionnaires, there were four parts, which were demographic (and anonymous), system knowledge and experience (4 questions), components of organization's MPTS (8 questions), and comments and suggestions. Most of the answers were one choice from yes, no, and not sure (detail are in the results section). For components of MPTS, the participants chose only one answer from the list of brief description choices. Semi-structure questionnaires were developed to explain the MPT of each organization. There were four parts, which were demographic (and anonymous) and role of organization, system knowledge and experience, components of organization's MPTS, and comments and suggestions.

Approximately two weeks after the meeting, primary data collection was conducted using a combination of self-administered questionnaires, face-to-face interviews, in-depth interviews, and group discussions. For the in-depth interviews, key informants involved in maritime patient transfer (MPT) were purposively selected from all participating organizations. As each organization had only one representative per position, all eligible individuals were invited to participate. Inclusion and exclusion criteria are shown in **Table 1**.

Table 1 Inclusion and exclusion criteria of eligible individuals.

Category	Inclusion Criteria	Exclusion Criteria	Rationale
High-level managers	Senior executives responsible for organizational leadership	Unwilling to participate	To capture perspectives on policy formulation, strategic planning, and administrative decision-making
Mid-level managers	Managers overseeing programs or units related to MPT	Unwilling to participate	To obtain insights into program coordination, implementation oversight, and managerial challenges
Operational field staff	Personnel with extensive hands-on experience in MPT and a minimum of one year of service	No direct involvement in MPT activities or Unwilling to participate	To ensure informed, practice-based perspectives grounded in sustained field experience

This approach ensured representation of both strategic and operational viewpoints relevant to the functioning of the MPTS. In total, 42 representatives from 14 organizations (response rate of 100.0 %) involved in MPT in Samui District participated. Samui Hospital, as the primary operator of MPT and the sole government hospital in the district, was central to the study. All staff involved in MPT operations were invited to complete a self-administered questionnaire. Of 140 eligible personnel, 121 participated, yielding a response rate of 86.4 %. Secondary data were collected from participating organizations and included official documents such as reports, operational logbooks, photographs, regulations, and applicable legal documents. Researchers observed the transfer procedure and surveyed the ports and vessels used for patient transport.

The research team designed a preliminary MPTS model and collaborated with representatives from key organizations to form a working group. Together, they adjusted the model and presented it at a stakeholder meeting in Samui District for discussion, feedback, and consensus-building. The consultation process was extended to Koh Phangan Hospital in Phangan District. The working group presented the Samui District MPTS model to hospital leadership and staff, who agreed to participate, thereby expanding the model's scope to both Samui and Phangan Districts. Feedback from both

districts was consolidated, and the working group reconvened with stakeholders in Samui District to refine and finalize the model. Upon achieving consensus, the MPTS was formally endorsed.

2.3 Data analysis

Descriptive statistics were used to characterize the study population and transfer situations. Continuous variables were summarized as means with standard deviations (SD) for normal distribution or medians with ranges for non-normal distribution. Categorical variables were presented as proportions (%) with 95 % confidence intervals (CI). To explore potential factors associated with challenges in maritime patient transfer (MPT), univariate analyses were conducted using the Chi-square test or Fisher's exact test (expected cell count < 5 in a contingency table), as appropriate for cell sizes. Statistical significance was defined at an alpha level of 0.05. Results are reported as p-values or risk ratios (RR) with corresponding 95 % CI. For qualitative data, coding procedure and content analysis were used. Triangulation was also applied.

The statistical formulas used for RR and 95 % confidence interval are presented below (Szklo & Nieto, 2018).

2.3.1 Relative Risk (RR)

$$RR = \frac{a/(a+b)}{c/(c+d)}$$

Where

p1 = Probability of having outcome (a) for exposed individuals (a+b)

p2 = Probability of having outcome (c) for unexposed individuals (c+d)

RR = p1/p2

2.3.2 The 95 % Confidence Interval (CI) for RR

The standard error (SE) of ln (RR) is:

$$SE[\ln(RR)] = \sqrt{\left(\frac{1}{a} - \frac{1}{a+b}\right) + \left(\frac{1}{c} - \frac{1}{c+d}\right)}$$

The 95 % CI for RR is calculated as:

$$95\% \text{ CI} = \exp [\ln(RR) \pm 1.96 \times SE[\ln(RR)]]$$

Where

a, b = number of exposed individuals who do and do not have outcome, respectively, and

c, d = number of unexposed individuals who do and do not have outcome, respectively.

2.4 Ethical consideration

This study was reviewed and approved by the Research Ethics Committee of the Ranong Provincial Health Office, Ministry of Public Health, through an exemption review process (Study Code: COE No. 004/2568), dated January 20, 2025.

3. Results

3.1 Current situation of maritime patient transfer in Samui District

Setting

Samui Hospital serves as the primary facility responsible for MPT. Due to limited healthcare capacity in the Phangan district, patients are frequently referred to Samui Island. Maritime patient transfer procedures are managed independently by each hospital, with no unified operational protocol.

Transport modalities

Two modes of transport are utilized: modified speedboats and commercial ferry services. Speedboats are commonly used for inter-facility referrals and are operated by boat crews without formal medical or emergency training. While basic buoyancy aids are available onboard, life jackets for patients and healthcare personnel are generally absent. Ferry transfers involve placing patients inside standard ambulance vehicles driven onto commercial ferries. Ambulances are often parked in fixed rows with limited access to exits.

