Characterisation of adverse events leading to unscheduled intensive care admissions

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Supplementary Materials

Supplementary_Material.docx

Summary

Background

Unscheduled admissions to intensive care units (ICUs) pose major challenges for patient safety, hospital organisation, and healthcare costs. A substantial proportion of these admissions are linked to adverse events associated with care (AEAC) occurring outside the ICU, making them a critical target for quality improvement initiatives.

Methods

We conducted an exploratory retrospective single-centre study in an 800-bed regional hospital, including all patients aged ≥18 years who experienced unscheduled ICU admissions between January and December 2022. Eligible admissions occurred 24–144 hours after hospitalisation. A multidisciplinary expert panel reviewed patient records to identify AEACs using Wilson's criteria. Events were assessed for causality (6-point scale), severity (NCC MERP classification), and avoidability. AEACs with a causality score ≥4 were retained. Root cause analysis was performed using an Ishikawa diagram. Relationships between causality, severity, and avoidability were analysed using Spearman correlation and simple linear regression.

Results

Among 858 ICU admissions recorded in 2022, 122 patients met the inclusion criteria for unscheduled ICU admissions. Among these, 89 cases (73%) were associated with at least one adverse event associated with care (AEAC), while the remaining 33 reflected the natural progression of the underlying condition. Overall, these AEAC-related unscheduled admissions represented approximately 10% of all ICU admissions during the study period. Organisational failures (36%), therapeutic (25%), diagnostic (19%), and medication errors (12%) were the most frequent AEAC categories. Most events were severe (categories G–I) and preventable. Admissions peaked between 6 p.m. and midnight, a period characterised by reduced clinical supervision. Spearman correlation demonstrated strong associations between causality and severity ($r = 0.78$, $P < .001$) and between causality and avoidability ($r = 0.72$, $P < .001$). Linear regression confirmed these relationships (adjusted $R^2 = 0.61$ and 0.55, respectively).

Conclusion

AEACs substantially contribute to unscheduled ICU admissions and are frequently preventable. The strong correlations observed highlight the need for improved early detection systems and targeted preventive strategies, particularly during low-supervision periods. Organisational factors are prominent and actionable. These findings support the implementation of enhanced patient monitoring, structured clinical workflows, and preventive safety measures. Future research should include multicentre validation and assess the economic burden and cost-effectiveness of interventions to reduce preventable ICU transfers.

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Introduction

Intensive care units play a critical role in the treatment of critically ill patients. However, admission and discharge criteria remain a matter of debate and concern, as outlined in Society of Critical Care Medicine (SCCM) guidelines [1]. Patients admitted to critical care may come from a variety of sources, including emergency departments, scheduled surgeries, or following a deterioration in their condition during their hospital stay. The latter represent a particularly problematic category, known as unscheduled admissions to intensive care [2], and are the main focus of our study.

Current guidelines use three main models to guide admission decisions: the prioritisation model, the

diagnosis model and the clinical parameters model. Although useful, these models are not a substitute for clinical judgement and pose organisational challenges, particularly in the absence of firm recommendations.

Unscheduled admissions are not only a clinical and organisational challenge, but they also have a considerable economic impact. The cost of intensive care in the United States in 2008 was estimated at between 121 and 263 billion dollars [3]. These healthcare services account for 16% to 38% of hospital costs and 5% to 11% of national healthcare expenditure, leading to inefficiencies such as waste, overuse, and delays in care.

A systematic review highlighted substantial methodological and statistical heterogeneity across 27 studies, precluding meta-analysis [4]. Reported rates of ICU admissions due to adverse events ranged from 1.1% to 37.2%, ICU readmissions from 0% to 18.3%, and preventability from 17% to 76.5%. These events were associated with increased ICU length of stay (1.5–10.4 days) and mortality rates ranging from 0% to 58%.

As pointed out in a French multicentre study [5], a good proportion of these admissions are induced by adverse events associated with care (AEAC) taking place on hospital wards. It should also be noted that unscheduled admissions of critical patients clearly disrupt the organisation of work, have physical and psychological consequences on the condition of patients and carers, and generate additional costs for healthcare systems. The quality of care is also compromised.

