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Predicting the unpredictable: unveiling hidden patterns of emergency department unexpected deaths - a retrospective study

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ABSTRACT

Objectives: Unexpected deaths in the emergency department (ED) are rare but may indicate missed opportunities to detect clinical deterioration. This study aimed to identify risk factors associated with unexpected deaths and to better characterize patients at risk during their ED stay.

Methods: A retrospective study was conducted in the two EDs of CHU Liège between 2019 and 2023. All adult deaths (≥16 years) were extracted from the hospital's electronic health records and classified as expected or unexpected based on predefined criteria. Demographic data, triage levels, vital signs, Early Warning Scores (EWS), Glasgow Coma Scale (GCS), care location, and timing of death were analyzed using R software.

Results: Among 461,958 ED admissions, 823 adult patients died. Of these, 42 (5.1%) were classified as unexpected. These cases were more frequently transported by non-medicalized ambulance (40.5% vs. 27.5%, $p = 0.006$), assigned lower triage levels ($p < 0.001$), and less often admitted to the resuscitation room (73.8% vs. 49.8%, $p = 0.002$). They also presented lower EWS (0–4: 77.4% vs. 48.5%, $p = 0.006$) and higher initial GCS scores ($p = 0.002$). In multivariate analysis, a high EWS (≥7) and an altered GCS were both associated with a lower likelihood of unexpected death (OR 0.10, $p = 0.03$, and OR 0.32, $p = 0.05$, respectively), indicating that these factors were more frequent among expected deaths.

Conclusion: Unexpected deaths represented 5.1% of ED fatalities and were often preceded by subtle signs such as behavioral changes or mildly abnormal vital signs. Many occurred after initial stabilization, particularly in short-stay areas, underscoring the need to reflect on the organization and role of these units within the hospital system.

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Unexpected deaths; emergency department; overcrowding; adverse events; quality of care

Introduction

Emergency departments (EDs) are essential for rapidly assessing and treating patients with urgent, life-threatening conditions. However, challenges like overcrowding, high patient turnover, staff shortages, and unpredictable cases create risks for adverse events such as diagnostic errors, complications, and delayed care [1–3]. Unexpected deaths in the ED are especially alarming as they indicate failures in early detection and timely intervention for clinical deterioration.

Unexpected deaths in emergency departments differ from expected deaths, which usually involve patients with terminal illnesses, severe trauma, or unsuccessful resuscitations, where the clinical pathway is more predictable [4,5]. In contrast, unexpected deaths occur suddenly, often in patients who initially appeared stable or were not considered high risk [6]. These deaths often happen outside high-monitoring areas like resuscitation zones [7]. This unpredictability raises critical concerns about missed warning signs, delayed interventions, and overall system efficiency [8].

The prevalence of unexpected deaths in emergency departments (EDs) varies widely due to differences in definitions and study methods. Some define unexpected deaths as those without clear signs of terminal illness or advance directives like DNR orders, while others include all deaths outside critical care as unexpected [5]. Across the literature, there is substantial heterogeneity in how the terms 'expected,' 'unexpected,' 'preventable,' and 'avoidable' are used, often interchangeably or without clear boundaries. A recent French study [9] sought

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to clarify this issue by conducting a scoping review and proposing a standardized definition for 'expected' deaths, based on prognostic and palliative criteria such as a life expectancy under six months. This definition has the merit of bringing conceptual clarity to mortality reporting in emergency care. However, other authors [10], have approached the question from a quality and safety perspective, focusing on the distinction between 'unexpected' and 'avoidable' deaths. In their retrospective review, most ED deaths were unpreventable, reinforcing the idea that avoidable deaths represent only a small subset of unexpected ones, those where system or clinical factors contributed to an otherwise non-inevitable outcome. Taken together, these perspectives highlight that 'unexpected' does not necessarily imply 'avoidable.' For the purpose of this study, we use the term 'unexpected death' to refer broadly to deaths that were not anticipated at the time of care, regardless of their potential preventability. This conceptual choice allows comparison with prior literature while focusing on clinical and organizational patterns preceding death.