Operational and safety characteristics

During ferry transport, all passengers are required to remain in designated passenger areas, except for ambulance drivers and attending healthcare personnel. Ambulance engines are typically kept running to maintain medical equipment functionality. In emergency situations, limited audibility of warning signals within the ambulance van, combined with restricted parking configurations, significantly impedes the efficiency of rapid evacuation. No flotation devices are available within ambulance vehicles.

For speedboats, decisions regarding transport continuation under adverse weather conditions are made by boat operators based on experience.

Transfer outcomes and logistical issues

Upon arrival at the port, the patient is either transferred directly to the destination hospital (if arriving via ferry) or to an ambulance at the pier (if arriving by speedboat), which completes the transport to the receiving facility. After transfer, personnel return to the sending hospital using the same boat and vehicle. In adverse weather conditions, the decision to proceed or turn back is made by the boat operator (based on experience). Incidents of mechanical failures, fuel shortages, and vessel accidents have been reported, sometimes requiring personnel to request emergency assistance from their respective hospitals. In the case of ferry transport, availability is sometimes limited by space constraints, which may delay timely transfers.

3.1.1 Situation in Samui Hospital

The majority of 121 participants were women (93.39 %; 95 % CI; 87.39 %, 97.10 %) and the mean age was 35.41 years (SD 10.47 years). The mean duration of work was 11.34 (SD 9.85) years.

Awareness and understanding

Among participants, 90.91 % (95 % CI; 84.32 %, 95.37 %) were aware of hospital MPT. Among 110 aware participants, 57.27 % did not or were not sure that they really understand the meaning of MPTS, whereas all of the unaware participants reported that they understand the meaning (p-value 0.005). They had awareness without adequate understanding.

MPT meeting attendance and awareness of the MPT system, awareness of the absence of a standardized ambulance boat, and team-related confidence during patient evacuation.

Of the 121 participants, 24 (19.83 %) attended the MPT meeting. Attendees were significantly more likely to report a lack of understanding or aware of the hospital's MPT (including its procedures, guidelines, safety equipment, and orientation) compared to non-attendees (**Table 2**). However, all attendees correctly identified that the terms "system," "procedure," and "guideline" refer to distinct components, whereas only 41.24 % of non-attendees answered this item correctly (p-value < 0.001) (**Table 2**). Most attendees of the meeting knew that their hospital did not have an MPTS, whereas none of non-attendees of the meeting reported this knowledge (p-value < 0.001) (**Table 2**). All meeting attendees were aware that the hospital lacked a standard ambulance boat for patient transfer, compared to only 32.99 % of non-attendees (p-value < 0.001) (**Table 2**). Attendees and non-attendees reported comparable self-confidence in patient evacuation from transfer boats during emergencies;

however, attendees had significantly lower confidence in the on-board team than non-attendees (**Table 2**, $p < 0.001$).

Attendance at MPT meetings was associated with greater awareness and knowledge of the MPTS, increased recognition of the absence of a standardized ambulance boat, and differences in team-related confidence during patient evacuation.

Table 2 Issues of maritime patient transfer system of Samui Hospital by attendance of meeting.

Issues	Attended the meeting		RR (95% CI)	P-value
	Yes n (%)	No n (%)		
Do you understand the meaning of the “maritime patient transfer (MPT)” of your hospital?				
No, I do not understand.	24 (100.00 %)	50 (51.55 %)	1.94 (1.60, 2.35)	< 0.001**
Yes, I do understand.	0	47 (48.45 %)		
You know that the “system,” “procedure,” and “guidelines” are....				
The same thing.	0	57 (58.76 %)		< 0.001**
Different components.	24 (100.00 %)	40 (41.24 %)		
Do you know that your hospital has procedure for MPT?				
I am aware that the hospital has no procedure.	8 (33.33 %)	0		< 0.001**
I am aware that the procedure is unclear or that the complete procedural workflow differs among hospital departments.	0	88 (90.72 %)		
I am aware that the hospital has a complete, correct procedure, and that it is consistently followed by everyone.	16 (66.67 %)	9 (9.28 %)		
Do you know that your hospital has guidelines for MPT?				
I am aware that the hospital has no guidelines.	0	17 (17.53 %)		0.008**
I am aware that the hospital guidelines are (1) complete but unclear, (2) clear but incomplete, or (3) incomplete and unclear.	14 (58.33 %)	62 (63.92 %)		
I am aware that the hospital has complete and clear guidelines.	10 (41.67 %)	18 (18.56)		
Does your hospital have a MPT system?				
The hospital has no MPT system.	21 (87.50 %)	0		< 0.001**
The hospital has an MPT system, but it is inadequate.	0	43 (44.33 %)		
The hospital has an MPT system, but the definition is inconsistent across hospital departments.	0	30 (30.93 %)		

Table 2 (continued) Issues of maritime patient transfer system of Samui Hospital by attendance of meeting.

