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Epidemiological and clinical characteristics of seawater drowning cases in Sinop, a Turkish coastal city: a 13-year retrospective study

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Abstract

Background Drowning is a significant public health issue, particularly in coastal regions such as Sinop, Turkey, where seasonal variations contribute to a high incidence of cases. However, there is a lack of long-term, population-based studies from the Black Sea region, where distinct environmental factors may influence drowning patterns. This study provides a comprehensive 13-year analysis of seawater drowning cases, including detailed demographic, clinical, and outcome characteristics, to inform prevention strategies and improve emergency response.

Methods A retrospective, observational study was conducted on all patients admitted to the regional referral Emergency Department (ED) due to seawater drowning between July 2011 and July 2024. Demographic characteristics, clinical parameters, and outcomes were retrieved from institutional and national health record systems. Descriptive statistical analyses were performed.

Results A total of 198 patients were included, of whom 69.2% were male, with a mean age of 29.6 years. The majority of cases (over 82%) occurred in July and August, and 51% involved tourists. Cardiopulmonary resuscitation (CPR) was performed in 17.7% of patients. Trauma was documented in 7.1% of patients; among these, the most commonly affected regions were the extremities (50.0%) and the head (35.7%). Laboratory analysis showed elevated lactate levels and reduced pH. On admission, most patients had preserved neurological status, while 19.2% presented with severe impairment (GCS ≤8). According to the Szpilman score, 37.9% had mild and 17.7% severe symptoms. The overall mortality was 19.7%, and 22.2% of patients required admission to the intensive care unit (ICU). Notably, 35.9% of all fatal cases ($n = 14$) involved individuals who drowned while attempting to rescue others.

Conclusions Drowning imposes a substantial burden in coastal regions, disproportionately affecting young males during the summer. Our findings highlight the need for enhanced emergency preparedness and structured clinical response, as well as public education on water safety and safe rescue practices. These findings contribute valuable insight for developing regional and international strategies to mitigate drowning outcomes.

Trial registration Not applicable. This study is a retrospective observational analysis and was not registered as a clinical trial.

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Background

Drowning is a leading global public health concern, accounting for approximately 300.000 deaths annually and ranking as one of the most common cause of unintentional injury-related mortality worldwide [1]. Despite notable advances in emergency medicine, coastal communities remain disproportionately affected. Vulnerable populations include children, adolescents, and young adults—particularly males—due to their increased exposure to high-risk aquatic behaviors [2].

In Turkey, drowning represents an escalating public health challenge, with nearly 900 annual deaths reported [3, 4]. The country's extensive coastline and pronounced seasonal variation significantly contribute to the incidence, particularly during summer months [5]. Nevertheless, regionally disaggregated data remain scarce, limiting the capacity for localized prevention and intervention.

Sinop, a coastal province on the Black Sea shoreline of Turkey, exemplifies this concern. Its popularity as a tourist destination coincides with a significant frequency of seawater drowning incidents [6]. Understanding the epidemiological and clinical features of such cases is essential for designing effective, region-specific preventive strategies and optimizing emergency response systems [7, 8].

Although several studies on drowning have been conducted in Turkey, most were short-term, restricted to pediatric populations, or not specific to seawater drowning [4, 5, 9–11]. In particular, there is a lack of long-term epidemiological analyses from the Black Sea region, where environmental factors such as rocky coastlines and rip currents may influence drowning patterns and outcomes [12].

This study adheres to the drowning definitions and data reporting recommendations outlined in both the World Health Organization guidelines and the Utstein-style consensus [13, 14]. In accordance with these standards, we classify drowning cases as 'fatal' or 'non-fatal' and present a range of standardized data variables—including demographic, prehospital, clinical, and outcome parameters—thereby ensuring methodological consistency and facilitating comparability with international studies.

Therefore, this study presents a comprehensive 13-year retrospective analysis of seawater drowning cases in Sinop. To our knowledge, this constitutes one of the most extensive long-term datasets in both national and regional contexts. Moreover, the findings may serve as an important reference for designing drowning prevention strategies in other coastal settings with comparable environmental and demographic challenges.