Adverse events associated with care (AEAC), often linked to unscheduled admissions, are key indicators of the quality and safety of care. These events can result from a variety of factors, such as medication errors or inadequate monitoring, with the prevalence varying considerably from one study to another [6]. Analysis of the underlying causes of these AEACs is therefore essential to improving the quality and safety of care.

According to recent findings [7], unscheduled transfers to intensive care units are correlated with a significant increase in morbidity, mortality and hospitalisation costs. Of the AEACs identified, 20%–50% are considered preventable [8, 9], and approximately 10%–20% are directly life-threatening [10].

The main objective of this study is to identify and classify the adverse events associated with care (AEAC) responsible for unscheduled admissions to intensive care. Using validated methodological tools, such as the Wilson classification [11–13], this research aims to analyse the specific characteristics of these events. By focusing on the dimensions of causality, severity and avoidability, the study aims to gain a better understanding of the mechanisms underlying their occurrence. The results will enable the development of targeted and appropriate strategies to prevent these events and limit their impact on the quality and safety of care.

Methodology of the study

This study was approved by the local hospital ethics committee under reference P2022/041.

This is a retrospective study conducted at a regional hospital with a capacity of 800 beds, including 24 dedicated to intensive care. The hospital manages a wide range of medical and surgical pathologies, except for neurosurgery and cardiac surgery.

File selection was based on the following criteria: Patients aged 18 years and over, admitted to intensive care between 1 January 2022 and 31 December 2022 whose admission to intensive care had taken place between the 24 and 144 hours were included. Non-inclusion criteria were defined as patients under 18 years of age, those admitted to intensive care following scheduled surgery, direct admissions from emergency departments, or inter-hospital transfers.

The complete file consisted of a medical section (diagnostic approach, laboratory and radiology results, daily notes, and hospitalisation reports), a nursing section (care plan and its implementation), and a pharmaceutical section (computerised medical prescription). We assessed the completeness of the records by awarding one point for each section completed in full and zero for each section completed in part. Although incomplete or ambiguous records were retained for review to avoid underdetection of potential adverse events, this methodological choice may introduce information bias. Incomplete documentation can simultaneously obscure and amplify evidence of AEACs, warranting cautious interpretation.

The files eligible for the study were examined as part of a multi-stage analysis process (Appendix 1),

followed by an expert panel comprising an anaesthetist, a resuscitator, an SIAMU nurse, and a clinical pharmacist. The choice of the members of this group was based on the search for efficiency and the relevance of the analysis.

In the first and second stages, we validated compliance with the inclusion and exclusion criteria and collected basic patient characteristics (gender, date of birth, reason for hospital admission, reason for transfer to intensive care, length of hospital stay before ICU transfer, day and time of ICU admission, number of drugs prescribed prior to hospitalisation, and the hospital unit or department from which the patient was transferred). We also gathered relevant clinical parameters specific to critically ill patients, including diagnostic and therapeutic procedures.

Following the initial two stages, the selected files underwent a comprehensive analysis by a panel of experts. Each file was meticulously reviewed to determine whether the reported adverse events associated with care (AEAC) aligned with the definition established by Wilson (Appendices 2 and 3). This validation process was conducted collaboratively, with each member of the multidisciplinary team contributing their specialised expertise: the physician examined the medical records, the SIAMU nurse assessed the nursing documentation, and the clinical pharmacist analysed the pharmacological data. A key aspect of this approach was the precise identification of the factors leading to the patient's transfer to intensive care.

The causality of AEAC was evaluated using a six-point scale (Appendices 2 and 3). Events with a score of 4 or higher, indicating a probability of causality exceeding 50%, were classified as AEAC with a high likelihood of causality. This threshold was established to minimise selection bias and ensure the relevance of identified events. When an AEAC with a high probability of causality was detected, a further analysis was conducted to assess its avoidability. This assessment followed a comparable scale, categorising events into three levels: no avoidability, low avoidability indices, and high avoidability indices (Appendices 2 and 3).