Based on this understanding, international studies have reported highly variable prevalence rates of unexpected deaths in EDs. A Swiss study found that 93.4% of patients who died in EDs were high-priority cases needing urgent interventions, yet many deaths still occurred outside these monitored areas, suggesting gaps in early detection [7]. Another European study reported ED mortality rates between 0.2% and 0.5%, with many deaths being unexpected [11]. These findings highlight the need for improved triage and continuous evaluation, especially since most unexpected deaths involve patients over 65, who often show atypical symptoms and are more vulnerable [7,12,13]. Unexpected deaths are often preceded by clear warning signs, such as abnormal vital signs or clinical deterioration within 48 hours [6,14]. Studies, including one by Roller et al. [4], found that 98% of such deaths involved indicators like hypotension, tachycardia, respiratory distress, or altered consciousness. Indeed, key predictors of in-hospital mortality include systolic hypotension, bradycardia, desaturation, and confusion, all of which significantly increase the risk of death if not promptly addressed [7,14,15]. However, systemic issues, such as overcrowding, poor communication, and heavy workloads, can delay recognition and response. Although Early Warning Scores (EWS) are designed to detect patient deterioration early, their use in emergency departments is still inconsistent. These tools evaluate physiological parameters to assess risk and guide interventions, but their effectiveness is often undermined by organizational challenges like overcrowding, staffing shortages, and long patient stays [16]. These delays can worsen patient outcomes and contribute to staff burnout, further limiting the ability to respond promptly [17,18]. Unexpected deaths in emergency departments have deep emotional and psychological effects on both healthcare providers and families. Clinicians may experience moral distress, especially when warning signs were missed, while families often face intensified grief and trauma [19]. Despite these serious consequences, the issue remains under-researched, and few strategies exist to prevent such events. This study seeks to identify the systemic, clinical, and organizational factors involved, with the goal of informing better prevention measures and enhancing patient safety.

Materials and methods

Objectives, hypotheses and design

The objective of this study was to identify the risk factors associated with unexpected deaths in EDs and, in a second phase, to identify patients at risk during their stay in the emergency department. We hypothesized that a specific patient profile could exists for those at higher risk of unexpected death in EDs and that it may also be possible to identify temporal and structural areas within the ED that present a higher risk for unexpected deaths. To address our hypotheses, a retrospective, analytical study design was chosen. This approach covers all deaths that occurred in two EDs over a five-year period, from 2019 to 2023.

Study site

Data were collected from two emergency departments within a single Belgian university teaching hospital, consisting of two geographically separate sites: the Main facility, a tertiary suburban hospital, and the Satellite, an urban secondary hospital. The Main ED originated from a public university hospital culture, while the Satellite ED began as part of a private clinic later merged with the Main Hospital. Together, the two sites handle about 100,000 ED visits annually, with the Main managing 57% and the Satellite 43%. The department employs approximately 50 physicians and 120 nurses.

Study population

The study included all patients over 16 who died in the emergency departments between 2019 and 2023. Deaths were classified into two groups: expected and unexpected. Unexpected deaths were defined as those occurring unexpectedly in the ED, outside the resuscitation room. Deaths not meeting these criteria were considered expected, meaning they occurred under predictable circumstances in the ED.

Inclusion criteria for expected deaths:

- Patients pronounced dead in the ED following failed pre-hospital or intra-hospital resuscitation efforts.
- Patients admitted to the ED with terminal, incurable conditions for whom palliative or comfort care was initiated.
- Patients presenting with acute conditions deemed immediately incurable and who received therapeutic de-escalation and comfort care.
- Patients in palliative care for terminal illnesses, with clear therapeutic plans and already comfort care in the ED.
- Patients deemed incurable or beyond medical intervention by the attending team and for whom therapeutic de-escalation and distress protocols were initiated in the ED.

Any other death was then considered unexpected.

Data collection

The hospital's official medical data department provided an anonymized database, which included reference numbers but excluded any patient-identifiable information. Using the hospital's electronic health record (EHR) system, the research team conducted a comprehensive review of medical and nursing records for each patient. All necessary ethical approvals were obtained prior to data access.

The primary objective of this initial phase was to verify the completeness and accuracy of the dataset. After confirming data integrity, the research team categorized each death as either expected or unexpected, following the inclusion and exclusion criteria established for the study.