Methods

Study design, setting, and ethical considerations

This retrospective, observational study was conducted at a regional referral ED and included all patients admitted for seawater drowning between July 2011 and July 2024. All cases recorded as seawater drowning were included regardless of data completeness, without applying any sampling or exclusion criteria based on missing variables. This approach ensured a full-case census over the 13-year period, maximizing representativeness. Ethical approval was obtained from the Human Research Ethics Committee of Sinop University (Approval No: 2024/244), and all procedures were conducted in accordance with the Declaration of Helsinki. Due to the retrospective nature of the study and the use of anonymized data, the requirement for informed consent was waived.

The primary objective of this study was to comprehensively present the demographic, clinical, and outcome-related characteristics of seawater drowning cases in Sinop, a Turkish coastal region, using available institutional and national registry data. In line with this objective, all relevant patient-level variables were systematically reported in accordance with STROBE guidelines. The secondary aim was to highlight contextual factors related to prehospital response, in-hospital emergency care, and seasonal patterns, with the intent to inform future prevention strategies and emergency preparedness.

To limit selection bias, all seawater drowning cases in both the institutional Hospital Information Management System (HIMS) and the Turkish National Personal Health Record System (e-Nabız) were included. Dual-source verification and independent double data-entry were used to ensure internal consistency and reduce information bias.

In the study setting, patients were managed within Turkey's publicly funded, physician-supervised Emergency Medical Services (EMS) system. Ambulances were equipped with Advanced Life Support (ALS) capabilities and staffed by paramedics and emergency medical technicians (EMTs). While physicians supervised operations remotely, they were not physically present at the scene. In urban and coastal areas such as Sinop, EMS response times typically remained under 10 minutes.

For patients transferred to external centres, some long-term outcomes and clinical or laboratory values could not be fully retrieved from e-Nabız. Missing variables were retained in the dataset and coded as "no data," with no imputation applied to preserve the integrity of the records and avoid analytic bias. Missing entries were clearly indicated in all tables, and all data were anonymised and securely stored in accordance with institutional and national standards.

Study population and data collection

The study included patients who presented to the ED with a confirmed diagnosis of seawater drowning between July 2011 and July 2024. Data were extracted using a standardized form that incorporated demographic variables (age, sex, residency status), comorbidities (e.g., diabetes, hypertension, coronary artery disease), and incident-related characteristics.

Presence of trauma and anatomical localization (head, cervical, thoracic, lumbar, and extremities) were recorded. Seasonal and monthly distributions of cases, as well as rescuer drowning, were documented. Drowning outcomes were classified as fatal or non-fatal based on ED records and follow-up data.

Prehospital and in-hospital resuscitation efforts—including CPR administration (by EMS or in the ED), response durations, and intubation status—were collected. ED disposition data included discharge status, ward or ICU admission, inter-facility transfers, and in-ED mortality.

Radiological imaging findings (PA chest radiograph, thoracic CT, brain CT, and brain MRI) were reviewed to identify pulmonary or neurological lesions. Laboratory parameters included arterial blood gas results (pH, pCO_2, pO_2, HCO_3^-, SO_2), serum lactate, hematologic indices (WBC, hemoglobin, hematocrit), renal (urea, creatinine) and hepatic markers (AST, ALT, LDH), cardiac enzymes (troponin, CK-MB, CK), serum electrolytes (Na^+, Cl^-, K^+), and ethanol levels when available.

Neurological status and clinical severity were assessed on admission using the Glasgow Coma Scale (GCS) and Szpilman score.

Statistical analysis

All statistical analyses were conducted using SPSS software (version 25.0, IBM Corp., Armonk, NY). The distribution of continuous variables was assessed using the Shapiro–Wilk test for sample sizes < 50 or the Kolmogorov–Smirnov test for sample sizes ≥50, alongside visual methods such as Q–Q plots and histograms.