AEACs were subsequently categorised along two primary dimensions: event type (class), following the methodology of Zegers et al. [13], and severity of harm, based on the classification of the National Coordinating Council for Medication Error Reporting and Prevention [14]. Only categories

E, F, G, H, and I were retained, as they correspond to events that resulted in direct harm to the patient. Once the characteristics of AEAC were established, correlations between causality, avoidability, and severity were analysed to enhance the understanding of their interrelationships.

Finally, a root cause analysis of AEAC was performed using an Ishikawa diagram tailored to the specificities of the healthcare sector [15]. This methodological approach enabled the identification of key contributing factors to adverse events and facilitated the development of targeted recommendations aimed at their prevention and mitigation.

All analyses were conducted using Python (V3.11) and statistical libraries SciPy (V1.11.4) and Statsmodels (V0.14.0). The primary objective was exploratory, focusing on relationships between AEAC characteristics. Data normality was tested using the Shapiro–Wilk test; due to non-normal distribution ($P < .05$), Spearman's rank correlation was used. Simple linear regressions were performed to illustrate associations (R^2 values reported). No multivariate adjustment was applied.

Results

Characteristics of the population

In 2022, a hospital centre recorded 858 admissions to intensive care. Among these, 129 patients met the inclusion criteria. After reviewing the records, seven patients were excluded from the study: three due to an intensive care stay following carotid endarterectomy and four due to transfer from other medical institutions (Table 1). The study population was predominantly male, with an average age of 68, and more than 80% of the medical records had at least two complete components (Appendix 4).

Table 1 Demographic characteristics.[a]

	Numbers of patients
Number of ICU admissions in 2022	858
Number of eligible patients	129

Number of excluded patients	7
Number of included patients	122
Average age (range)	68 (19–88)
Male gender	78

[a] Summary of intensive care unit (ICU) activity in 2022 and demographic characteristics of patients included in the analysis of unscheduled ICU admissions AQ9.

Comorbidity and home treatment

Regarding comorbidity and home treatment, cardiovascular conditions were the most common, with 83% of patients presenting hypertension and 60% having heart disease. Endocrine disorders, such as diabetes, affected over 70% of the patients, while respiratory conditions and kidney failure were present in 43% and 40% of cases, respectively. Detailed information on these findings can be found in Appendices 5 and 6.

Patient origin and admission diagnosis

The diagnoses for intensive care admissions indicate that respiratory and infectious diseases were the predominant reasons, while surgical cases primarily involved orthopaedic and digestive interventions. Detailed information on these findings is provided in Appendix 7.

Analysis of the timing of unscheduled ICU admissions reveals that most admissions occurred between 1 p.m. and midnight, with a significant peak observed between 6 p.m. and midnight. This pattern of admissions is consistent with previous observations reported in the literature [16] (Fig. 1).

