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Effects of emergency department length of stay on inpatient utilization and mortality

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Abstract

Introduction The annual increase in emergency department (ED) visits in Taiwan has led to overcrowding in major hospitals and extended patient stays in the ED. International studies suggest that prolonged ED stays may influence healthcare costs and clinical outcomes for hospitalized patients. However, such investigations are scarce in Taiwan. This study aims to explore the effects of ED stay duration on inpatient medical utilization and mortality risk.

Methods This study analyzed data from 42,139 patients at a central Taiwan medical center, using generalized estimating equations (GEE) to evaluate hospital stay duration and costs. Logistic regression assessed mortality risks after hospitalization.

Results GEE analysis showed longer ED stays led to increased hospital stays: patients with 24–48 h in the ED had an additional 2.27 days ($P<0.001$), and those with ≥ 48 h had an additional 3.22 days ($P<0.001$). Logistic regression indicated higher mortality risks for patients with 24–48 h (OR = 1.73, $P<0.001$) and ≥ 48 h (OR = 2.23, $P<0.001$) in the ED compared to those with ≤ 2 h. Conversely, longer ED stays were associated with lower hospitalization costs; patients with ≥ 48 h in the ED incurred $1,211 less in costs compared to those with ≤ 2 h ($P<0.001$). Logistic regression revealed that longer ED stays were linked to higher mortality risks, with patients staying 24–48 h in the ED showing an OR of 1.726 ($P<0.001$) and those with ≥ 48 h an OR of 2.225 ($P<0.001$).

Conclusion Prolonged ED stays are associated with longer hospital stays, higher mortality risks, and lower hospitalization costs due to resource consumption in the ED. These findings highlight the need for strategies to reduce ED stay durations to improve patient outcomes and optimize resource use.

Keywords EDLOS, Hospital length of stay, Hospitalization costs, Mortality risk, Healthcare quality

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Introduction

The rapid increase in emergency department visits has led to an imbalance between supply and demand in large hospitals' emergency departments, a phenomenon known as emergency department overcrowding. This overcrowding results in the improper allocation of medical staff and bed resources, adversely affecting the quality of emergency medical services. Previous studies have indicated that when there is an imbalance between supply and demand for emergency medical resources, patients cannot receive appropriate care, potentially leading to the deterioration of their condition or even death [1]. Furthermore, emergency department overcrowding leads to a waste of medical resources and impacts the healthcare rights of individuals who genuinely require emergency services [2–4].

Emergency department length of stay (EDLOS) is a critical indicator for evaluating ED efficiency, particularly for patients requiring hospitalization [5, 6]. These patients often have a higher level of severity, necessitating continued care and treatment in the hospital. Research shows that the duration of EDLOS is associated with the length of hospital stay and mortality risk. Longer EDLOS typically correlates with increased hospital stay duration and mortality rates, along with rising medical expenses [7, 8]. This is particularly critical for severely ill emergency patients; if they cannot be admitted to the intensive care unit (ICU) within six hours, both their hospital stay and mortality rate significantly increase [9]. A 2007 study of 187 acute care hospitals in California found that patients with longer EDLOS had a 5% higher probability of in-hospital mortality [10], underscoring the importance of managing EDLOS to reduce patient mortality risk.

EDLOS is defined as the interval from the time a patient enters the emergency department until they are transferred to a hospital ward or discharged. A U.S. study indicated that patients with an EDLOS of less than two hours had an average hospital stay of 5.6 days, whereas those with an EDLOS exceeding 24 h had an average stay of 8.7 days. These results remained significant even after adjusting for comorbidities and other factors [11]. A study from the United Kingdom demonstrated that patients with an EDLOS greater than 12 h had a 12.4% longer hospital stay and an 11% increase in hospitalization costs [12]. Research using the Victoria Health Service Database in Australia found that patients with an EDLOS of 4–8 h had hospital stays approximately 20% longer than the national DRG average, and those with an EDLOS over 12 h saw an increase of up to 50% in hospital stay duration [13]. Additionally, numerous international studies have highlighted various safety issues associated with prolonged EDLOS, including an increased incidence of adverse events, a higher risk of ventilator-associated pneumonia in acutely intubated patients, higher ICU mortality rates for patients with an EDLOS over six hours, higher overall hospitalization rates, increased medication error rates, and a rise in preventable adverse events [9, 14–16].