Descriptive statistics were used to summarize the data. Normally distributed variables are presented as mean ± standard deviation (SD), while non-normally distributed variables are reported as median and interquartile range (IQR). Categorical variables are summarized as counts and percentages. Missing data were not imputed; instead, missing entries were explicitly coded as "no data" and retained in the dataset. Subgroup comparisons were performed using the Mann–Whitney U test. Since all eligible drowning cases over a 13-year period were included, no sampling strategy or weighting was applied.

Results

Patient demographics and baseline characteristics

A total of 198 patients were included in the final analysis, representing the entire eligible cohort. Long-term outcome data were unavailable for some patients transferred to external hospitals, as discharge information was not consistently recorded in national databases.

The mean age of the patients was 29.63 ± 19.27 years, with a median of 24.93 years (range: 1.9–77.4). The majority were male (69.2%, $n = 137$), while females comprised 30.8% ($n = 61$). In terms of age distribution, 60.1% of patients were aged 18–64 years, 33.3% were aged ≤17 years, and 6.6% were aged ≥65 years (Table 1).

Residency status was recorded in 91.4% of cases; 51.0% were tourists and 40.4% were local residents. Comorbidity data were available for 185 patients (93.4%). The most common pre-existing comorbidities included physical disability (8.1%), hypertension (5.1%), and psychological disorder (4%), and coronary artery disease (4%) (Table 1).

Trauma was documented in 7.1% of patients ($n = 14$), while 85.4% had no trauma and 7.6% lacked documentation. Among trauma cases, the most frequently affected regions were the extremities (50.0%), head (35.7%), and thorax (28.6%) (Table 1).

Event profile, acute management and overall clinical outcomes

In terms of event characteristics, non-fatal drowning accounted for 73.7% ($n = 146$) and fatal drowning for 19.7% ($n = 39$). Outcome could not be ascertained in 6.6% ($n = 13$) of patients; all had been transferred to external centers.

Rescuer drowning, defined as fatal submersion during an attempted rescue of another person, occurred in 14 cases (7.0%). In contrast, most cases (85.4%) did not involve a rescue attempt, and in 7.6% rescuer involvement was not documented. A pronounced seasonal pattern was evident: July (42.4%) and August (40.4%) together accounted for 82.8% of all incidents, followed by September (6.6%), June (4.5%), and May (3.0%). Approximately 1% of cases occurred in March, October, or November, respectively (Table 2).

CPR was administered in 35 patients (17.7%), including 30 (15.2%) who received CPR by EMS before ED arrival and 5 (2.5%) who were first resuscitated in the ED. The majority (75.3%) did not receive CPR, and documentation was missing in 7.0% of cases.

Endotracheal intubation was performed in 39 patients (19.7%) in the ED, while EMS initiated intubation in two patients (1.0%), both of whom were subsequently re-intubated on ED arrival. Most patients (73.7%) were not intubated, and data were unavailable for 6.6% of cases (Table 3).

Table 1 Demographics, comorbidities, and trauma profiles of patients

Variable	n	%/Value
Sex		
Male	137	69.2
Female	61	30.8
Age Group		
≤17	66	33.33
18–64	119	60.10
≥65	13	6.57
Overall age (years)	Mean ± SD: 29.63 ± 19.27; Median (Min–Max): 24.93 (1.9–77.4)	
Residency		
Local	80	40.4
Tourist	101	51.0
No data	17	8.6
Comorbidities*		
Diabetes	7	3.5
Hypertension	10	5.1
Cerebrovascular disease	2	1.0
Coronary artery disease	8	4.0
Chronic obstructive pulmonary disease	7	3.5
Intellectual disability	1	0.5
Physical disability	16	8.1
Psychological disorder	8	4.0
Others	13	6.6
No data	13	6.6
Presence of Trauma		
None	169	85.4
Yes	14	7.1
No data	15	7.6
Trauma Location (n = 14)**		
Head	5	35.7
Cervical	1	7.1
Thoracic	4	28.6
Lumbar	2	14.3
Extremity	7	50

