


**Research Article**

## Marine Related Injuries and Fatalities in Tourism areas in Surat Thani Province of Thailand between 2016 and 2022

Massayu Engkapisakorn<sup>1</sup>, Sornwit Osothsinlp<sup>2</sup>, Lakkana Thaikruea<sup>\*,3</sup>

### Abstract

**Introduction:** This study aimed to determine the incidents, characteristics, and potential factors associated with marine related injuries and fatalities in tourism areas, which were Samui and Phangan districts.

**Methods:** A retrospective study was conducted. Cases with diagnoses of International Classification of Diseases Revision 10th code T171, T751, T70.3, W94, W56, X26, V90-V94 and T78.0-T78.9 were eligible for the study. Data between 2016 and 2022 were retrieved from Hospital Information System, Java Health Center Information System, and Injury Surveillance systems from medical facilities in Phangan and Samui districts.

**Results:** There were 202 victims. Predominantly comprising men (74.75%), Thai nationals (61.39%), and individuals employed in various capacities (55.94%). Mean age was 33.82 years (+ 16.41). Victims primarily had diagnosis of unspecified effects of drowning and nonfatal submersion at 35.15%. Victims were categorized into three disease groups: drowning, accident, and animal. Statistically significant differences were observed in the proportions Thai nationals ( $p$ -value < 0.001) across the groups. Discharge outcomes exhibited variance, with a 100% improvement in the animal group, in contrast to 56.34% and 82.14% improvements in the drowning and accident groups, respectively ( $p$ -value < 0.001). Treatment expenses were lowest in the animal group and highest in the accident group ( $p$ -value < 0.001).

**Conclusions:** The emphasis on different disease groups allows for more understanding of the diverse causes of incidents. The findings contribute information for developing surveillance and prevention measures. Further studies should be conducted to identify risk factors and causes of injuries and fatalities, underscoring the imperative need for expeditious outbreak investigation courses.

**Keywords:** Injury; fatality; marine; tourism; accident; drowning; envenomation; Thailand

### Introduction

Marine related injuries and fatalities encompass a spectrum of events, including drowning, accidents, and envenomation by animal and plant. Drowning, recognized as a significant source of preventable harm, has gained attention through a resolution by the United Nations General Assembly [1]. The World Health Organization estimated 236,000 lives lost globally in 2019 [2]. This estimate is likely to be significant underreport due to the exclusion

### Affiliation:

<sup>1</sup>Samui Hospital, Ko Samui district, Surat Thani province, Thailand

<sup>2</sup>Institute of Occupational and Environmental Medicine Nopparat Rajathanee Hospital, Bangkok, Thailand

<sup>3</sup>Samui Comprehensive Maritime Safety Center, Ministry of Public Health, Surat Thani province, Thailand

### \*Corresponding author:

Lakkana Thaikruea, Samui Comprehensive Maritime Safety Center, Koh Samui Hospital, Surat Thani, Thailand.

**Citation:** Massayu Engkapisakorn, Sornwit Osothsinlp, Lakkana Thaikruea, Marine Related Injuries and Fatalities in Tourism areas in Surat Thani Province of Thailand between 2016 and 2022. *Fortune Journal of Health Sciences*. 7 (2024): 87-94.