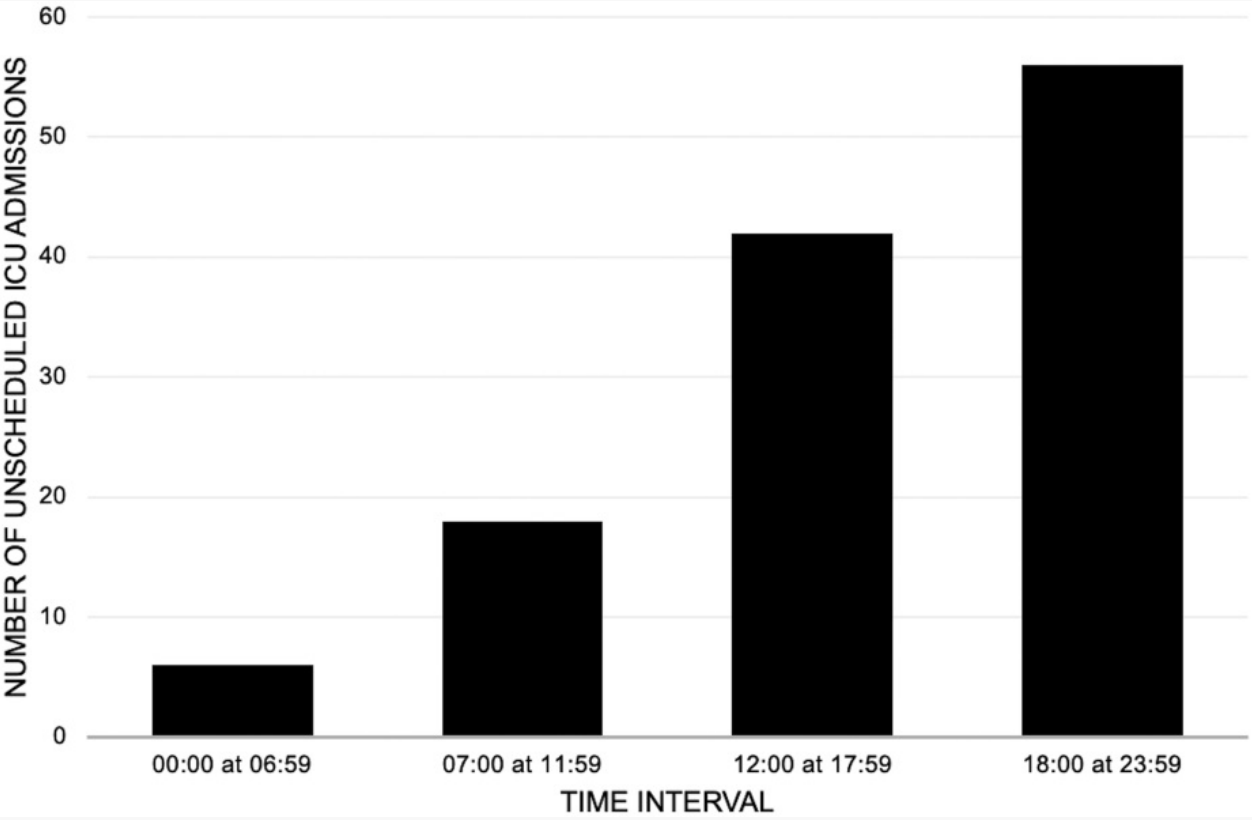

Figure 1 Temporal distribution of unscheduled ICU admissions over a 24-hour period. Histogram showing the number of unscheduled intensive care unit (ICU) admissions recorded between January and December 2022 in a regional hospital, according to the time of admission AQ8.

Characterisation of adverse events associated with healthcare (AEACs)

Using the definition established by Wilson et al. [11], our study identified 122 patients with unscheduled ICU admissions during the study period. Among them, 89 cases (73%) were associated with at least one adverse event associated with care (AEAC), while the remaining 33 admissions reflected the natural progression of the underlying condition (Table 2). Overall, these AEAC-related unscheduled admissions accounted for approximately 10% of all ICU admissions in 2022. AEACs were distributed across seven categories (Appendix 3, Table 2). Most were considered avoidable (Table 3), and detailed graphical representations are provided in Appendix 8.

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Table 2 Adverse event associated with care.[a]

Classes of adverse event associated with care	Number of AEAC	Percentage (%)
Organisational	58	36
Therapeutic	39	25
Diagnostic	30	19
Medication	20	12
Surgical	10	6
Anaesthesia	1	1
Procedure	1	1
Human factor	0	0
Equipment	0	0
Total adverse event associated with care	159	100
Natural evolution (number of patients)	33	

[a] Number and proportion of adverse events associated with care (AEAC) by incident family among patients with unscheduled ICU admissions AQ10.

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Table 3 Characteristic of adverse event associated with care.[a]

Incident Family	Causality > 4	Severity G	Severity H	Severity I	High avoidability 2	High avoidability 3	Combined severity	Combined avoidability
Organisational	46	6	6	22	12	22	34	34
Therapeutic	34	2	2	18	8	23	22	31
Diagnostic	29	1	6	16	5	18	23	23
Medication	19	0	4	10	1	16	14	17
Surgical	11	0	1	2	3	8	3	11
Anaesthetic	2	0	1	0	0	2	1	2

[a] ~~Distribution of AEACs by incident family according to causality score (>4), severity categories (G–I), and high avoidability indices~~ AQ11. [a]Distribution of AEACs by incident family according to causality score (>4), severity categories (G–I), and high avoidability index (scores 2 and 3) AQ11.