Issues	Attended the meeting		RR (95% CI)	P-value
	Yes n (%)	No n (%)		
The hospital has a robust MPT system with shared agreement across departments regarding procedures, operational directions, and definitions (e.g., transfer criteria, severity classification, and equipment use for staff and patients).	3 (12.50 %)	24 (24.74 %)		
Do you know whether your hospital has safety equipment used or worn by personnel involve in patient transfer?				
No, I do not know.	16 (100.00 %)	18 (18.56 %)	5.39 (3.55, 8.18)	< 0.001**
Yes, I do know.	0	79 (81.44 %)		
Do you know that the hospital provides orientation and training on all equipment used in patient transfer (including safety for the transfer personnel)?				
No, I do not know.	14 (100.00 %)	49 (50.52 %)	1.98 (1.63, 2.41)	< 0.001*
Yes, I do know.	0	48 (49.48 %)		
Are you confident that the team on board can evacuate patients from the transfer boat in emergencies (e.g., boat sinking or accident) during MPT operation?				
Not confident.	12 (100.00 %)	67 (69.07 %)	1.45 (1.27,1.65)	< 0.001**
Confident.	0	30 (30.93 %)		
Does your hospital have a standard ambulance boat for patient transfer?				
My hospital does not have this.	24 (100.00 %)	32 (32.99 %)		< 0.001*
My hospital has this.	0	36 (37.11 %)		
I do not know whether my hospital has this.	0	29 (29.90 %)		
Does Thailand have a standard for ambulance boats used for patient transfer?				
Thailand does not have this.	11 (45.83 %)	0		< 0.001**
Thailand has this.	0	64 (65.98 %)		
I do not know whether Thailand has this.	13 (54.17 %)	33 (34.02 %)		

* Statistically significant when Chi square test p-value is 0.05 or below.

** Statistically significant when Fisher's exact test p-value is 0.05 or below.

3.1.1.1 Previous experience in transferring patients

Among 121 participants, 76.03 % (95 % CI; 67.43 %, 83.32 %) had experience in transferring patients via sea. The majority of the participants who had (79.35 %: 95 % CI; 69.64 %, 87.08 %) and did not have experience (82.76 %: 95 % CI; 64.23 % 94.15 %) did not attend the meeting.

Influence of MPT experience on evacuation confidence of onboard teams and knowledge of MPT system, acknowledgment of orientation and training on equipment, confidence in individual ability to evacuate patients, and awareness of the existence of standard ambulance boats

Experienced participants reported significantly different responses compared to those without experience, particularly regarding the existence of procedures, guidelines, systems, and safety equipment. They were more likely to provide accurate answers than their inexperienced counterparts (**Table 3**). Experienced and non-experienced participants reported comparable self-confidence in patient evacuation from transfer boats during emergencies; however, experienced participants had significantly lower confidence in the on-board team than non-attendees (**Table 3**, $p = 0.021$).

Notably, MPT experience was not significantly associated with understanding the concept of MPT within the hospital, knowledge of the distinctions among systems, procedures, and guidelines, acknowledgment of orientation and training on equipment used for patient transfer (including personnel safety), or awareness of the existence of hospital- or Thailand-standard ambulance boats for patient transfer.

Table 3 Issues of maritime patient transfer system of Samui Hospital by maritime patient transferring experience.

Issues	Previous experience in transferring patients		RR (95 % CI)	P-value
	Yes n (%)	No n (%)		
Do you know that your hospital has procedure for MPT?				
I am aware that the hospital has no procedure.	7 (7.61 %)	1 (3.45 %)		< 0.001**
I am aware that the procedure is unclear or that the complete procedural workflow differs among hospital departments.	65 (70.65 %)	23 (79.31 %)		
I am aware that the hospital has complete, correct procedure, and that it is consistently followed by everyone.	20 (21.74 %)	5 (17.24 %)		
Do you know that your hospital has guidelines for MPT?				
I am aware that the hospital has no guideline.	15 (16.30 %)	2 (6.90 %)		0.008*
I am aware that the hospital guidelines are (1) complete but unclear, (2) clear but incomplete, or (3) incomplete and unclear.	54 (58.70 %)	22 (75.86 %)		
I am aware that the hospital has complete and clear guidelines.	23 (25.00 %)	5 (17.24 %)		
Does your hospital have a MPT system?				
The hospital has no MPT system.	14 (15.22 %)	7 (24.14 %)		< 0.001**
The hospital has an MPT system, but it is inadequate.	36 (39.13 %)	7 (24.14 %)		

Table 3 (continued) Issues of maritime patient transfer system of Samui Hospital by maritime patient transferring experience.

Issues	Previous experience in transferring patients		RR (95 % CI)	P-value
	Yes n (%)	No n (%)		
The hospital has an MPT system, but the definition is inconsistent across hospital departments.	22 (23.91 %)	8 (27.59 %)		
The hospital has a robust MPT system with shared agreement across departments regarding procedures, operational directions, and definitions (e.g., transfer criteria, severity classification, and equipment use for staff and patients).	20 (21.74 %)	7 (24.14 %)		
Do you know whether your hospital has safety equipment used or worn by personnel involve in patient transfer?				
No, I do not know.	26 (28.57 %)	8 (36.36 %)	5.39 (3.55, 8.18)	< 0.001**
Yes, I do know.	65 (71.43 %)	14 (63.64 %)		
Are you confident that the team on board can evacuate patients from the transfer boat in emergencies (e.g., boat sinking or accident) during MPT operation? (excluded three participants who did not have duty)				
Not confident.	68 (77.27 %)	11 (52.38 %)	1.48 (0.97, 2.25)	0.021*
Confident.	20 (22.73 %)	10 (47.62 %)		

* Statistically significant when Chi square test p-value is 0.05 or below.