**Received:** February 07, 2024

**Accepted:** February 16, 2024

**Published:** February 22, 2024

of fatal unintentional drowning caused by transportation and disaster-related causes [2]. Exclusion of such cases is shown to underreport drowning between 40 and 60% [3]. Moreover, there is limited global data on the impact of intentional drowning as a cause of death [3]. Water-related fatalities rank as the third leading cause of accidental death in the USA and second in the UK and Australia, with drowning constituting a major global public health concern. Various factors contribute to drowning, including ignorance of danger, overestimation of swimming ability, lack of knowledge about the area, inadequate supervision, coping difficulties, water temperature, and a lack of awareness of safety procedures and first aid [3-5]. A large number of rescues in drowning incidents are performed but most often not reported by individuals or state rescue agencies worldwide. Multifaceted prevention strategies targeting both individuals at risk and structural considerations, such as regulatory measures, are more likely to succeed than single-focused programs [6, 7]. Recreational boating, gaining popularity in recent decades, has led to increased accidents resulting in property damage and personal injury. About 5,000 recreational boating accidents in USA are reported annually, ranking recreational boating as a leading cause of transportation accidents, second only to automotive [6, 8]. Venomous aquatic animals pose hazards to swimmers, surfers, divers, and fishermen, ranging from mild stings and bites to severe envenomation, with certain species capable of causing life-threatening consequences, particularly box jellyfish [9-15].

Timely and effective treatment is crucial to improve immediate outcomes and minimize secondary complications. Treatment recommendations evolve in response to acquisition of data, clinical observations, and expert opinion [9, 15-18]. In Thailand, tourism revenue ranks as the 10th highest among national incomes globally [10]. Predominantly, tourist attractions in the country are centered around cultural experiences, sunlight, sea, and sand [10]. The Samui and Phangan islands in the Surat Thani province are key tourist destinations [10]. The primary motivator for tourists visiting Thailand is engagement in marine-related activities. Human-marine wildlife interaction is a routine occurrence for individuals globally. Despite its ubiquity, this interaction is not consistently safe, as numerous marine wildlife species possess the potential to inflict severe and fatal injuries upon humans [9, 12, 15, 16, 19]. Immediate first aid before full medical treatment is critical to mitigate the dangerous consequences of marine envenomation [16-19]. Several marine animals have the capability to cause significant injuries and fatalities, with jellyfish stings and shark attacks being major contributors to deaths in Australia [11]. Consequently, immediate first aid is imperative to mitigate the perilous consequences of marine injuries [14, 16-20].

The collection, analysis, interpretation of data are

imperative for addressing and preventing marine-related injuries and fatalities. Surat Thani province, situated in the southern region of Thailand, encompasses popular tourism areas in Samui and Phangan districts, characterized by islands and beaches. Tan and Ang Thong islands locate in Samui district. Toa island is in Phangan district. While box jellyfish incidents are well-documented in these areas, limited information is available on other marine-related injuries and fatalities [15, 16, 19-22]. Incidents such as the "Phuket boat accident" on July 5, 2018, resulting in numerous casualties, underscore the need for investigation into ship accidents [23]. Such investigations serve diverse purposes, acting as performance indicators for policymaking, supplying data for scientific research, addressing legal aspects to allocate blame and liability, and providing lessons for the prevention of similar events [24]. This study aimed to determine the incidents, characteristics, and potential factors associated with marine related injuries and fatalities in Samui and Phangan districts. The findings are useful information for the development of first aid, surveillance and prevention measures relevant to the context.

## Methods

**Study design and Setting:** Study design was a retrospective study. All diagnosed cases of marine related diseases between 2016 and 2022 in the Samui and Phangan districts of Surat Thani province were included.

**Cases selection:** All cases with diagnoses of International Classification of Diseases Revision 10th (ICD 10th) code T171, T751, T70.3, W94, W56, X26, V90-V94 and T78.0-T78.9 were considered eligible for inclusion. Data encompassing all relevant cases were retrieved from Hospital Information System, Java Health Center Information System, and Injury Surveillance systems from medical facilities in Phangan and Samui districts. Personally identifiable information such as names, citizen identification numbers, and addresses were meticulously removed from the initial dataset. The extracted information was then compiled into a new data file, capturing demographic details (Nation, age, gender, and district), incident date, incident place, characteristics of injury and death, treatment outcome, and treatment expense.