Study variables

The primary dependent variable was a binary indicator for 'unexpected death' (Yes/No). This outcome variable was examined in relation to several independent variables, including:

- **Demographic and Clinical Characteristics**: Gender, age, initial and final vital signs (e.g. blood pressure, heart rate, respiratory rate, temperature, oxygen saturation, and Glasgow Coma Scale (GCS) score.
- **Triage category** was determined using a 5-level triage algorithm (ELISA scale) as previously reported [20].
- **Care Pathway data**: Requirement for oxygen administration, admission to or bypass of the resuscitation room, mode of admission, length of stay, and ED area where the death occurred. The reason for admission and the cause of death were extracted directly from the free-text clinical documentation (anamnestic notes and physician conclusions) without any retrospective recoding or reinterpretation of the underlying etiologies.
- **Temporal Variables**: Work shift during which the death occurred, weekday versus weekend.
- **Physiological Risk Scores**: EWS at admission and nursing score.

For unexpected deaths, additional data were extracted from medical and nursing records to identify early warning signs and other risk factors. Early warning signs were defined as the presence of at least one of the following physiological abnormalities:

- **Hypotension**: Systolic blood pressure (SBP) <90 mmHg.
- **Heart Rate Abnormalities**: Tachycardia (>130 bpm) or bradycardia (<50 bpm).
- **Respiratory Distress**: Oxygen saturation <90%.

Additional clinical indicators included confusion, agitation, and altered Glasgow Coma Scale (GCS) scores. The quality of the final database was assessed using graphical methods, such as scatter plots, to identify potential outliers and ensure data consistency.

Statistical analysis

Continuous variables were checked for normality using graphical methods (histograms, QQ-plots) and tests like the Shapiro-Wilk test. Normally distributed data were reported as mean ± standard deviation (SD), while non-normal data were reported as medians with interquartile ranges (IQR). Categorical variables were summarized as counts and percentages. Group comparisons between expected and unexpected deaths used Welch's t-test for normal continuous variables, Mann-Whitney U test for non-normal variables, and Chi-square or Fisher's exact tests for categorical variables. In the logistic regression models, the dependent variable was 'unexpected death' (Yes/No), coded as 1 for unexpected and 0 for expected deaths. Statistical significance was set at $p < 0.05$. Binary logistic regression identified independent predictors of unexpected death, starting with univariate analysis followed by multivariate models including variables with $p \leq 0.05$. Results were reported as odds ratios (OR) with 95% confidence intervals (CI). Survival analysis with Kaplan-Meier curves and Log-Rank tests compared time to death between groups. Analyses were performed on all available data for the variables concerned. Given the exploratory design and the limited number of unexpected deaths, no a priori power calculation was performed. The number of covariates in the multivariable model was restricted to respect the events-per-variable rule.

Ethical considerations and general data protection regulation (GDPR)

This retrospective study did not fall within the scope of the 7 May 2004 law on human subject research, as it involved only the review of medical records from deceased patients. However, the study protocol received approval from the Ethics Committee of CHU Liège on 7 November 2023 (approval number 2023/302). Additionally, authorization for data extraction from the medical record system was obtained from the medical data department in November 2023, ensuring full compliance with data protection regulations.

Results

Descriptive analysis of the population and epidemiology of ED Deaths

Between 2019 and 2023, 461,958 patients were admitted to the EDs of CHU Liège (ST and NDB). After excluding one pediatric patient, 823 patients aged 16 years or older died in the EDs during this period, resulting in an overall mortality rate of 1.8 per 1,000 admissions. Of these, 42 (5,1%) were classified as unexpected based on the predefined inclusion criteria, while the remaining 781 (94,9%) were considered expected (Figure 1). The majority of deceased patients were over 75 years old ($n = 565$; 68,6%), with a slight female predominance ($n = 428$; 52%). Respiratory complaints were the most common reason for patients admission ($n = 251$; 33,2%). The leading causes of death were shock states ($n = 236$; 28,7%), followed by respiratory and neurological conditions. Deaths occurred mostly in short-stay units ($n = 438$; 53,2%) or resuscitation rooms ($n = 280$; 34%), with a notable concentration during the afternoon nursing shift ($n = 293$; 35,6%). The most frequent admission transport modality was via mobile intensive care unit (SMUR) ($n = 485$; 58,9%). In terms of triage categories, a substantial proportion of patients were classified as emergency priority Level 1 ($n = 341$; 46,9%) or Level 2 ($n = 227$; 31,3%). (Table 1)

Comparison of epidemiology between expected and unexpected deaths

We found significant differences between expected and unexpected death as regards the following factors:

