

FACTORS ASSOCIATED WITH MARITIME TRAFFIC ACCIDENTS IN ÉQUATEUR PROVINCE (DRC) IN 2025: A MIXED CASE-CONTROL STUDY

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ABSTRACT

Background: Maritime traffic accidents constitute a major public health problem in the Democratic Republic of Congo, particularly in Équateur Province where river transport is predominant. This study aimed to analyze the factors associated with maritime traffic accidents that occurred in 2025 within the jurisdiction of the Provincial Health Directorate of Équateur.

Methods: A mixed cross-sectional study was conducted, combining a case-control survey (190 cases, 190 controls) and qualitative interviews with 18 key informants. Quantitative data were analyzed using binary logistic regression, and qualitative data were analyzed using thematic content analysis.

Results: Factors independently associated with accidents were overloading (adjusted OR = 4.82; 95% CI: 2.98-7.80), absence of life jackets (OR = 3.56; 95% CI: 2.12-5.98), alcohol consumption by the boat operator (OR = 4.21; 95% CI: 2.36-7.52), operator inexperience (OR =

2.98; 95% CI: 1.69-5.26), night navigation (OR = 2.76; 95% CI: 1.62-4.70), adverse weather conditions (heavy rain: OR = 8.94; 95% CI: 4.62-17.29) and hazardous waterways (OR = 5.21; 95% CI: 2.71-10.02). More than half of the victims (51.6%) took over two hours to access care. Qualitative findings revealed the influence of economic pressure, lack of enforcement, and inadequate organized rescue services.

Conclusion: Maritime accidents in Équateur are multifactorial. An integrated approach combining stricter regulation, operator training, safety equipment, and improved emergency response is essential to reduce preventable morbidity and mortality.

Keywords: *maritime traffic accidents, associated factors, public health, waterway safety, Équateur, DRC.*

INTRODUCTION

The problem of transport accidents occupies a growing place in the field of public health, due to their considerable impact on morbidity, mortality, and healthcare systems worldwide (World Health Organization, 2018). While road traffic accidents have received sustained attention over recent decades, the issue of waterway and maritime transport safety, particularly in low- and middle-income countries, remains a blind spot in research and health policies (Bhattacharya, 2019).

In the Democratic Republic of Congo (DRC), a country with a dense hydrographic network, river transport is ubiquitous. Équateur Province, traversed by the Congo River and its tributaries, perfectly illustrates this reality. In this context, the Provincial Health Directorate (DPS) of Équateur is regularly confronted with the health consequences of maritime traffic accidents, which result in massive influxes of victims to healthcare facilities, preventable deaths, and often severe trauma (Ministry of Public Health of the DRC, 2022). Despite the recurrence of these events, the underlying factors remain insufficiently documented in this specific area.

This study aimed to analyze the factors associated with maritime traffic accidents that occurred within the jurisdiction of the DPS of Équateur in 2025, adopting an integrated epidemiological and socio-environmental approach.

METHODS

Study Design and Type of Research

This is a mixed cross-sectional study (quantitative and qualitative). The quantitative design is a retrospective case-control survey, and the qualitative component is based on an exploratory phenomenological design (Creswell & Creswell, 2018).

Study Setting

The study was conducted in Équateur Province, DRC, specifically in the health zones of Mbandaka, Bikoro, and Ingende, among the most affected by maritime accidents according to DPS data (DPS/Équateur, 2025).

Population and Sample

The study population comprised victims of maritime accidents occurring in 2025, controls (non-accidentated users), and key informants.

Quantitative Sample: The sample size was calculated using the Schwartz formula ($n = Z^2p(1-p)/d^2$), with $Z = 1.96$, $p = 0.50$, and $d = 0.05$, giving a minimum sample of 384 subjects. The final sample consisted of 190 cases (victims) and 190 controls, totaling 380 participants.

Qualitative Sample: 18 semi-structured interviews were conducted with key informants (DPS officials, health workers, transport authorities, boat operators, civil society), until data saturation was reached (Guest et al., 2020).

Inclusion Criteria: For cases, any person involved in a maritime accident in 2025 in the selected health zones. For controls, any adult user who used river transport on the same routes in 2025 without having been a victim. For interviews, any key actor involved in accident management or waterway safety.

Data Collection

Quantitative data were collected using a face-to-face questionnaire, pre-tested on 20 people. Qualitative data were collected through semi-structured interviews that were recorded and transcribed.

Data Analysis

Quantitative Analysis: Data were entered into Excel and analyzed using SPSS version 25. Descriptive analysis (frequencies, percentages, means) was performed, followed by bivariate analysis (Pearson's chi-square test, crude ORs with 95% CI) and binary logistic regression to identify factors independently associated with accidents.

Qualitative Analysis: Thematic content analysis was conducted according to the Miles and Huberman method (2014), with coding, categorization, and identification of themes.

Ethical Considerations

The study received approval from the Management Committee of ISTM/Mbandaka and authorization from DPS/Équateur. Written informed consent was obtained from each participant. Confidentiality and anonymity were guaranteed.

RESULTS

Characteristics of the Sample

The quantitative sample (n = 380) had a male predominance (59.7%), with a mean age of 39.3 ± 12.1 years. The 31-45 age group was the most represented (42.4%), and traders constituted the main occupation (34.2%) (Table I).

Factors Related to Health Response

More than half of the victims (51.6%) took over two hours to reach a healthcare facility, with a mean delay of 132 ± 78 minutes. Evacuation was mainly by improvised rescue canoe (58.9%) (Table II).