**Data analysis:** Descriptive analysis included frequency, proportion, rate, mean (Standard Deviation; SD), or median (Interquartile ranges; IQR) depended on data distribution. Diagnoses were categorized into three disease groups - drowning that could not identify cause (T751) (drowning group), accident (V9002 to V9479) (accident group) and exposed to animals and plants (X2600 to X2689 and W5601 to W5689) (animal group) - to determine potential risk factors. Univariate analysis included Chi square test, Fisher exact test, or non-parametric test depends on data distribution. Alpha level of 0.05 or less was considered statistically significant.

**Ethics:** The study underwent a review and received approval through an exemption review process by the Research Ethics Committee of Surat Thani provincial health office, Ministry of Public Health (Study code: STPHO2022-063 on November 7, 2022).

## Results

### Characteristics of injured and deceased victims

During the period from 2016 to 2022, the study identified a total of 202 victims, with a mean age of 33.82 years ( $\pm 16.41$  years) among the 191 victims with known ages. The majority of victims were men (74.75%), Thai nationals (61.39%), and individuals employed in various capacities (55.94%) (Table 1).

**Table 1:** Characteristics of 202 injured and dead victims during the period from 2016 to 2022

Characteristics	Frequency	Percent
Gender		
Men	151	74.75%
Women	51	25.25%
Nationality		
Thai	123	64.39%
Burma	12	6.28%
China	12	6.28%
England	8	4.19%
Russia	8	4.19%
Germany	6	3.14%
France	3	1.57%
Laos	2	1.05%
South Korea	2	1.05%
Switzerland	1	0.52%
Italy	1	0.52%
Norway	1	0.52%
Ireland	1	0.52%
Czech	1	0.52%
Australia	1	0.52%
Ukraine	1	0.52%
India	1	0.52%
Malaysia	1	0.52%
Unknown	6	3.14%
Occupation		
Employee	113	55.94%
Student/housewife	33	16.34%
No job	21	10.40%
Under guardianship	18	8.91%
Commerce	2	0.99%
Farming/ orchard	1	0.50%
Fishery	1	0.50%
Nurse	1	0.50%
Teacher	1	0.50%
Unknown	11	5.45%

### Incident characteristics

The highest rates of marine-related injuries and fatalities were observed in 2018 (31.68%), followed by 2020 (24.75%) and 2021 (16.83%). Other incident rates were 2017 (5.94%), 2022 (5.45%), and 2016 (2.97%). Elevated incidences were notably concentrated in August (16.83%), April (13.86%), and March (13.37%). Other incident rates were February (9.41%), May (9.41%), September (5.94%), June (5.45%), October (5.45%), December (5.45%), July (4.46%), and November (2.48%). Discharge outcomes revealed that 82.18% of victims exhibited improvement, while mortality and referrals to alternative healthcare facilities were observed in 16.83% and 0.99% of cases, respectively. Median treatment expense among 191 victims with known expense was 21.97 United States dollars (USD) (10.57 – 108.06 USD), utilizing a conversion rate of 35.00 baht per USD.

### Causal attribution based on ICD 10th

The categorization of causal factors based on the ICD-10th included codes T171, T751, T70.3, W94, W56, X26, V90-V94, and T78.0-T78.9. Predominantly, victims were diagnosed with unspecified effects of drowning and nonfatal submersion (T751) at 35.15%, followed by contacted with venomous marine animals and plants during other specified work (X2688) and unspecified activities (X2689) at 6.93% each. Drowning and submersion resulting from accidents involving ship passengers during unspecified activities (V9019) accounted for 5.45% (Table 2).

### Characteristics of victims by disease group

The victims were categorized into three disease groups: drowning (T751) with 71 victims, accident (V9002 to V9479) with 28 victims, and animal (X2600 to X2689 and W5601 to W5689) with 103 victims. The mean age within the accident, drowning (excluded 11 unknown age), and animal were 37.32 years ( $\pm 14.67$  years), 35.89 years ( $\pm 18.25$  years), and 31.67 years ( $\pm 15.55$  years), respectively.