Categorical variables are presented as number (n) and percentage (%) based on a total of 198 patients, unless otherwise indicated. Continuous variables are shown as mean ± standard deviation (SD) or median (min–max), depending on distribution. Data distribution was assessed using the Shapiro–Wilk or Kolmogorov–Smirnov test. *Comorbidity data were missing for 13 patients (6.6%). Accordingly, comorbidity percentages were calculated based on the 185 patients with complete records.** Percentages for trauma locations refer to the subgroup with documented trauma ($n = 14$), and multiple trauma sites per patient were allowed. “No data” indicates missing documentation in the medical records

Overall, 22.2% of patients were admitted to an intensive-care unit, 18.2% to an inpatient ward, and 10.1% were transferred to external ICUs. The in-hospital mortality rate, including deaths in the ED and during subsequent hospitalization, was 19.7%. A total of 37.4% were discharged directly from the ED, while outcome data were missing for 5.1% of cases. Among patients with available follow-up, 73.7% survived to hospital discharge (Table 3).

Table 2 Clinical outcomes, rescuer involvement, and seasonal distribution of cases

Variable	n	%
Drowning Outcome		
Non-fatal Drowning	146	73.7
Fatal Drowning	39	19.7
No data	13	6.6
Rescuer Drowning		
No	169	85.4
Yes	14	7.0
No data	15	7.6
Month		
September	13	6.6
October	2	1.0
November	2	1.0
March	2	1.0
May	6	3.0
June	9	4.5
July	84	42.4
August	80	40.4

Drowning outcomes are classified as non-fatal (survivors) and fatal (deaths). Categorical variables are presented as number (n) and percentage (%) based on a total cohort of 198 patients. “No data” indicates missing documentation in the medical records

Table 3 Resuscitation status and emergency outcome of patients

Resuscitation	n	%
CPR		
No CPR	149	75.3
CPR performed	35	17.7
• Initiated by EMS and continued in ED	30	15.2
• Initiated by ED	5	2.5
No data	14	7
Response to CPR (among 35 patients)		
No response	13	37.1
5 min	2	5.7
10 min	6	17.1
13 min	1	2.9
> 15 min	13	37.1
Intubation		
Not intubated	146	73.7
Emergency Medical Service	2	1
Emergency Department	39*	19.7
No data	13	6.6
Emergency Room Outcome		
Discharged uneventfully	74	37.4
Ward admission	36	18.2
ICU admission	44	22.2
External ICU Transfer	20	10.1
Emergency Department Mortality	14	7.1
No data	10	5.1

CPR: cardiopulmonary resuscitation, ICU: intensive care unit *2 patients intubated in Emergency Medical Service were also re-intubated in the emergency room. “No data” indicates missing documentation in the medical records

Laboratory and imaging findings on admission

Laboratory evaluation demonstrated marked metabolic abnormalities. Arterial pH ($n=173$) averaged 7.16 ± 0.29, with lactate levels ($n=104$) of 8.60 ± 6.95 mmol/L. Partial pressure of carbon dioxide (pCO_2, $n=173$) was 51.45 ± 32.27 mmHg. Arterial oxygen saturation (SaO_2, $n=168$) measured 65.81 ± 27.62%, whereas peripheral oxygen saturation (SpO_2, $n=134$) was higher at 81.48 ± 30.63%. Electrolytes remained largely within reference limits: sodium (Na, $n=174$) 142.57 ± 5.62 mmol/L and potassium (K, $n=173$) 4.53 ± 1.23 mmol/L.

Cardiac and tissue injury markers showed wide variability: AST ($n=173$) 65.86 ± 202.22 U/L, ALT ($n=173$) 62.66 ± 230.83 U/L, troponin ($n=117$) 16.73 ± 67.88 ng/L, and creatine kinase ($n=165$) 425.41 ± 2484.42 U/L. Blood ethanol was assessed in a limited subgroup ($n=10$), with a mean concentration of 167.34 ± 98.33 mg/dL (Table 4A).