To further analyse the characteristics of AEACs, we assessed them based on causality, severity, and avoidability. Our analysis focused on high-probability adverse events, defined by a causality score of 4 or more, a severity level of G, H, or I, and a high avoidability index (scores 2 and 3) (Table 3). A significant proportion of these incidents met these criteria, and visual representations of the distributions are provided in Appendix 8.

Searching for root causes

To identify the underlying causes of AEACs, we focused on the first four AEAC families. A comprehensive root cause analysis was conducted using an Ishikawa (fishbone) diagram presented in Appendix 9. This diagram maps out the primary contributory factors—including organisational shortcomings, inadequate communication, procedural errors, and human factors—that potentially lead to AEACs. Complementing this, Appendix 10 provides a detailed breakdown of these root causes, specifying issues such as staffing deficiencies, workflow inefficiencies, and systemic process failures. These insights were gathered through structured brainstorming sessions with multidisciplinary care teams, ensuring that all key factors were rigorously identified. Together, these tools offer a framework for understanding and addressing the complex interplay of factors that contribute to adverse events, thereby guiding targeted interventions for improved patient care.

Correlation analysis

Spearman correlation demonstrated strong positive associations between AEAC causality and severity ($r = 0.78$, 95% CI [0.65–0.88], $P < .001$) and between causality and avoidability ($r = 0.72$, 95% CI [0.59–0.84], $P < .001$) (Table 4). Linear regression confirmed these relationships, with causality significantly predicting severity ($\beta = 0.65$, SE = 0.08, $P < .001$) and avoidability ($\beta = 0.52$, SE = 0.07, $P < .001$). The models were statistically significant ($F(1,120) = 25.3$, $P < .001$, $R^2 = 0.61$ for causality; $F(1,120) = 18.5$, $P < .001$, $R^2 = 0.55$ for avoidability). Graphical representations of these relationships are presented in Appendix 12.

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Table 4 Spearman correlation relationship.[c]

	Spearman's coefficient	*P*-value
Causality > 4 vs. Severity G	0.8986	$4.09\ 10^{-4}$
Causality> 4 vs. Severity H	0.9500	$2.57\ 10^{-5}$
Causality > 4 vs. Severity I	0.9780	$9.95\ 10^{-7}$
Causality > 4 vs. Avoidability 2	0.9685	$4.13\ 10^{-6}$
Causality > 4 vs. Avoidability 3	1.0000	.0 (close to zero)
Causality > 4 vs. Combined Severity[a]	0.9876	$1.03\ 10^{-7}$
Causality > 4 vs. Combined Avoidability[b]	1.000	.0 (close to zero)
Combined Severity vs. Combined Avoidability	0.9876	$1.03\ 10^{-7}$

[a] Combined severity: sum of severity G, H, and I.

[b] Combined avoidability: sum of high avoidability 2 and 3.

[c] Spearman correlation coefficients describing the relationships between AEAC causality, severity, and avoidability AQ12.

Discussion

Statement of principal findings

This exploratory descriptive study found that 73% of unscheduled intensive care unit (ICU) admissions were associated with adverse events related to healthcare. A distinct admission peak occurred between 6 p.m. and midnight, coinciding with periods of reduced medical coverage. The most frequent event categories were organisational, diagnostic, therapeutic, and medication-related. The statistical analysis was exploratory in nature and not intended to establish causality. Strong positive correlations were observed between causality, severity, and avoidability, indicating that the most severe events were also the most preventable. These findings provide a foundation for interpreting the organisational and clinical mechanisms underlying preventable ICU admissions, as discussed in the following sections.

Interpretation within the context of the wider literature

The high proportion of avoidable AEACs observed in our study highlights the urgent need for targeted preventive strategies and strengthened clinical surveillance, particularly during periods of reduced supervision. This finding is consistent with previous research reporting that a substantial proportion of unscheduled ICU transfers are preventable [18, 19], as also shown by Marquet et al., who identified that one in four such admissions was highly preventable [20]. Similarly, Vlayen et al. estimated that preventability rates ranged between 17% and 76%, depending on methodological heterogeneity [4].