### Drowning group

All 71 victims were diagnosed with drowning in the sea. The majority of them were Thai nationals (43.66%) and men (64.79%). Among 60 victims with known occupation, they were employees (51.67%), had no job (21.67%), students/housewives (13.33%), under guardianships (11.67%), and teachers (1.67%). Incidents primarily occurred during activities such as playing in the sea (35.21%), fishing (11.27%), staying in inappropriate areas (7.04%), engaging in water sports (4.23%), working in the sea (1.41%), and unidentified (40.85%). The top five incident places were Phangan island (19.72%), Chaweng in Samui island (18.31%), Bo Phut in Samui island (12.68%), Tao island in Phangan district (11.27%), and Lamai (7.04%) and Lipa Noi (7.04%) in Samui island (Figure 1). Other places were located in Samui island, including Mae Nam (2.82%), Maret (2.82%), and Taling Ngam (2.82%) (unknown 7.04%) (Figure 1).

**Table 2** Causes of injuries and fatalities among 202 victims based on International Classification of Diseases Revision 10th

Causes of injury and dead based on ICD 10th	Frequency	Percent
T751 Unspecified effects of drowning and nonfatal submersion	71	35.15%
X2688 Contact with venomous marine animals and plants other specified places while doing other types of work	14	6.93%
X2689 Contact with venomous marine animals and plants other specified places while performing unspecified activities	14	6.93%
V9019 Drowning and submersion due to accident to ship passenger during unspecified activity	11	5.45%
W5681 Contact with nonvenomous marine animal other specified places While doing leisure activities	9	4.46%
W5689 Contact with nonvenomous marine animal other specified places While performing unspecified activities	9	4.46%
X2601 Contact with venomous marine animals and plants Area of the house While doing leisure activities	9	4.46%
X2681 Contact with venomous marine animals and plants other specified places While doing leisure activities	8	3.96%
W5601 Contact with nonvenomous marine animal Area of the house While doing leisure activities	6	2.97%
W5609 Contact with nonvenomous marine animal Area of the house While performing unspecified activities	6	2.97%
Others	45	22.23%

**Accident group**

The accident group consisted of 28 victims, predominantly Thai nationals (67.86%) and males (82.14%), primarily involved in activities such as being passengers (71.43%) and engaging in water sports (10.71%), fishing (10.71%), playing in the sea (3.57%), and staying in inappropriate areas (3.57%). Incidents included shipwrecks (60.71%), slips and falls on ships (14.29%), ships colliding with individuals (7.14%), ships colliding with other ships (7.14%), falls from ships (7.14%), and ships colliding with objects (3.57%). All accident occurred in Samui district, which were Si and Ha islands (46.43%), Samui island (Chaweng 14.29%, Lamai 7.14%, Mae Nam 3.57%, and Bo Phut 3.57%) and Tan island (3.57%) (Figure 1).

**Animal group**

In the animal group, the majority of 103 victims were Thai (71.84%), men (79.61%), and employees (58.25%). The incidents included being stabbed/penetrated (69.90%), exposed to tentacles (22.33%), hold/touch (1.94%), being bitten (0.97%) and non-specified (4.85%). Common causative marine organisms included poison jellyfish (23.30%), striped sea catfish (19.42%), sea urchin (13.59%), and string ray (10.68%). Other marine animals and plants included unidentified fish (8.74%), stone fish (7.77%), cobia fish (3.88%), poison coral (1.94%), swordfish (0.97%), frog fish (0.97%), puffer fish (0.97%) and unknown (7.77%). Accident places could be identified 80.52%. Most of accidents happened in Samui district, which were Ang Thong island (27.18%) and Samui island where were Lamai (15.53%), Mae Nam (12.62%), Taling Ngam (11.65%), Maret (4.85%), Chaweng (3.88%), Na Mueang (1.94%) and Bo Phut (1.94%). One victim was reported from Phangan district (0.97%) (Figure 1).