Radiological imaging demonstrated substantial pulmonary and neurological involvement. Thoracic computed tomography (CT) was obtained in 63 patients, showing abnormalities in 77.8%. PA chest radiography was available in 84 patients, with pathological findings identified in 29.8%. Cranial CT was performed in 25 patients, revealing abnormalities in 16.0%. Brain MRI was carried out in two patients and demonstrated acute hypoxic–ischemic injury in one case (Table 4B).

Neurological status on admission

On presentation, 72.7% of patients ($n=144$) had a GCS of 13–15, indicating mild or no neurological impairment. Severe impairment (GCS 3–8) was noted in 19.2%

Table 4 Laboratory parameters and radiological imaging findings of drowning patients

A. Laboratory Parameters

Test	n	Mean±SD	Median (Min-Max)	Reference Range
pH	173	7.16 ± 0.29	7.27 (6.04–7.54)	7.35–7.45
pCO_2 (mmHg)	173	51.45 ± 32.27	40.9 (12.9–199.8)	35 - 45
pO_2 (mmHg)	173	55.86 ± 40.48	44.1 (2.5–294)	80–100
HCO_3 (mmol/L)	173	17.17 ± 5.90	18.5 (3.6–28.2)	22–26
SaO_2 (%)	168	65.81 ± 27.62	71.3 (0–99.8)	95–100
SpO_2 (%)	134	81.48 ± 30.63	96 (0–100)	95–100
CO (%)	134	1.53 ± 1.98	0.7 (0–10)	< 1.5
Lactate (mmol/L)	104	8.60 ± 6.95	6.33 (0.9–27.84)	0.5–2.2
WBC (10^3/μL)	171	12.46 ± 13.60	10.8 (3.53–180.8)	4.0–10.0
Hemoglobin (g/dL)	171	14.41 ± 1.88	14.7 (9.3–18.2)	13.0–17.5 (M)/12.0–15.5 (F)
Hematocrit (%)	171	42.98 ± 5.93	43.2 (29.3–57)	38–50 (M)/34–46 (F)
Urea (mg dL^{-1})	173	29.11 ± 9.18	28 (10–70)	10–50
Creatinine (mg dL^{-1})	173	0.93 ± 0.30	0.88 (0.36–1.9)	0.6–1.2
AST (U L^{-1})	173	65.86 ± 202.22	27 (13–2431)	5–40
ALT (U L^{-1})	173	62.66 ± 230.83	21 (5–2756)	5–41
LDH (U L^{-1})	169	365.99 ± 310.91	291 (131–3356)	125–220
Troponin (ng L^{-1})	117	16.73 ± 67.88	2.5 (0–684)	< 15
CK-MB (ng mL^{-1})	124	1.96 ± 1.71	1.55 (0–9.89)	< 5
CK (U L^{-1})	165	425.41 ± 2484.42	167 (44– 31,800)	20–200 (F)/20–400 (M)
Na (mmol L^{-1})	174	142.57 ± 5.62	141 (125–164)	135–145
Cl (mmol L^{-1})	174	108.98 ± 3.81	108 (100–119)	98–106
K (mmol L^{-1})	173	4.53 ± 1.23	4.2 (2.9–12.01)	3.5–5.5
Etanol (mg dL^{-1})	10	167.34 ± 98.33	181 (10–315)	0

B. Radiological Imaging Findings

Imaging Modality	Performed (n)	Pathological Findings Detected (n)	% with Lesion
PA Chest X-ray	84	25	29.8
Thorax CT	63	49	77.8
Brain CT	25	4	16.0
Brain MRI	2	1	50.0