** Statistically significant when Fisher's exact test p-value is 0.05 or below.

3.1.1.2 Problems of maritime patient transfer

The participants identified challenges in the current MPT as follows:

System and infrastructure limitations

Participants reported the absence of a formalized and structured MPTS, including the lack of nationally standardized ambulance boats for MPT.

Human factors and personal safety constraints

Challenges included seasickness or motion-related discomfort during maritime operations, as well as limited basic swimming proficiency among majority of personnel.

Workforce organization and orientation gaps

An absence of specialized teams dedicated to MPT was noted. In addition, orientation programs for newly assigned or involved personnel were limited, and instruction on the use of maritime safety equipment was often inadequate.

Training and competency deficiencies

Participants identified insufficient training in critical areas, including maritime patient evacuation, survival skills, emergency preparedness, and maritime operational protocols.

3.1.2 Situation in involved organizations

Awareness of MPT system

None of the organizations has a MPTS in place, nor do they have standards for ambulance boats used in patient transfers.

Effect of MPT meeting attendance on awareness and knowledge of MPT system and components, awareness of the existence standard ambulance boats, organizational involvement in MPT, organizational awareness of MPT system, and conceptual understanding of MPT system, and standardized ambulance boats

Among the 42 representatives, 17 had attended a meeting on the MPTS of Samui District. Of those who attended, 64.71 % knew that Thailand lacks standardized ambulance boats, compared to only 16.00 % of those who did not attend the meeting (p-value = 0.002).

Notably, no statistically significant associations were observed for other assessed issues, including:

Organizational involvement in MPT

- Whether participants' organizations had a role in, or were involved in, district-level MPT activities.

Organizational awareness of MPT system

- Awareness of the organization's MPTS among participants whose organizations were involved in district-level MPT.

Conceptual understanding of MPT system

- Understanding of the meaning and function of the organization's MPTS.

Knowledge of different components of MPT system

- Knowledge of the distinctions among a "system," "procedure," and "guideline."

3.1.2.1 Previous maritime patient transferring experience

Among the 42 representatives, 27 (64.29 %) had experience in transferring patients by sea. Approximately forty percent of representatives in both the experienced (40.00 %; 95 %CI 16.34 %, 67.71 %) and non-experienced (40.74 %; 95 % CI 22.39 %, 61.20 %) groups attended the meeting.

Influence of MPT experience on organizations' roles, knowledge of MPT system and components, and standard ambulance boat

The experienced representatives were more likely to know that their organization has a role or involve in the MPT in the district (p-value < 0.001) and understood the meaning of the organizations' MPT (p-value = 0.031) than those without experience (**Table 4**). All representatives knew that their organizations lack a standard ambulance boat (p-value > 0.05). However, 48.15 % of those with experience knew that Thailand does not have a national standard for ambulance boats, compared to only 13.33 % of representatives without experience (p-value = 0.013) (**Table 4**).

Notably, MPT experience was not significantly associated with absence of knowledge of the organizations' MPTS (all of them aware of the absence of the system) and knowledge of the distinctions among a "system," "procedure," and "guideline." (limited knowledge).

3.1.2.2 Problems of maritime patient transfer

The participants identified challenges in the current MPT as follows:

System, policy, and regulatory gaps

Representatives reported the absence of a formal or standardized system governing MPT at the district level, as well as the lack of national standards for maritime ambulance vessels. Existing

legal frameworks were described as outdated, insufficient, and difficult to enforce. There are no dedicated regulations governing the use and standards of ambulance boats, and current laws are often difficult to enforce or implement in practical scenarios.

Table 4 Issues of maritime patient transfer system within involved organizations by previous maritime patient transferring experience.

Issues	Previous maritime patient transfer experience		RR (95 % CI)	P-value
	Yes n (%)	No n (%)		
Do you know that your organization has a role or is involved in the maritime patient transfer (MPT) in the district?				
No, I do not know.	0	12 (80.00 %)	5.00 (1.82, 13.76)	< 0.001*
Yes, I do know.	27 (100.00 %)	3 (20.00 %)		
Do you understand the meaning of the “maritime patient transfer” of your organization?				
I am not sure.	16 (59.26 %)	14 (93.33 %)	6.11(0.87, 42.84)	0.031*
Yes, I do understand.	11 (40.74 %)	1 (6.67 %)		
Does Thailand have a standard for ambulance boats used for patient transfer?				
No, it does not.	13 (48.15 %)	2 (13.33 %)	-	0.013*
Yes, it does.	3 (11.11)	0		
I do not know.	11 (40.74 %)	13 (86.67 %)		

* Statistically significant when Fisher’s exact test p-value is 0.05 or below.

Organizational roles and inter-organizational coordination deficiencies

Individual organizations often lack clarity regarding their specific roles and responsibilities within the MPT process. Coordination between organizations- particularly among governmental bodies- is limited, hindered by overlapping mandates and unclear jurisdiction. Additionally, standardized referral procedures and formalized inter-organization coordination mechanisms are absent at both the district and institutional levels. The organizational structure remains unclear, further impeding efficient operations.

Workforce and training limitations

Participants highlighted the absence of trained or dedicated operational teams specifically for MPT. Effective MPT requires specialized knowledge, maritime operational experience, and survival skills, which are often lacking. No formal curriculum or structured training program existed for MPT teams, particularly for patient handling and evacuating during maritime transfer.