**Figure 1:** Marine-related injuries and fatalities by disease group (drowning, accident, and animal groups) and incident place (Samui, Phangan, Ang Thong, and Toa islands)

### Factors associated with cause of injuries and fatalities

Comparison of the three disease groups (drowning, accident, and animal) revealed no statistically significant differences in occupation (Fisher's exact p-value 0.107) and mean age (Sidak p-value 0.136). Incidents within these groups were disproportionately distributed across April, March, and August, precluding a comprehensive analysis of seasonal variation due to small incidence numbers.

Factors associated with causes of injuries and fatalities were gender, nationality, outcome upon discharged from medical facilities, and treatment expense (Table 3). Statistically significant differences were observed in the proportions of men (p-value 0.054) and Thai nationals (p-value < 0.001) across the groups (Table 3). The highest and lowest percentage of men were in accident and drowning groups, respectively. The highest and lowest percentage of Thai nationals were in animal and drowning groups, respectively (Table 3). Significantly disparate outcomes upon discharge were noted, with 100% improvement in the animal group, contrasted with 56.34% and 82.14% improvement in the drowning and accident groups, respectively (p-value <0.001)

(Table 3). Median treatment expenses varied, with the animal group having the lowest median value (13.54 USD, IQR: 7.51-21.97 USD), followed by the drowning group (22.29 USD, IQR: 125.23-539.89 USD) and the accident group (56.29 USD, IQR: 30.14-77.01 USD), indicating statistically significant differences (nonparametric equality-of-median test p-value < 0.001). (Table 3).

### Discussion

This study founded the incident rates of marine related injuries and fatalities spanning the years 2016 to 2022. Incidence rates pertaining to exposure to marine animals and plants appear to be ostensibly low, attributable in part to instances of misdiagnosis and under-report. Notably, within the Thai context, diagnostic prerogatives are confined to physicians, further compounded by the limited knowledge and proficiency in diagnosing marine animal and plant envenomation [12, 15, 16, 19]. Furthermore, the lack of capacity within healthcare service laboratory facilities for toxicology testing further hampers the elucidation of accurate diagnoses in such cases. Additionally, victims of mild cases might seek assistance from drug stores, private

**Table 3:** Factors associated with marine related injuries and fatalities by disease group

Factors	Animal group (n 103)	Drowning group (n 71)	Accident group (n 28)	Total	P-value*
Gender (n 152)					0.054*
Men	82	46	23	151	
Col%	79.61%	64.79%	82.14%	74.75%	
Women	21	25	5	51	
Col%	20.39%	35.21%	17.86%	25.25%	
Nationality					< 0.001*
Thai	74	31	19	124	
Col%	71.84%	43.66%	67.86%	61.39%	
Non-Thai	29	40	9	78	
Col%	28.16%	56.34%	32.14%	38.61%	
Outcome upon discharged					<0.001**
Improved	103	40	23	166	
Col%	100.00%	56.34%	82.14%	82.18%	
Referred	0	1	1	2	
Col%	0.00%	1.41%	3.57%	0.99%	
Dead	0	30	4	34	
Col%	0.00%	42.25%	14.29%	16.83%	
Treatment Expense lower than median (exclude 11 unknown)					<0.001***
Median in USD (IQR)	13.54 (7.51-21.97)	22.29 (125.23-539.89)	56.29 (30.14-77.01)		
Yes	78	13	5	96	
Col%	75.72%	21.67%	14.29%	17.85%	
No	25	47	23	95	
Col%	25.28%	78.33%	14.29%	82.15%	

\*Chi-square test

\*\* Fisher exact test

\*\*\* Nonparametric equality-of-medians test

clinics, or traditional folk remedies, often circumventing diagnosis and recordation within the official data system. The elucidation of information pertaining to toxic animals/plants assumes paramount significance for accurate diagnoses, however, the ability of all victims to identify these entities remains circumscribed [15, 16, 19]. This phenomenon of underreporting is corroborated by similar findings in other study [8]. Drowning is further limited due to a lack of data globally on non-fatal drowning. A lack of uniform classifications for non-fatal drowning and a lack of data has hampered global estimates [3].