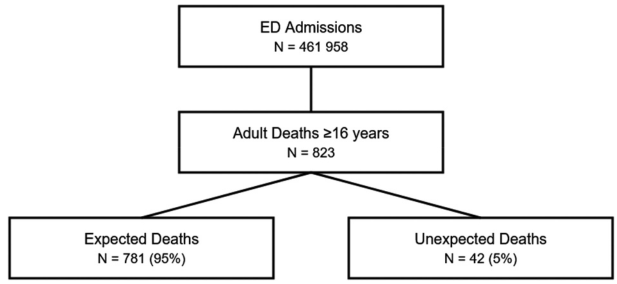

Figure 1. Classification of emergency department (ED) deaths, 2019–2023. Among 461,958 ED admissions from 2019 to 2023, 823 patients aged ≥16 years died. Based on clinical and organizational criteria, 42 deaths (5.1%) were classified as unexpected.

- **Mode of admission** significantly differed between groups: unexpected deaths were more frequently transported by non-medicalized ambulances, whereas expected deaths more often arrived via SMUR ($p = 0.006$).
- **Triage category**: Expected deaths were more often classified as level 1 ($n = 338$; 49,3%), while unexpected deaths were more frequently level 2 ($n = 21$; 51,2%) or level 3 ($n = 15$; 36.58%) ($p < 0.001$).
- **Care pathway**: Care pathway also differed significantly between groups: 392 (50.2%) of expected deaths were initially admitted to the resuscitation room, whereas 31 (73.8%) of unexpected deaths bypassed it ($p = 0.002$).
- **Location of death**: Unexpected deaths mostly occurred in short-stay units ($n = 23$; 54,8%) or consultation rooms ($n = 9$; 21,4%), though this difference was not statistically significant ($p = 0.09$).

We found no significant differences in age or gender between expected and unexpected deaths. Both groups shared similar primary causes of death, mainly septic shock from pulmonary, urinary, or cardiogenic origins. Unexpected deaths occurred more often during night shifts ($n = 17$; 40,5%), but this was not statistically significant ($p = 0.26$).

Prevalence of early warning indicators for unexpected deaths

Among the 39 patients with available vital sign data, 16 (40%) showed at least one abnormal hemodynamic or respiratory parameter before death. Hypotension was the most common abnormality, occurring in 10 (25,6%) of cases. Additionally, confusion or agitation was noted in 17 (40,5%) of the patients (Table 2). Of these 39 patients, a complete EWS could be calculated for 31 individuals, based on the availability of all required parameters (Table 3).

Comparison of clinical signs by nature of death

Most vital signs showed no significant differences between groups, but expected deaths had a significantly lower initial GCS score ($p = 0.002$). The EWS was significantly different: 24 (77%) of unexpected deaths had a low score (0–4), compared to 264 (49%) of expected deaths ($p = 0.006$). (Table 3)

Risk factors for unexpected deaths

Univariate analysis (Table 4) revealed that patients triaged as level 2 and level 3 had a significantly higher risk of unexpected death compared to level 1, with odds ratios of 2.8 ($p = 0.001$) and 2.9 ($p = 0.002$), respectively. Passing through the resuscitation room reduced the risk by 65% ($p = 0.004$), while patients arriving without medicalized transport had double the risk of unexpected death ($p = 0.02$). Lower GCS scores ($p = 0.002$) and higher EWS (≥7) scores ($p = 0.008$) were more strongly associated with expected deaths. In multivariate analysis (Table 4), an EWS ≥7 was associated with a tenfold lower likelihood of unexpected death (OR 0.10, $p = 0.03$), and an altered GCS was associated with a lower probability of unexpected death (OR 0.32, $p = 0.05$), indicating that these factors were more often present among expected deaths.

Table 1. Comparison of sociodemographic and organizational characteristics between patients with unexpected and expected deaths.