Resource and financial constraints

Financial limitations were reported as a major barrier, restricting organizations’ capacity to establish, develop, and sustain effective MPT capabilities.

3.2 Recommendation for developing a maritime patient transfer system

The findings identify opportunities to further enhance the MPTS in Samui District, with key recommendations outlined below (**Table 5**).

Table 5 Key recommendation for development of Samui maritime patient transfer system.

Category	Key Recommendations
1. Governance, Coordination, and System Structure	Establish a standardized district-wide MPTS collaboratively developed by all relevant organizations; define and formalize lines of authority, command, and responsibility; ensure formal communication and consistent implementation; establish a district MPT Operational Center responsible for consultation, operational support, transfer monitoring, and rescue operations; define refer-out (outbound) and receive-in (inbound) transfer pathways (Figure 2).
2. Operational Protocols and Equipment Readiness	Develop and implement a clearly defined patient transfer protocol; ensure availability of medical-grade equipment in adequate quantities and maintained in a constant state of readiness; deploy ambulance boats compliant with recognized medical and maritime safety standards; conduct routine inspection and official certification of all equipment and vessels.
3. Workforce Capacity, Training, and Competency Standards	Implement standardized orientation and continuous training programs for all MPT personnel; provide regular training in MPT procedures, maritime rescue and survival skills, emergency response, patient handling and evacuating, and equipment operation; define personnel qualifications, competency requirements, and certification standards.
4. Legal and Regulatory Framework Strengthening	Review and revise existing laws and regulations to improve feasibility and enforceability; designate maritime traffic zones; clarify inter-organizational responsibilities; eliminate regulatory redundancies; streamline enforcement mechanisms; enact comprehensive legislation governing MPT protocols, equipment specifications, personnel qualifications, and certification requirements for ambulance boats and medical ports.

4. Discussion

4.1 Current situation of MPT in Samui District

The findings show that the current situation of MPT in Samui district is operated separately by hospitals and lacks a unified and standardized MPTS. Samui hospital currently serves as the primary facility responsible for MPT. The context is different from those of Indonesia but similar to some small countries in the Western Pacific Region (Handayani et al., 2018; Aryani et al., 2022; Ferguson et al., 2023).

4.1.1 Samui hospital

For Samui hospital, the results show that the participation percentage was very high. The majority of participants were women, reflecting the gender distribution of staff commonly assigned to patient transfer duties and gender distribution of nurses in Thailand. Older personnel were less likely to be involved in such duties (World Health Organization, 2020 Mišković & Wang, 2025). Attending a meeting on the MPTS had a positive effect on knowledge and awareness of the MPTS. Those who attended the meeting were more likely to recognize their previous misconceptions about the MPTS, structure, and procedures. This was evident in their ability to more accurately distinguish between these components compared to those who did not attend. Furthermore, only a few participants could clearly articulate these concepts, reinforcing the overall finding of limited knowledge in this area. Previous experience in MPT was also positively associated with knowledge

accuracy. Experienced participants provided more precise responses than their inexperienced counterparts. Notably, none of the participants expressed confidence in the evacuation capabilities of onboard teams, a concern likely tied to the absence of standardized ambulance boats, training deficiencies, and insufficient safety equipment. Both experienced and inexperienced groups demonstrated a low understanding of MPTS concepts. These findings underscore significant deficiencies in MPTS and knowledge.