The current study establishes that despite Surat Thani province's status as a prominent tourist destination, the majority of victims are Thai nationals, particularly. The study ascertains that the majority of victims comprised Thai men employed in various capacities. The preponderance of incidents on Samui island can be attributed to factors such as popular beaches, entertainment complexes, business establishments, and airport locations. A notable exception is the elevated incidence of drowning on Tao island, specifically at Nang Yuan island, where two beaches are separated by a narrow sand bar that connecting an island to mainland. Another place that has similar geographic is Ma island in Phangan district where drown victims were reported. Victims may not realize variances in water depths and slopes of the beaches. Further outbreak investigations are warranted to delineate this risk factor.

The demographic composition of drowning group, characterized by a substantial proportion of foreigners, women, and non-employees (had no job, students, housewives, and under guardianships), diverges from other groups. For employee occupation, the data in the system fail to distinguish whether reported victims were tourists. Employees could be either white- or blue-collar workers. While overall post-discharge improvement rates are high, discernible variations exist among disease groups, with the drowning group exhibiting the highest case fatality rate. Water-related fatalities stand as the third leading cause of accidental death in the USA, second in the UK and Australia, with drowning being a major public health concern globally [3-5]. Treatment expenses were notably lowest in the animal group, aligning with a high improvement rate. Outcomes upon discharge might reflect severity of the incidents, particularly drowning that had the lowest improvement rate. Based on author's experiences in Thailand (Thaikruea L.), rip current lead to multiple victims because families or friends attempting rescues, which made them exposed themselves to a high level of risk. The combination of high risk and lack of ability to manage that risk means that the rescuer (non-train) is likely to drown while trying to help a victim in distress [25, 26]. This has been described as Aquatic-Victim-Instead-of-Rescued syndrome [26].

Seasonal variations, though hindered by small incidence numbers, tentatively elevated incident rates in August with the jellyfish sting season and also rainy season in the south which is potential risk for marine accident [13, 15, 19, 22]. Several marine animals have the capability to cause significant injuries and fatalities, with jellyfish stings and shark attacks being major contributors to deaths in Australia. Consequently, immediate first aid is imperative to mitigate the perilous consequences of marine injuries [16-18, 27]. April and March are in summer season in Thailand. Moreover, Thai New Year festival was about ten-day period in April, thus, more tourists took trips to the beaches and islands. Summer season and festival may attribute to high incidents of drowning and accident. This study found accident primarily occurred during activities such as being passengers and the most common incident were shipwrecks, aligning with findings in the USA [10]. However, the classification of all watercraft, including boats, long-tail boats, speed boats, and jet skis, as ships. Beyond shipwrecks, other watercraft-related accidents, such as collisions with humans or objects and falls, are noted. It is worth to further investigating for engaging in water sports and recreation. The detail of causes and risk factors are valuable information for appropriate prevention and control measures. Ship accidents are subject to investigation for various reasons and purposes including, serving as performance indicators for policymaking, supplying data for scientific research, or dealing with legal aspects to allocate blame and liability. Such incidents may also lead to disciplinary action against the officers on board and offer lessons to prevent similar events. More concern is public health purpose. Unfortunately, these important data are not available in routine system. Furthermore, it requires knowledge and skill of maritime outbreak investigation to collect these data. At least ten accidents in Thailand reported in the BBC news between 2005 and 2018 [28]. The latest two speedboat accidents in Phuket province found amphetamine from the boat drivers [29, 30]. There is no epidemiological outbreak investigation of these accidents, thus, it cannot confirm that amphetamine are the causes of both accidents. However, this finding brings the issue of law enforcement because regulation for public car driver is not the same as that of boat driver. The law of boat driver is far back to the year 1481 with a minor adjusted in 1992 by Marine Department of Ministry of Transport. In 2023, Professor Emeritus Dr. Thaikruea initiated training initiatives for teaching assistants and personnel conducted outbreak investigation in marine animal envenomation, marine-related drowning, and marine-related accidents, albeit constrained by a dearth of experts, lecturers, and budgetary. These constraints limited numbers of participants. More courses are provided in 2024. Community engagement and policy commitment play important part for successful surveillance and prevention measures [15, 20].