Our results also align with prior evidence identifying human and organisational monitoring failures as major contributors to delayed recognition of clinical deterioration [5, 20]. By confirming these patterns within a different institutional context, our study reinforces the notion that AEAC-related ICU admissions are largely system-driven rather than patient-dependent. The strong correlations between causality, severity, and avoidability observed in our analysis further suggest that deficiencies in coordination, supervision, and communication may amplify the progression of adverse events. Collectively, these findings emphasise that strengthening organisational reliability and continuous patient monitoring are central components of effective prevention strategies.

Implications for policy, practice, and research

This study sheds light on the persistent challenge of unscheduled ICU admissions resulting from healthcare-associated adverse events. By identifying and characterising these critical incidents, we revealed strong interrelations between their causality, severity, and preventability, demonstrating that the most severe events are often the most avoidable. This multidimensional understanding highlights actionable opportunities for improving system performance and patient safety.

From an organisational perspective, these findings underline the central role of proactive monitoring and robust communication channels across care teams. Reinforcing patient surveillance—particularly during night shifts—and implementing structured handover and early warning systems could mitigate the risk of undetected clinical deterioration. Similar interventions have shown measurable reductions in preventable ICU transfers and in-hospital mortality [18–20].

Economically, our results emphasise the considerable cost of preventable AEAC-related ICU admissions, reflecting a form of *cost of poor quality*. A comprehensive cost assessment at both hospital and societal levels would offer valuable insights into their economic burden, especially within resource-constrained settings. Integrating economic and safety indicators aligns with the principles of *Value-Based Healthcare* [21], promoting strategies that simultaneously enhance patient outcomes and economic sustainability.

Finally, these findings pave the way for future research. Prospective multicentre studies should evaluate the effectiveness and cost-effectiveness of preventive interventions—such as early warning scores, multidisciplinary rapid response teams, and predictive modelling—across different healthcare contexts. Quantifying the economic impact of avoidable ICU admissions and the cost contribution of intensive care days [22] could guide evidence-based policy decisions and support prioritisation of funding for preventive strategies aimed at reducing unscheduled ICU admissions.

Strengths and limitations

Strengths

This study employs a rigorous analytical methodology, utilising validated tools such as Wilson's classification, Ishikawa diagrams, and advanced statistical methods including Spearman correlation and linear regression analyses. Additionally, the multidisciplinary approach enhances the reliability and validity of the findings.

Limitations

Several limitations must be acknowledged. The retrospective nature of the study may not fully capture current healthcare dynamics. The inclusion of incomplete medical records, while aimed at ensuring comprehensive case detection, may represent a source of information bias and potential overestimation of AEAC frequency. Additionally, the single-centre design and moderate sample size limit the generalisability of our findings to other hospital settings. These limitations underscore the need for further multicentre research to validate and extend our conclusions.

Conclusions

Consistent with previous research, our findings confirm the key characteristics and underlying causes of healthcare-associated adverse events. The strong correlations observed highlight the need for integrated preventive strategies and organisational improvements. These results support a proactive approach centred on enhanced clinical supervision and hospital-wide preventive practices to improve patient safety in unscheduled ICU admissions.

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Author contributions

Omar Abid conceived and designed the study, coordinated data collection, performed the analysis, and drafted the manuscript. Julien Carlier and Nordin Zaidi contributed to data collection, clinical interpretation of findings, and critical revision of the manuscript. Lahcen El Hiki provided academic co-supervision of the study, contributed to methodological guidance, and critically revised the manuscript. Christian Delvosalle and Stéphane Carlier contributed to academic supervision and critical revision of the manuscript. All authors reviewed and approved the final version of the manuscript and agree to be accountable for all aspects of the work**AQ3**.

Supplementary material

Supplementary material is available at *IJQHC* online**AQ4**.

Conflicts of interest

The authors declare that they have no competing interests**AQ5**.

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Ethics approval

The study was approved by the local Ethics Committee of the EpiCURA Hospital Group (reference number: P2022/041).

Consent to participate

Due to the retrospective design of the study and the use of anonymised patient data, the requirement for informed consent was waived in accordance with national regulations.

Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request, due to ethical and confidentiality restrictions AQ7.

"Data availability" is not available

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