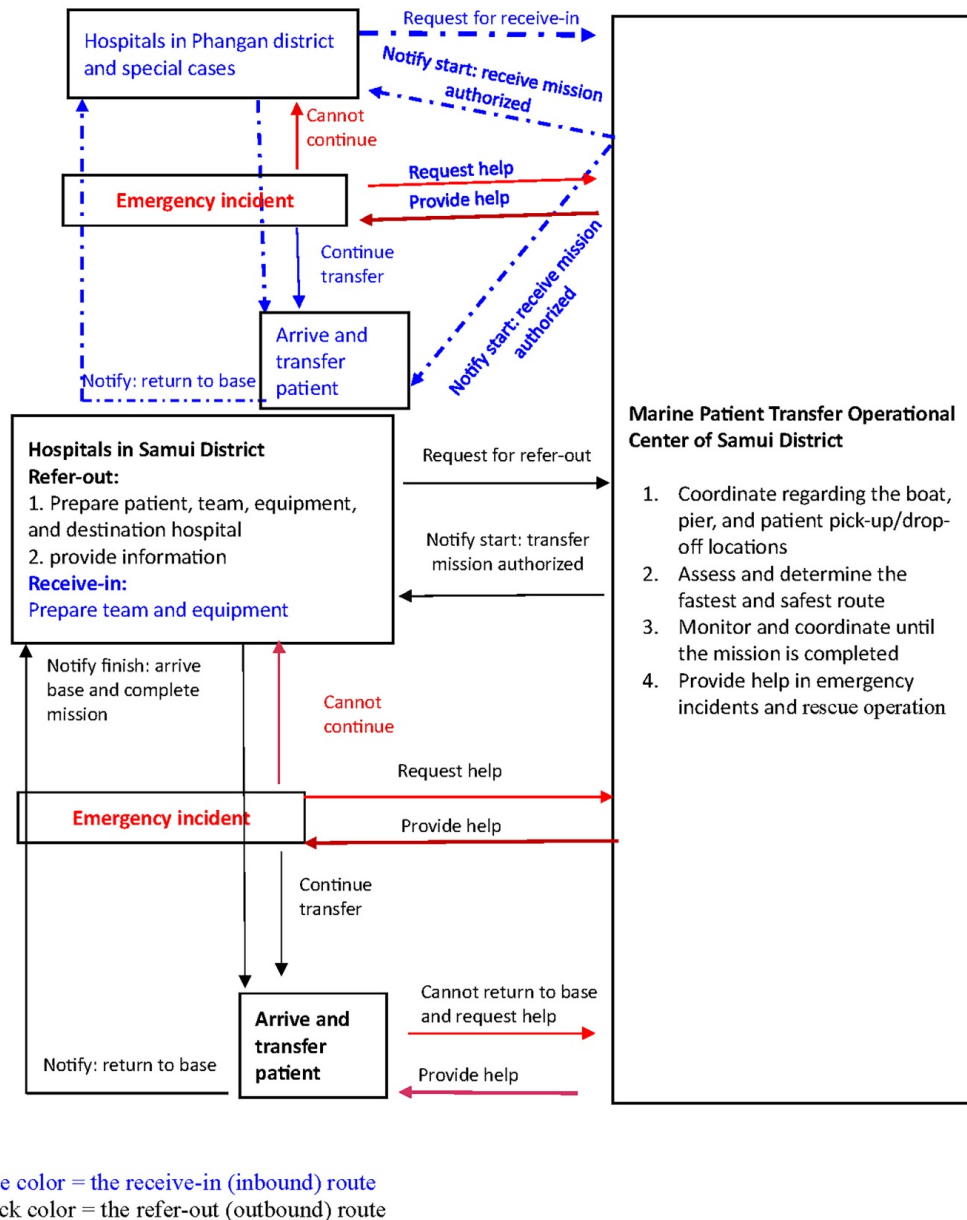


Figure 2 Flowchart of the marine patient transfer system.

4.1.2 Involved organizations

Similar patterns were identified across all involved organizations, reflecting those seen in the district hospital. Although all representatives with prior experience in MPT were aware of their organizations' roles within the district's MPTS, the majority of them had limited understanding of their organizations' specific MPTS. None of the organizations reported having a formal MPTS or access to standardized ambulance boats. The representatives from involved organizations were concerned about responsibility/role, inter-organization collaborations, district-level system, and law

and regulation. These findings contributed to recommendations that are appropriate for the context of Samui District.

4.1.3 Contextual comparison across settings

Experiences from Pacific Island nations demonstrate that resilient maritime patient transport (MPT) systems can be developed in resource-constrained archipelagic settings through contextualized adoption of World Health Organization standards (Casey et al., 2025; Ferguson et al., 2023; World Health Organization, 2020). Palau's Emergency Medical Team (KLEMAT) illustrates how globally endorsed frameworks can be operationalized through locally adapted standard operating procedures, clear governance arrangements, and integration within national disaster management systems (Ferguson et al., 2023). These experiences support the conclusion that institutional alignment and system coherence- rather than financial capacity alone- are central to effective MPTS performance.

Evidence from high-income settings, including Norway and the state of Maine in the United States, further demonstrates that safe and effective MPT requires professionalized, medically governed transport systems, with purpose-built ambulance vessels associated with substantial annual operating costs (Kjaervoll et al., 2024). While such models are not directly transferable to middle-income contexts, they reinforce a principle directly relevant to the Samui-Phangan-Koh Tao system: reliance on informal or non-medical transport assets is incompatible with safe MPT (Kjaervoll et al., 2024). The continued use of modified speedboats within the Samui district reflects pragmatic adaptation to geographic constraints, while simultaneously identifying clear opportunities for incremental standardization and risk reduction.

Findings from Samui District align with broader evidence that resilient MPTS depend on coordinated development across vessel standards, safety equipment, operational protocols, workforce training, and governance (Mišković & Wang, 2025). Fragmented transfer practices across Samui, Phangan, and Koh Tao illustrate how partial system implementation contributes to transfer delays and undermines confidence in team-based evacuation. Aligning the MPTS with the four World Health Organization pre-hospital care pillars- governance and regulation, operational standards, emergency communication and dispatch, and medical control- provides a practical and scalable framework for system strengthening (Casey et al., 2025; World Health Organization, 2020). Consistent with the study's conclusions, strengthening formal inter-agency coordination and governance within the existing EMS structure represents a feasible, high-impact strategy to reduce transfer delays and improve patient safety in island-based healthcare systems (Sittichanbuncha et al., 2014; Qiao et al., 2022).

4.2 Maritime patient transfer system model

Patients who suffer life-threatening conditions at sea require immediate, accurate, and safe transportation to higher-level medical facilities (Handayani et al., 2018; Aryani et al., 2022; Lodde et al., 2019). Moreover, patient transfers from maritime environments carry greater risks than in-hospital care (Handayani et al., 2018; Kjaervoll et al., 2024; Lodde et al., 2019). Without such a system in place, the outcomes for patients in urgent need of medical intervention are significantly compromised. The recommendations of this study are based on the findings and context of the study areas and maritime safety regulations such as Guidelines and International Regulations for Preventing Collisions at Sea (Sawaengdee et al., 2016; Australian Maritime Safety Authority, 2024; International Maritime Rescue Federation, 2025). To improve MPT, a unified MPTS should be implemented across the three islands (Samui, Phangan, and Tao) of the two districts. A district-level operational center for MPT should be established in Samui District, with responsibilities for consultation, operational support, transfer monitoring, and rescue operations. The successful implementation of the MPTS demands urgent action to establish standardized technical protocols, strengthen inter-organizational coordination, and secure sustainable funding for vessel maintenance and medical equipment. These