The study may be limited by the available data, and the findings might not be generalizable to other regions or time periods. Insufficient sample sizes in time trend attenuate the statistical power of the analysis. These limitations do not affect the important findings. All available data were retrieved and verified by maritime medicine and occupational medicine experts. The data sources, being cost-effective and accessible from medical facilities, albeit not originally designed for surveillance, prevention, and control, constitute the primary repositories of information.

## Conclusion

The study provides valuable insights into the demographics, temporal trends, and specific characteristics of marine-related incidents, including drowning, accident, and exposed to animals and plants. The emphasis on different disease groups allows for a more understanding of the diverse causes of injuries and fatalities. The identification of specific locations with higher incident rates could inform targeted surveillance and preventive measures. Factors such as gender, nationality, outcomes upon discharge, and treatment expense contribute to a comprehensive understanding of the impact of marine-related incidents. This study provides essential information for communities, healthcare professionals, policymakers, and researchers to develop surveillance and prevention measures. Further studies should be conducted to identify risk factors and causes of injuries and fatalities, underscoring the imperative need for expeditious outbreak investigation courses.

## Funding

This study did not receive any funding.

## Acknowledgment

We would like to express our appreciation to Miss Wasinee Wongin from Koh Samui hospital and staffs from Koh Phangang hospital and Koh Toa hospital for information.

## Transparency declaration

The lead author affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

## Authors Contributions

All authors contributed equally to this work.

## References

1. United Nations General Assembly. Global drowning prevention: resolution / adopted by the General Assembly. New York: United Nations (2021).
2. World Health Organization. Global report on drowning: Preventing a leading killer [Internet]. Geneva: WHO; (2014).
3. Peden AE, Isin A. Drowning in the Eastern Mediterranean region: A systematic literature review of the epidemiology, risk factors and strategies for prevention. *BMC Public Health* 22 (2022): 1477.
4. Leavy JE, Gray C, Della Bona M, D'Orazio N, Crawford G. A review of interventions for drowning prevention among adults. *J Community Health* 48 (2023): 539-56.
5. World Health Organization. Preventing drowning: An implementation guide. [Internet]. Spain: WHO (2017).
6. Claesson A, Lindqvist J, Ortenwall P, Herlitz J. Characteristics of lifesaving from drowning as reported by the Swedish Fire and Rescue Services 1996-2010. *Resuscitation* 83 (2012): 1072-7.
7. Koçak H, Altıntaş HK. Evaluation of maritime accident reports of main search and rescue coordination centre between 2001 and 2012. *Int Marit Health* 72 (2021): 163-71.
8. Willcox-Pidgeon S, Peden AE, Franklin RC, Scarr J. Boating-related drowning in Australia: Epidemiology, risk factors and the regulatory environment. *J Safety Res* 70 (2019): 117-25.
9. Hornbeak KB, Auerbach PS. Marine envenomation. *Emerg Med Clin North Am* 35 (2017): 321-37.
10. Suwannahong S, Inmor S. Marine tourism behavior and tourists' risk. *International Journal of Applied Computer Technology and Information Systems* 9 (2020): 46-50.
11. Taylor DM, Ashby K, Winkel KD. An analysis of marine animal injuries presenting to emergency departments in Victoria, Australia. *Wilderness Environ Med* 13 (2002): 106-12.
12. Thaikruea L. Irukandji-like syndrome caused by single-tentacle box jellyfish found in Thailand, 2007–2019. *Int Marit Health* 7 (2020): 91-6.
13. Thaikruea L, Siriarayapon P. Situation of injuries and deaths. In: *Injuries and Deaths Caused by Toxic Jellyfish: Surveillance, Prevention, and Treatment*. Chiang Mai: Faculty of Medicine of Chiang Mai University (2018): 29-84.
14. Thaikruea L, Siriariyaporn P. Severe dermatonecrotic toxin and wound complications associated with box jellyfish stings 2008-2013. *J Wound Ostomy Continence Nurs* 42 (2015): 599-604.
15. Thaikruea L. A Decade of Fighting Box Jellyfish Health Issues. In: *Civic Engagement in Asia Transformative Learning for a Sustainable Future*. Indrawan M, Luzar J,