Moreover, EDLOS is closely associated with the emergency department bed occupancy rate (EDBOR), which measures the proportion of ED beds occupied at a given time. A higher EDBOR indicates more severe hospital overcrowding, potentially exacerbating admission delays and prolonging EDLOS. Previous studies have demonstrated that when EDBOR exceeds 90%, hospital length of stay significantly increases, and the risk of adverse patient outcomes rises accordingly [17].

Although international studies have examined the relationship between EDLOS, hospital stay duration, costs, and mortality risk, such research is relatively scarce in Taiwan. The unique characteristics of Taiwan's healthcare system, particularly its universal health insurance payment model, introduce potential differences in these relationships that have not been adequately explored. However, whether these findings hold true in Taiwan's healthcare context, where hospital payment structures and healthcare accessibility differ significantly, remains unclear.

To address this gap, this study aims to analyze data from a medical center in central Taiwan to determine the impact of EDLOS on hospital utilization patterns, including length of stay, costs, and mortality risk. By doing so, this research seeks to provide context-specific insights that contribute to the understanding of EDLOS within Taiwan's healthcare system and inform healthcare policy development.

Materials and methods

Data sources

Using the clinical data repository developed by the Clinical Information Development Center of a medical center in central Taiwan, this study utilized data from 2012 to 2016. The study population consisted of patients who were admitted to the hospital following an emergency department visit, totaling 80,403 cases. After applying the inclusion and exclusion criteria, 59,703 cases (involving 42,139 individuals) were included for statistical analysis.

Inclusion and exclusion criteria

The inclusion criteria were patients admitted through the hospital's emergency department during the study period, covering all patients in both general wards and intensive care units. The exclusion criteria were as follows: patients under the age of 20, patients admitted through pediatric emergency or obstetrics and gynecology departments (as these specialties were considered irrelevant to the study of emergency and inpatient

medical utilization and mortality risk), and patients with a hospital stay of 30 days or more, who were defined as long-term hospitalizations.

Independent variable

The independent variable in our study is the EDLOS, which is categorized into five groups: <2 h, ≥2 and <6 h, ≥6 and <24 h, ≥24 and <48 h, and ≥48 h. EDLOS is calculated as the duration of time from the moment a patient enters the emergency department to the time they leave, whether through discharge, death, or transfer to an inpatient ward. Any duration less than an hour is rounded up to the nearest full hour to ensure consistency in measurement.

Dependent variable

The dependent variables in our study include three outcomes. The first is Length of Hospital Stay, measured in days and classified as a continuous variable. This variable is calculated from the time a patient is admitted to the ward until they leave the hospital, whether through discharge, transfer, or death. Any stay less than a full day is rounded up to one day. The second dependent variable is hospitalization costs, also a continuous variable, representing the total medical expenses incurred during a single hospitalization. These costs include consultation fees, ward fees, treatment costs, nursing fees, diagnostic fees, medication costs, anesthesia fees, material costs, and other related expenses. The third dependent variable is mortality, defined as a binary variable, representing all-cause death occurring during the hospitalization period.

Statistical analysis

We primarily investigate the length of EDLOS. According to the Taiwan Clinical Performance Indicator (TCPI) [18], EDLOS is categorized into five groups: <2 h, ≥2 and <6 h, ≥6 and <24 h, ≥24 and <48 h, and ≥48 h. For each group, we analyze mortality risk and hospital utilization, including the length of hospital stay and hospitalization costs. We initially employed descriptive statistics to examine the distribution of each variable. Additionally, we utilized a logistic regression model (Logit model) to investigate the risk factors associated with mortality. Additionally, to account for potential repeated measures in the calculation of hospital stay duration and costs, we employ the Generalized Estimation Equation (GEE) in our analysis. To avoid potential bias in the study findings, we conducted Collinearity Diagnostics prior to presenting the analysis results.