Characteristics	Total (%) (*n* = 823)	Unexpected Deaths (%) (*n* = 42)	Expected Deaths (%) (*n* = 781)	*p*-value
Gender				0.71
Women	428 (52)	21 (50)	407 (52)	
Men	395 (48)	21 (50)	374 (48)	
Median Age (P25-P75)	81 (71–88)	82 (73–89)	81 (71–88)	0.56
Age Groups (Years)				
≥75 years	565 (69)	29 (69)	536 (69)	
51–74 years	222 (27)	11 (26)	211 (27)	
31–50 years	30 (4)	2 (5)	28 (4)	
16–30 years	6 (1)	0 (0%)	6 (1)	
Hospital Site				0,87
ST	444 (54)	22 (52)	422 (54)	
NDB	379 (46)	20 (48)	359 (46)	
Reason for Admission				NC
Respiratory Disorders	251 (33)	13 (32)	238 (33)	
General health deterioration	178 (24)	9 (22)	169 (24)	
Other	112 (15)	7 (17)	105 (15)	
Neurological Disorders	100 (13)	4 (10)	96 (13)	
Trauma	47 (6)	1 (2)	46 (6)	
Shock	30 (4)	4 (10)	26 (4)	
Abdominal Pain	20 (3)	1 (2)	19 (3)	
Chest Pain	18 (2)	2 (5)	16 (2)	
Presumed Cause of Death				NC
Shock	236 (29)	16 (38)	220 (28)	
Respiratory pathologies	160 (19)	8 (19)	152 (20)	
Neurological pathologies	121 (15)	8 (19)	113 (14)	
Cardiac Arrest	117 (14)	3 (7)	114 (15)	
Traumas	59 (7)	3 (7)	56 (7)	
Oncological and terminal pathologies	51 (6)	2 (5)	49 (6)	
Covid19	33 (4)	1 (2)	32 (4)	
Others	30 (4)	1 (2)	29 (4)	
Gastro-enterological pathologies	16 (2)	0 (0)	16 (2)	
Emergency Department area				0.09
Temporary Hospitalization Unit	438 (53)	23 (55)	415 (53)	
Resuscitation room	280 (34)	10 (24)	270 (35)	
Consultation rooms	95 (12)	9 (21)	86 (11)	
Others	10 (1)	0 (0)	10 (1)	
Day of the Week				0.99
Weekday	569 (69)	29 (69)	540 (69)	
Weekend	254 (31)	13 (31)	241 (31)	
Nurse shift				0.26
Morning	288 (35)	13 (31)	275 (35)	
Afternoon	293 (36)	12 (29)	281 (36)	
Night	242 (29)	17 (40)	225 (29)	
Mode of Admission				0.006*
Mobile Emergency Unit (SMUR)	485 (59)	15 (36)	470 (60)	
Ambulance	232 (28)	17 (40)	215 (28)	
Personal Means	58 (7)	7 (17)	51 (6)	
Internal Transfer	48 (6)	3 (7)	45 (6)	
Triage Score				< 0.001*
Level 1	341 (47)	3 (7)	338 (49)	
Level 2	227 (31)	21 (51)	206 (30)	
Level 3	140 (19)	15 (37)	125 (18)	
Level 4	10 (1)	1 (2)	9 (1)	
Level 5	8 (1)	1 (2)	7 (1)	
Passage through the resuscitation room				0.002*
No	420 (51)	31 (74)	389 (50)	
Yes	403 (49)	11 (26)	392 (50)	

* *$p < 0.05$; statistically significant.*

Survival duration before death in the ED

The median time from ED admission to death was 6.2 hours (IQR: 2.1–17.2). Older patients (≥75 years) had significantly longer median survival times (8.0 hours) compared to younger patients ($p < 0.001$). Although patients who experienced unexpected deaths had a slightly longer median survival (8.4 hours) than those with expected deaths (6.1 hours), this difference was not statistically significant ($p = 0.3$). (Figure 2)

Table 2. Prevalence of early warning indicators for unexpected deaths.

Precursor signs: Presence of at least one altered vital sign (n = 39)	N	Occurrences n (%)
Hypotension < 90 mmHg	39	10 (26)
Tachycardia > 130/min	39	1 (3)
Bradycardia < 50/min	39	1 (3)
Oxygen saturation < 90%	39	7 (18)
Altered initial Glasgow score	18	7 (38)
Presumed Risk Factors:		
State of confusion and/or agitation	42	17 (40)

Table 3. Comparison of initial clinical scores between unexpected and expected deaths.

First Parameters	N	Unexpected deaths n = 42 (5%)	N	Expected deaths n = 781 (95%)	*p*-value	95% CI[a]
Systolic pressure (mm Hg)	39	131.1 ± 36	642	122.1 ± 40	0.14	[−3.0; 21.0]
Heart Rate	40	87.9 ± 23	664	94.7 ± 28	0.08	[−14.5; 0.8]
O2 saturation	39	94 (92–96)	639	94 (90–97)	0.83	[−1.0; 2.0]
Glasgow coma scale	18	15 (13–15)	234	11 (7–15)	0.002	[8×10^{-6}; 5]
Early warning signs (%)	31		544		0.006	
Low = (0–4)		24 (77)		264 (48)		
Medium = (5–6)		4 (13)		109 (20)		
High ≥7		3 (10)		171 (31)		

[a]95% confidence intervals (CI) for the difference in location parameters (mean or median) between unexpected and expected deaths.