- Hanna H and Mayer T (Eds) Springer Nature Singapore Pte Ltd. Singapore. November (2022): 129-144.
16. Thaikruea L. The Dermatological Effects of Box Jellyfish Envenomation in Stinging Victims in Thailand: Underestimated Severity. *Wilderness & Environmental Medicine* 34 (2023): 462-472.
  17. Thaikruea L, Siriarayapon P. First aid and treatment. In: *Injuries and Deaths Caused by Toxic Jellyfish: Surveillance, Prevention, and Treatment*. Chiang Mai: Faculty of Medicine of Chiang Mai University (2018): 115-156.
  18. Thaikruea L, Siriarayapon P, Pruedthiphap M, et al. Clinical Practice Guideline of Jellyfish envenomation, especially box jellyfish envenomation. *Royal Thai Navy Medical Journal* 47 (2020): 518-524.
  19. Thaikruea L Differences in clinical manifestations between cases stung by single-tentacle and multiple-tentacle box jellyfish over two decades. *Heliyon* 9 (2023): e16374.
  20. Thaikruea L, Siriarayapon P. Surveillance system and prevention for injuries and deaths. In: *Injuries and Deaths Caused by Toxic Jellyfish: Surveillance, Prevention, and Treatment*. Chiang Mai: Faculty of Medicine of Chiang Mai University (2018): 177-240.
  21. Thaikruea L, Santidherakul S. The public health impact of a new simple practical technique for collection and transfer of toxic jellyfish specimens and for nematocyst identification. *Journal of Public Health Policy* 39 (2018): 143-155.
  22. Thaikruea L, Siriarayaporn P. The magnitude of severe box jellyfish cases on Koh Samui and Koh Pha-ngan in the Gulf of Thailand. *BMC Res Notes* 9 (2016): 108.
  23. Niyomsilpa S, Thianlai K. The tragic boat accident in Phuket: Thai tourism lessons. In Chamchan C, Kanchanachitra M, Podhisita C, Samutachak B, Niyomsilpa S, ed. *Thai Health 2019: Online social media a double-edged sword Thai health in the context of a socially-connected world [e-book]*. Nakorn Pathom (Thailand): Institute for Population and Social Research, Mahidol University Publications. (2019): 77-80.
  24. Stoop JA. Maritime accident investigation methodologies. *Inj Control Saf Promot* 10 (2003): 237-42.
  25. Claesson A, Lindqvist J, Ortenwall P, et al. Characteristics of lifesaving from drowning as reported by the Swedish Fire and Rescue Services 1996-2010. *Resuscitation* 83 (2012): 1072-7.
  26. Leavy JE, Gray C, Della Bona M, et al. A Review of Interventions for Drowning Prevention Among Adults. *Journal of Community Health* 48 (2023): 539-556.
  27. Thaikruea L, Siriarayaporn P, Wutthanarungsan R, et al. Review of Fatal and Severe Cases of Box Jellyfish Envenomation in Thailand. *Asia-Pacific Journal of Public Health* 27 (2015): NP1639-51.
  28. BBC News, Phuket Shipwreck: A Recurring Water Tragedy (2018).
  29. Matichon Online. Speedboat crashed into the rocks of Maiton Island; Amphetamine found in captain (2024).
  30. Thai PBS. Phuket-Phi Phi speedboat hits a navigation signal towers in the middle of the sea, more than 30 people were injured. (2023).