reforms are not merely procedural but essential to safeguard patient lives and ensure operational reliability. Strategic engagement at all administrative levels is, therefore, critical to institutionalize maritime medical preparedness as a national priority. Although coordination among diverse organizations poses the main challenge, the system's reliance on existing budgets and personnel minimizes financial and human resource constraints. This demonstrates the model's practicality and scalability, even in resource-limited island contexts. The experience of Palau- where a small island nation successfully established a self-sufficient EMT capable of national and regional deployment- illustrates the transformative potential of coordinated maritime health systems (Ferguson et al., 2023). Importantly, no official documentation on MPTS exists for other archipelagic provinces; thus, its results cannot be addressed for the differences and gaps among provinces in Thailand. Nevertheless, the MPTS model could similarly serve as a replicable framework for other archipelagic provinces seeking to strengthen their emergency medical response and maritime health resilience because they have similar healthcare infrastructure and maritime patient transferring.

For long-term sustainability, national-level support is needed (Casey et al., 2025; IMRF, 2025; International Maritime Organization, 1989). The Thai government should prioritize the development of standardized ambulance boats, establish new regulations governing health screenings and qualifications for ambulance boat operators, and create dedicated MPT training units. These units should offer standardized certification programs for MPT teams. Certification systems should also be developed for naval architects and marine engineers responsible for vessel inspection and maritime safety compliance.

4.3 Limitations and strengths

This study has limited generalizability to broader emergency contexts, such as incidents occurring on offshore oil and gas platforms or in deep-sea environments, which require specialized triage teams, advanced transport resources, and larger operational systems. Nonetheless, the findings can be extended to other archipelagic provinces in Thailand, as these areas share a similar health care infrastructure and comparable maritime patient transfer mechanisms. Key operational resources- such as modified ambulance boats, boat drivers, crews, and collaborating organizations- are also consistent across provinces. The only notable variation lies in seasonal differences between the Gulf of Thailand and Andaman coasts, which can be addressed by applying standardized sea-state criteria.

A major strength of this study is its comprehensive data collection process and the active involvement of all relevant stakeholders, which enabled the generation of robust insights into the current status and future needs of the MPTS in Samui District. This approach enhanced data validity by promoting shared understanding and accurate reporting among participants. Nevertheless, the findings of this study provide an evidence-based foundation for the design and implementation of a prototype MPTS in Samui District, while also contributing to the development of a standardized, nationally endorsed framework for MPT across Thailand.

5. Conclusions

This study underscores the urgent need for a MPTS in Samui District, where current practices are fragmented and heavily reliant on individual hospitals. The lack of formal protocols, standardized ambulance boats, and adequately trained personnel compromises both patient safety and operational efficiency. Establishing a district-level MPTS framework, supported by a centralized Operations Center, has the potential to improve coordination, clinical consultation, real-time transfer monitoring, and emergency response. At the national level, policy development to standardize ambulance boat design, implement regulatory mechanisms for operator training and certification, and integrate maritime patient transfer into formal education programs is essential for building long-term system capacity. These strategies are critical to ensuring the safety, effectiveness, and sustainability of MPTS services across Thailand's island regions. Given the comparable healthcare infrastructure and maritime transport conditions in other archipelagic provinces, the findings of this study may be

broadly applicable. Furthermore, system implementation using existing budgets and personnel enhances both feasibility and scalability, supporting the potential for nationwide adoption.

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Declaration of generative AI in scientific writing

The authors acknowledge the use of ChatGPT (OpenAI) and Grammarly for assistance in structuring and grammar refinement of the manuscript. Additionally, Gemini (OpenAI) was used in the development of Figures 1. All final edits, interpretations, and conclusions are the sole responsibility of the authors. The authors are ultimately responsible and accountable for the contents of the work, including the correctness of the references in the reference list.

CRedit author statement

Lakkana Thaikruea: Conceptualization; Methodology; Validation; Formal analysis; Investigation; Data Curation; Writing - Original Draft; Writing - Review & Editing. **Jackrit Suwantap:** Project administration; Resources; Writing - Review & Editing; Supervision. **Massayu Engkapsakorn:** Project administration; acquisition; Investigation; Data Curation; Visualization; Writing - Review & Editing.