Table 4. Risk factors for unexpected deaths (Univariate and multivariate analysis).

Risk Factor (Univariate analysis)	Odds Ratio (95% CI)	*p*-value
L2 Triage (vs. L1)	2.8 (1.6–4.8)	0.001
L3 Triage (vs. L1)	2.9 (1.7–5.0)	0.002
Admission Mode: Independent (vs. SMUR)	2.0 (1.1–3.6)	0.02
Resuscitation Room Admission	0.35 (0.2–0.7)	0.004
Risk Factor (Multivariate Analysis)	Odds Ratio (95% CI)	*p*-value
Glasgow Coma Scale (Altered)	3.13 (0.99–9.94)	0.05
EWS ≥7	1.9 (1.1–3.4)	0.03

Outcome variable: unexpected death (Yes = 1, No = 0). Odds ratios (OR) <1 indicate a stronger association with expected deaths.

Discussion

Unexpected deaths in EDs are serious adverse events that deeply affect healthcare teams both emotionally and professionally [6]. They are frequently associated with diagnostic mistakes, insufficient patient monitoring, and delays in treatment [21]. This study aimed to identify risk factors for unexpected deaths in EDs and to pinpoint patients at higher risk during their stay. Our results highlight several early warning signs and precursor indicators that could help predict and prevent these events.

The study partially confirmed our main hypothesis. Although multivariate analysis did not identify statistically significant risk factors for unexpected deaths in the ED, several early clinical warning signs were found. Most unexpected deaths occurred in the ED short-stay unit, especially during night shifts, aligning with findings by Petit et al. [6]. This unit cares for clinically unstable patients awaiting transfer to inpatient units, often requiring close monitoring and advanced respiratory support like non-invasive ventilation. The combination of high patient acuity and less continuous monitoring compared to intensive care likely contributes to the higher death rate there. This raises concerns about staffing and resource allocation in such unit. Indeed, the Belgian Health Care Knowledge Centre (KCE) recommends a nurse-to-patient ratio not exceeding 1:8 for conventional units [22], but this may be insufficient for ED short-stay unit, where patients need more intensive surveillance. Given the critical nature of such area, more structured staffing and monitoring approaches are needed to reduce unexpected deaths.

In this study, unexpected deaths represented 5.1% of all ED deaths – a rate slightly lower than the 8.3% reported by Petit et al. [6], likely due to differences in classification criteria and clinical settings, as their study focused on general hospital wards. Notably, 40% of patients who died unexpectedly had at least one abnormal vital sign during their ED stay, underscoring the need for targeted prevention strategies.

We noticed that, surprisingly, none of the 42 unexpected deaths were formally reported as adverse events, limiting opportunities for systemic learning. Strengthening adverse event reporting and developing

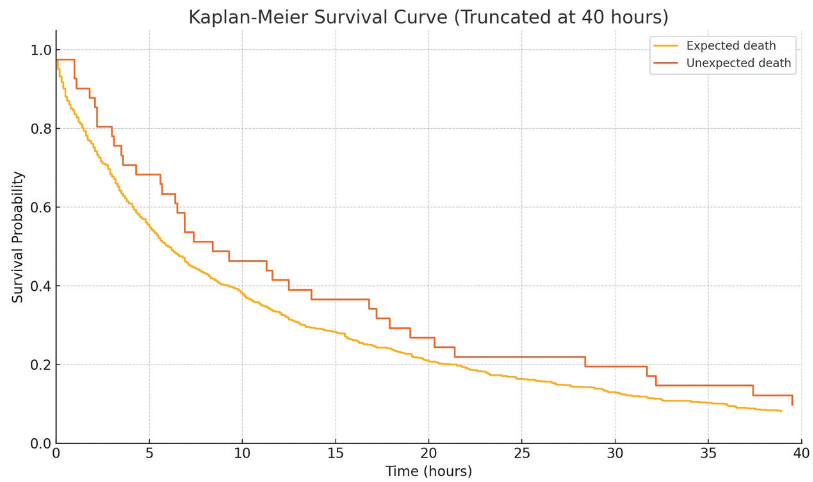

Figure 2. Kaplan – Meier survival curves for expected and unexpected deaths in the emergency department. The x-axis is truncated at 40 hours to enhance visual interpretation. No statistically significant difference in time to death was observed between groups (log-rank test, $p = 0.30$).