Laboratory values are reported as mean ± standard deviation (SD) and/or median (minimum–maximum), depending on data distribution. Normality was assessed using the Shapiro–Wilk or Kolmogorov–Smirnov test. Reference ranges reflect standard adult laboratory values. "Pathological findings" refer to radiologically confirmed abnormalities judged by physicians to be attributable to drowning-related complications. Abbreviations: pCO_2 – partial pressure of carbon dioxide; pO_2 – partial pressure of oxygen; HCO_3^- – bicarbonate; SaO_2 – arterial oxygen saturation; SpO_2 – peripheral oxygen saturation; CO – carboxyhemoglobin; WBC – white blood cell count; AST – aspartate aminotransferase; ALT – alanine aminotransferase; LDH – lactate dehydrogenase; CK – creatine kinase; CK-MB – creatine kinase MB isoenzyme; Na^+ – sodium; Cl^- – chloride; K^+ – potassium; PA – posteroanterior; CT – computed tomography; MRI – magnetic resonance imaging

Table 5 Distribution of Glasgow coma scale and szpilman scores among patients

Clinical Scale	n	%
Glasgow Coma Score		
3–8	38	19.2
9–12	3	1.5
13–15	144	72.7
No data	13	6.6
Szpilman Score		
0	4	2
1	75	37.9
2	39	19.7
3	25	12.6
4	4	2
5	35	17.7
No data	16	8.1

The Glasgow Coma Scale (GCS) and Szpilman scores were evaluated upon admission. Scores are reported as number (n) and percentage (%), based on the total study cohort ($N = 198$). "No data" indicates missing documentation of the corresponding score in the patient records

Table 6 Outcome-related prognostic factors between survivors and non-survivors

	n	Survivors Me (Q1–Q3)	n	Non-survivors Me (Q1–Q3)	*p
GCS	145	15 (15–15)	38	3 (3–3)	< 0.001
Szpilman score	142	1 (1–2)	38	5 (5–6)	< 0.001
pH	138	7.31 (7.21–7.37)	33	6.66 (6.51–6.85)	< 0.001
SpO_2 (%)	106	97 (95–98)	26	20 (0–40)	< 0.001
pCO_2 (mmHg)	138	38.75 (33–44.8)	33	98.3 (66.5–132.7)	< 0.001
HCO_3 (mmol/L)	138	19.55 (14.4–22.6)	33	11.7 (8.3–14)	< 0.001
Lactate (mmol/L)	88	4.67 (2.6–9.67)	16	17.71 (13.94–23.5)	< 0.001
Na (mmol/L)	139	141 (139–142)	34	151 (148–153)	< 0.001

Values are expressed as median (interquartile range). All *p* values were calculated using the Mann–Whitney U test. Abbreviations: GCS, Glasgow Coma Scale; SpO_2, peripheral oxygen saturation; pCO_2, partial pressure of carbon dioxide; HCO_3, bicarbonate; Na, sodium

($n = 38$), and moderate impairment (GCS 9–12) in 1.5% ($n = 3$). GCS data were unavailable for 6.6% ($n = 13$) of the cohort (Table 5).

The Szpilman score, which grades drowning-related respiratory and neurological compromise, was also documented. The most frequent category was score 1 (37.9%, $n = 75$), followed by score 2 (19.7%, $n = 39$) and score 5 (17.7%, $n = 35$), reflecting a wide spectrum of severity. Less common presentations included score 3 (12.6%, $n = 25$), while scores 0 and 4 were each reported in 2.0% ($n = 4$). Documentation was missing for 8.1% ($n = 16$) of cases (Table 5).

Outcome-related prognostic factors

Comparison of survivors and non-survivors revealed significant differences in admission clinical and laboratory parameters (Table 6). Median GCS and Szpilman scores were substantially lower among non-survivors ($p < 0.001$). Non-survivors also presented with lower pH, SpO_2, and bicarbonate levels, together with higher pCO_2, lactate, and serum sodium concentrations (all $p < 0.001$). Because of missing data, the number of patients analyzed for each parameter varied slightly, as indicated in Table 6.