References

- Aryani, P., Harjana, N. P. A., Januraga, P. P., Kurnianingsih, D. K. D. S., Wirawan, G. B. S., Swapatni, N. M. A., & Wibawa, I. K. G. S. (2022). Water ambulance service provision to improve healthcare access for community in Nusa Penida Island, Bali: A qualitative feasibility study. *Public Health and Preventive Medicine Archive*, 10(2), 160-170. <https://doi.org/10.53638/phpma.2022.v10.i2.p07>
- Australian Government. (2024). *Safety equipment*. Retrieved from <https://www.amsa.gov.au/safety-navigation/safety-equipment>
- Battineni, G., Chintalapudi, N., & Amenta, F. (2022). Maritime telemedicine: Design and development of an advanced healthcare system called marine doctor. *Journal of Personalized Medicine*, 12(5), 832. <https://doi.org/10.3390/jpm12050832>
- Casey, S. T., Noste, E. E., Cook, A. T., Muscatello, D., & Heslop, D. J. (2025). Emergency medical teams in WHO's Western Pacific Region. *Western Pacific Surveillance and Response Journal*, 14(6), 1-17. <https://doi.org/10.5365/wpsar.2023.14.6.1184>
- Ferguson, M. M., Casey, S. T., Omengkar, W., Uherbelau, G. J., Ngiraingas, T., & Eungel, B. (2023). Developing and maintaining health emergency response capacity: Palau's national emergency medical team. *Western Pacific Surveillance and Response Journal*, 14(6), 1-4. <https://doi.org/10.5365/wpsar.2023.14.6.1039>
- Handayani, P. W., Saladdin, I. R., Pinem, A. A., Azzahro, F., Hidayanto, A. N., & Ayuningtyas, D. (2018). Health referral system user acceptance model in Indonesia. *Heliyon*, 4(12), e01048. <https://doi.org/10.1016/j.heliyon.2018.e01048>
- Institute for Population and Social Research. (2019). *The tragic boat accident in Phuket: Thai tourism lessons, in Thai Health 2019: Online social media—a double-edged sword: Thai health in the context of a socially-connected world* (pp. 77-80). Institute for Population and Social Research, Mahidol University; Thai Health Promotion Foundation; National Health

- Commission Office of Thailand: Nakhon Pathom, Thailand. Retrieved from https://ipsr.mahidol.ac.th/en/post_research/thai-health-2019-th/?utm_source=chatgpt.com
- International Maritime Organization. (1989). *Resolution A.656(16): Fast rescue boats*. London: IMO. Retrieved from <https://www.wcdn.imo.org/localresources/en/KnowledgeCentre/IndexofIMOResolutions/AssemblyDocuments/A.656%2816%29.pdf>
- International Maritime Rescue Federation. (2025). *Search and rescue with medical needs: Best practices*. Retrieved from <https://www.international-maritime-rescue.org>
- Kjaervoll, H. K., Andersson, L. J., Bakkelund, K. E. N., Harring, A. K. V., & Tjelmeland, I. B. M. (2024). Description of the prehospital emergency healthcare system in Norway. *Resuscitation Plus*, 17, 100509. <https://doi.org/10.1016/j.resplu.2023.100509>
- Lodde, B., Querellou, G. E., Morel, A., & L'Her, E. (2019). SEA-mulation: Training for technical treatment related to emergency situations in maritime environment. *Critical Care*, 23(1), 310. <https://doi.org/10.1186/s13054-019-2599-y>
- Messelink, D. M., van der Ploeg, G. J., van der Linden, T., Flameling, R. D., Bierens, J. (2023). Medical emergencies at sea: An analysis of ambulance-supported and autonomously performed operations by lifeboat crews. *BMC Emergency Medicine*, 23(1), 108. <https://doi.org/10.1186/s12873-023-00879-7>
- Mišković, D., & Wang, H. (2025). Exploring the impact of the maritime regulatory framework on the barrier system in ship operations. *Journal of Marine Science and Engineering*, 13(7), 1361. <https://doi.org/10.3390/jmse13071361>
- Qiao, W., Huang, E., Guo, H., Liu, Y., & Ma, X. (2022). Barriers involved in the safety management systems: A systematic review of literature. *International Journal of Environmental Research and Public Health*, 19(15), 9512. <https://doi.org/10.3390/ijerph19159512>
- Rut, A., Klosiewicz, T., Mandecki, M., Nowicki, M., & Maciejewski, A. (2017). The functioning of the maritime medical rescue team: The example of Slupsk emergency medical service water ambulance. *Disaster and Emergency Medicine Journal*, 2(4), 160-163. <https://doi.org/10.5603/DEMJ.2017.0036>
- Sawaengdee, K., Tangcharoensathien, V., Theerawit, T., Thungjaroenkul, P., Thinkhamrop, W., Prathumkam, P., Chaichaya, N., Thinkhamrop, K., Tawarungruang, C., & Thinkhamrop, B. (2016). Thai nurse cohort study: Cohort profiles and key findings. *BMC Nursing*, 15, 10. <https://doi.org/10.1186/s12912-016-0131-0>
- Sittichanbuncha, Y., Prachanukool, T., Sarathap, P., & Sawanyawisuth, K. (2014). An emergency medical service system in Thailand: Providers' perspectives. *Journal of the Medical Association of Thailand*, 97(10), 1016-1021. <http://www.jmatonline.com/view.php?id=1299>
- Szklo, M., & Nieto, F. J. (2019). *Measuring associations between exposures and outcomes* (pp. 87-118). In Szklo, M., & Nieto, F. J. (Eds.). *Epidemiology: Beyond the basics* (4th eds.). Jones & Bartlett Learning.
- Willcox-Pidgeon, S., Peden, A. E., Franklin, R. C., & Scarr, J. (2019). Boating-related drowning in Australia: Epidemiology, risk factors and the regulatory environment. *Journal of Safety Research*, 70, 117-125. <https://doi.org/10.1016/j.jsr.2019.06.005>
- World Health Organization. (2020). *State of the world's nursing 2020: Investing in education, jobs and leadership*. Geneva: WHO. Retrieved from <https://www.who.int/publications/i/item/9789240003279>