predictive tools, such as those supported by AI algorithms, as shown by Coslovsky et al. [23], could help identify high-risk patients earlier. Additionally, ED overcrowding remains a critical risk factor; an Australian study demonstrated reduced mortality after implementing the '4-hour rule' [24]. In this study, the median time to death for unexpected cases was 8.4 hours, similar to that of expected deaths ($p = 0.3$), suggesting that other clinical or organizational factors likely contribute to these outcomes [18].

Another key finding of the study is that many patients classified as expected deaths were admitted to the ED under comfort care, care limitations, or distress protocols. These patients, often in terminal or palliative phases of chronic, neurological, respiratory, or advanced cancer diseases, frequently died in the ED's Temporary Hospitalization Unit (THU), sometimes with family present. Since the 1990s, emergency departments have increasingly become the final care setting for many end-of-life patients, with a substantial number dying there [11,25]. Future research should better quantify the proportion of palliative patients receiving comfort care in the ED and investigate alternative care pathways. Given the high volume and workload in EDs, these environments may not be optimal for delivering the attention and support terminal patients and their families require [11,26].

Limitations and bias

The study has several limitations: its retrospective design made accurate data collection on causes and circumstances of death difficult due to incomplete records. Classifying deaths as expected or unexpected was subjective, though mitigated by regular case reviews. The imbalance between expected (94.9%) and unexpected (5.1%) deaths reduced statistical power and may have biased some analyses, particularly in the multivariable logistic model, which may not have detected certain existing associations. Additionally, the study did not consider ED occupancy rates, which are known to affect patient outcomes; future studies should include this variable for better understanding of how workload impacts unexpected deaths. Finally, the categorization of admission reasons and causes of death relied on the clinical documentation present in the medical records without re-coding, which may have introduced variability in diagnostic precision.

Conclusion

The study aimed to determine the incidence of unexpected deaths in the ED and identify associated risk factors. It found that 5,1% of deaths were unexpected, with 40% of those patients showing at least one abnormal vital sign and 40% exhibiting confusion or agitation during their stay. These findings emphasize the importance of proactive monitoring and early interventions. The fact that several UD occurred in short-stay areas questions the current role and organization of these units within the hospital. Their positioning at the interface between emergency and inpatient care may expose patients with latent risks to delayed recognition or suboptimal escalation of care. Detailed analysis of death circumstances and patient risk profiles could guide targeted prevention strategies, potentially reducing adverse events and improving care quality. Future research should refine risk prediction models and examine organizational factors to help EDs better anticipate and manage early signs of patient deterioration.

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RG was responsible for writing – original draft. FS contributed to the methodology, formal analysis, and writing – review & editing. FS contributed to the methodology, formal analysis, and writing – review & editing. MA contributed to the methodology, formal analysis, and writing – review & editing. MB writing – review & editing. AG contributed to writing – review & editing, formal analysis, and supervision. MP contributed to the conceptualization, methodology, project administration, writing – review & editing, and supervision.

Author contributions

CRediT: **Raphael Gontier:** Writing – original draft; **Sophie Klenkenberg:** Formal analysis, Methodology, Writing – review & editing; **Mario Ambrozic:** Formal analysis, Methodology, Writing – review & editing; **François Stifkens:** Formal analysis, Methodology, Writing – review & editing; **Marine Bastide:** Writing – review & editing; **Alexandre Ghuysen:** Formal analysis, Supervision, Writing – review & editing; **Méryl Paquay:** Conceptualization, Methodology, Project administration, Writing – review & editing.

Disclosure statement

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Availability of data and materials

The datasets generated and/or analysed during the current study are not publicly available due to ethical restrictions. The ethics committee required that the data remain confidential given the sensitive nature of the information collected. However, data are available from the corresponding author on reasonable request and with appropriate ethical clearance.

Ethics approval and consent to participate

Ethical approval was obtained from the University Hospital Faculty Ethics Committee in Liège (approval number 2023/302). Additionally, authorization for data extraction from the medical record system was obtained from the medical data department in November 2023, ensuring full compliance with data protection regulations.

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