Discussion

The present study highlights the significant public health burden of drowning in coastal Turkey while providing novel region-specific insights from a 13-year dataset. Beyond confirming established risk factors—such as male predominance, young adult involvement, and marked summer seasonality [4, 5, 9–11]—our analysis identifies two critical issues with direct public health and clinical relevance: the high rate of rescuer drownings (35.9% of fatalities) and gaps in prehospital airway management. These findings should also be interpreted within the broader geographical context of the Black Sea region, where rocky coastlines and strong rip currents may further exacerbate drowning risks [12].

In our cohort, seasonal clustering of drowning cases was evident, with over 82% occurring in July and August, likely reflecting the combined effects of increased beach attendance, favorable weather, and seasonal tourism. Notably, 51% of the cases involved tourists, further emphasizing the impact of transient populations on drowning risk in Sinop. This seasonal pattern is consistent with national and regional data from Turkey, where previous studies have shown a summer peak in drowning incidents [4, 5, 9–11]. While the seasonal distribution appears to follow the nationwide trend, Sinop's Black Sea coastline is characterized by rocky shores and strong rip currents [12], suggesting that the underlying environmental mechanisms may differ from those in the Aegean, Marmara, or Mediterranean regions. These findings underscore the need for targeted, time-specific prevention strategies, with a particular focus on tourist populations during high-risk summer months.

The overall mortality rate of 19.7% in our cohort is consistent with findings from previous meta-analysis [15]. Although no inferential statistical analyses were performed, the relatively lower rates of prehospital and in-hospital intubation observed in our cohort, when compared to international reports, may warrant further evaluation of airway management protocols and training practices in similar regional settings. Considering that timely intubation is often critical for survival in severe drowning cases, efforts to strengthen prehospital and emergency airway management capabilities appear warranted [16, 17].

In our cohort, significant metabolic derangements and neurological deterioration were common on admission. When survivors and non-survivors were compared, non-survivors had markedly lower GCS and higher Szpilman scores, as well as more severe metabolic abnormalities, including lower SpO_2 and bicarbonate, and higher lactate, pCO_2, and serum sodium levels. These findings are consistent with previous reports in the literature, where early neurological status and metabolic acidosis have been identified as strong predictors of drowning-related mortality [15–18]. Furthermore, these prognostic indicators highlight the importance of rapid clinical and laboratory assessments in guiding early decision-making and triage in drowning cases [18].

The presence of trauma in patients presenting to the ED with drowning is known to contribute to worse clinical outcomes, particularly in open-water settings or high-impact environments [17, 19]. It is generally associated with an increased risk of injury-related complications during submersion events [20]. In our cohort, trauma was documented in 7.1% of cases, most frequently involving the extremities and head regions. This prevalence appears slightly higher than those reported in previous studies, which noted trauma rates of approximately 4.9% in pediatric and adolescent populations [21] and 4.7% in mixed-age cohorts [22]. Notably, in these prior studies, traumatic injuries were primarily linked to diving incidents or high-risk aquatic sports—activities that are uncommon in Sinop. Instead, the relatively elevated trauma rate observed in our setting may be attributable to the region's rocky coastal topography, which may increase the risk of injury during water entry or untrained rescue attempts [12].

Although a substantial proportion of the study cohort comprised pediatric patients (≤17 years old, 33.3%), the absence of long-term follow-up data limits our ability to evaluate neurological sequelae in this vulnerable subgroup. Prior research has consistently highlighted the importance of structured rehabilitation and ongoing neurocognitive monitoring in pediatric drowning survivors [23, 24]. Accordingly, future prospective studies should prioritize the assessment of long-term functional and cognitive outcomes in children, who may be particularly susceptible to hypoxic–ischemic injury and its developmental consequences.

Rescuer drowning, observed in 7.1% of all cases in our cohort, underscores the need for public education not only in personal water safety but also in safe bystander rescue techniques. Notably, 35.9% ($n = 14$) of all fatal drowning cases involved individuals who drowned while attempting to rescue others, highlighting a substantial yet often underrecognized contributor to drowning-related mortality. A media-based review of drowning rescue incidents in China similarly reported a 13% fatality rate among rescuers, though calculated within the context of rescue attempts themselves [25]. Taken together, these findings emphasize that rescuer drowning is a globally relevant but underappreciated problem requiring urgent attention.