Factors Associated with Accidents (Bivariate Analysis)

Bivariate analysis showed that overloading (OR = 5.73; 95% CI: 3.71-8.84), absence of life jackets (OR = 4.92; 95% CI: 3.18-7.61), alcohol consumption (OR = 6.04; 95% CI: 3.57-10.22), operator inexperience (OR = 4.04; 95% CI: 2.42-6.76), night navigation (OR = 4.08; 95% CI: 2.58-6.47), heavy rain (OR = 12.04; 95% CI: 6.58-22.03), and hazardous waterways (OR = 7.78; 95% CI: 4.36-13.88) were significantly associated with accidents ($p < 0.001$) (Tables III, IV, V).

Independent Factors (Multivariate Analysis)

After adjustment for sex, age, and health zone, logistic regression identified eight factors independently associated with accidents (Table VI):

Factor	Adjusted OR	95% CI	p
Heavy rain	8.94	[4.62-17.29]	< 0.001
Hazardous waterways	5.21	[2.71-10.02]	< 0.001
Overloading	4.82	[2.98-7.80]	< 0.001
Operator alcohol consumption	4.21	[2.36-7.52]	< 0.001
Absence of life jackets	3.56	[2.12-5.98]	< 0.001
Moderate wind	3.34	[1.84-6.07]	< 0.001

Factor	Adjusted OR	95% CI	p
Operator inexperience (< 2 years)	2.98	[1.69-5.26]	< 0.001
Night navigation	2.76	[1.62-4.70]	< 0.001

Qualitative Results

Analysis of interviews revealed four main themes:

Theme 1: Structural regulatory deficiencies. Stakeholders highlighted the absence of mandatory certification for boat operators and the rarity of inspections: *"Here, anyone can operate a canoe, there is no license"* (boat operator, Mbandaka).

Theme 2: Subsistence imperatives. Economic pressure justifies overloading: *"If you refuse passengers, you lose money. The river is our livelihood"* (boat operator, Bikoro).

Theme 3: Absence of rescue infrastructure. Stakeholders deplored the lack of rescue boats and alert systems: *"When a boat capsizes, people manage on their own. There is no rescue boat, no emergency number"* (health worker, Ingende).

Theme 4: Cultural fatalism. Reliance on religious beliefs justifies rejection of protective equipment: *"Many don't wear life jackets because they think if they are meant to die, it will happen anyway"* (civil society member, Mbandaka).

DISCUSSION

This study identified several factors associated with maritime traffic accidents in Équateur Province, confirming the multifactorial nature of this public health problem. The results are consistent with studies conducted in other riverine contexts in Africa and Asia (Bhattacharya et al., 2021; Okonkwo, 2019; Mulaku et al., 2022).

Overloading: A Central Factor

Overloading was the most important technical factor (OR = 4.82), present in 74.7% of cases versus 33.7% of controls. This result is consistent with Nigerian studies where 70% of shipwrecks were linked to overloading (Okonkwo, 2019). On Lake Victoria, Mulaku et al. (2022) highlighted that overloading was perceived by users as the primary cause of accidents. In the Équateur context, economic pressure, highlighted by qualitative analysis, explains this practice: transporters accept passengers beyond authorized capacity to maximize their income, a behavior described by Wilde's (1982) risk homeostasis theory.

Absence of Life Jackets: An Aggravating Factor

The absence of life jackets multiplies the risk by 3.56, with only 17.9% of cases reporting their presence. This finding corroborates studies conducted in Bangladesh (Bhattacharya et al., 2021) and Cameroon (Ngoa et al., 2021). The low availability is explained by cost, lack of effective enforcement, and cultural fatalism, as highlighted by local stakeholders.

Human Factors: Inexperience and Alcohol

Operator inexperience (< 2 years) multiplies the risk by 2.98, consistent with the findings of Tshimanga et al. (2020) in the DRC. Alcohol consumption (OR = 4.21) is also highly detrimental, an association well documented in the international literature (Psarros et al., 2020). Qualitative interviews revealed the absence of systematic enforcement and mandatory certification.

Environment: Weather and Night Navigation

Heavy rain (OR = 8.94) and moderate wind (OR = 3.34) emerged as the most powerful environmental factors. Night navigation was also an independent risk factor (OR = 2.76). These results confirm the work of Haveman et al. (2020), who identified adverse weather conditions as the primary trigger for small vessel accidents. In Équateur, the seasonality of rains concentrates accidents, and the absence of light beacons exacerbates vulnerability.

Health Response: A Weak Link

More than half of the victims (51.6%) took over two hours to reach healthcare, and evacuation was mainly by improvised canoe. This finding corroborates the results of Boloko (2022) in Mbandaka, who reported a median delay of six hours. Qualitative interviews confirmed the absence of a coordinated rescue system.

Strengths and Limitations

Strengths of the study include the mixed design, adequate sample size, rigorous case-control matching, and triangulation of sources. Limitations include recall bias, underreporting of accidents, lack of data on immediate deaths, and limited generalizability to three health zones.

CONCLUSION

Maritime accidents in Équateur are multifactorial, combining technical determinants (overloading, absence of life jackets), human factors (inexperience, alcohol), and environmental factors (weather conditions, night navigation), along with an insufficiently organized health response. An integrated multisectoral approach is essential to reduce preventable morbidity and mortality: strengthening regulations, effective enforcement, operator training, safety equipment, and improved emergency response. These findings advocate for the establishment of an epidemiological registry of maritime accidents within DPS/Équateur and for further research on the socio-anthropological dimensions of risk.

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