Addressing this challenge requires both community-level and institutional strategies. Public education on safe rescue practices, structured swimming training, and broad water safety campaigns are essential to reduce preventable deaths. At the same time, enhancing the training of EMS and ED personnel in early recognition, resuscitation, and effective airway management is critical to strengthen clinical preparedness for severe drowning cases.

Beyond these general implications, our findings have informed practical steps. Recognizing the high proportion of rescuer drownings, we have collaborated with local authorities to promote public awareness campaigns and to place accessible rescue equipment (e.g., lifebuoys, ropes) at frequently used beaches. Additionally, given that more than half of the cases in our cohort involved tourists, we have recommended seasonal reinforcement of lifeguard systems during peak summer months. These interventions are tailored to the local context of Sinop but may also serve as a framework for other coastal hospitals and health systems facing similar challenges.

In conclusion, this 13-year retrospective study offers one of the most comprehensive regional profiles of seawater drowning in Turkey's Black Sea coast. Despite the inherent limitations of a retrospective, single-center design, the systematic reporting of demographic, clinical, and outcome data provides valuable insights for both clinical practice and public health. Reducing the drowning burden will require collaboration with local authorities, public awareness initiatives, strengthened EMS and ED training, and future multicenter studies to inform evidence-based prevention.

Conclusion

This 13-year retrospective study provides a comprehensive profile of seawater drowning cases from Turkey's Black Sea coast, offering region-specific insights that have been largely absent from the literature. Drowning imposes a substantial burden in coastal settings, disproportionately affecting young males during the summer. Notably, rescuer drownings accounted for 35.9% of all fatal cases, highlighting a critical but often underrecognized contributor to drowning-related mortality. These findings underscore the urgent need for enhanced emergency preparedness, structured clinical response pathways, and public education campaigns on water safety and safe rescue practices. Future studies should address long-term neurological outcomes, particularly in children, and expand to multicenter designs to guide evidence-based interventions and reduce preventable drowning outcomes.

Limitations

This study has several limitations. Its retrospective, single-center design was associated with missing or incomplete data, particularly for patients transferred to external centers, where outcomes could not always be retrieved. Although missing data were explicitly coded as "no data," this remains a limitation of the dataset. The single-center setting also restricts generalizability, as findings may not apply to regions with different aquatic environments, tourism dynamics, or healthcare systems. Furthermore, the focus on seawater drownings limits extrapolation to freshwater contexts. The absence of long-term follow-up, especially in pediatric patients, precludes assessment of neurological sequelae. Finally, small subgroup sizes (e.g., trauma, pediatrics) reduce the strength of subgroup analyses. Future multicenter, prospective studies with standardized reporting frameworks are warranted to validate and expand upon these findings.

Abbreviations

ALS	Advanced Life Support
ALT	Alanine Aminotransferase
AST	Aspartate Aminotransferase
CK	Creatine Kinase
CK-MB	Creatine Kinase-MB Isoenzyme
CPR	Cardiopulmonary Resuscitation
CT	Computed Tomography
ED	Emergency Department
EMS	Emergency Medical Services
GCS	Glasgow Coma Scale
HIMS	Hospital Information Management System
ICU	Intensive Care Unit
LAC	Lactate
LDH	Lactate Dehydrogenase
MRI	Magnetic Resonance Imaging
PA	Posteroanterior (chest radiograph)
pCO_2	Partial Pressure of Carbon Dioxide
pO_2	Partial Pressure of Oxygen
SaO_2	Arterial Oxygen Saturation
SpO_2	Peripheral Oxygen Saturation
WBC	White Blood Cell Count

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Data availability
The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
This study was approved by the Sinop University Local Ethics Committee (Approval No: 2024/244). Due to the retrospective nature of the study and the use of anonymized data, the requirement for informed consent was waived.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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