Results

After applying the exclusion criteria, our study sample comprised 59,703 cases. The group with the longest EDLOS, according to the Taiwan Clinical Performance Indicator (TCPI) classification, was the ≥6 and <24 h group, accounting for 41.1% of the sample, followed by the ≥24 and <48 h group, which made up 23.8%. Females constituted the majority of the sample (60.5%), and nearly half of the patients were aged 65 or older (49.3%). Based on the Taiwan Triage and Acuity Scale (TTAS), the majority of patients were classified as level 3 (53.7%). Most patients (58.2%) arrived at the hospital independently. According to Elixhauser's Comorbidity Measure, which includes 30 disease categories, patients with at least one comorbidity at the time of diagnosis were classified as having comorbidities. This group comprised 65.5% of the sample (Table 1).

Healthcare utilization

Our study on healthcare utilization focused solely on events occurring during the inpatient period, including the length of hospital stay and hospitalization costs. Hospitalization costs encompassed, but were not limited to, consultation fees, room charges, treatment fees, nursing fees, examination fees, medication costs, anesthesia fees, and material costs. Before analysis, we performed Collinearity Diagnostics and found no collinearity issues among the variables. In the GEE results, after controlling for other variables, we found that patients in the ≥2 and <6 h group had a hospital stay that was 2.01 days longer than the reference group ($p<0.0001$, 95% CI: 1.65–2.37). The ≥6 and <24 h group had a stay that was 1.8 days longer ($p<0.0001$, 95% CI: 1.44–2.11), and the ≥24 and <48 h group had a stay that was 2.27 days longer ($p<0.0001$, 95% CI: 1.92–2.61). The group with the longest stay was the ≥48 h group, with a stay that was 3.22 days longer than the reference group ($p<0.0001$, 95% CI: 2.86–3.57). These results indicate that the length of hospital stay increases with longer EDLOS (Table 2).

When examining hospitalization costs, using the group with the shortest EDLOS as the reference group, we found an inverse relationship between hospitalization costs and EDLOS. The ≥48 h group had the lowest hospitalization costs, which were US$1,211 less than the reference group ($p<0.0001$, 95% CI: -47,067 to -32,866). The ≥24 and <48 h group had lower costs (β: -1,100, $p<0.0001$), followed by the ≥6 and <24 h group (β: -9,51.71, $p<0.0001$), and the ≥2 and <6 h group (β: -6,31, $p<0.0001$). This suggests that longer EDLOS is associated with lower hospitalization costs (Table 2), a finding that intrigued us.

Mortality risk

Using unadjusted binary logistic regression to examine the relationship between EDLOS and mortality risk, we found that longer EDLOS was associated with higher mortality risk after controlling for other variables. The mortality risk for the ≥48 h group was double

Table 1 Characteristics of the samples studied

Variable	n	%
EDLOS		
< 2 h	1521	2.5
≧2 and < 6 h	9740	16.3
≧6 and < 24 h	23,864	41.1
≧24 and < 48 h	14,219	23.8
≧48 h	9729	16.3
Gender		
Female	23,350	39.5
Male	35,723	60.5
Age (years)		
20–34	4933	8.4
35–49	8467	14.3
50–65	16,533	28
>=65	29,140	49.3
Triage Classification Levels		
Lv.1	6990	11.8
Lv.2	18,433	31.2
Lv.3	31,733	53.7
Lv.4	1703	2.9
Lv.5	214	0.4
Way of Arrival to Emergency Department		
Self-Arrival	34,351	58.2
Referred Self-Arrival	13,565	23
119 Ambulance	5117	8.7
Private Ambulance	961	1.6
Transferred from Outpatient Department	5036	8.5
Other	41	0.1
Comorbidity		
Y	20,398	34.5
N	38,675	65.5
Experience for Specialist Attending Physician		
<=5 years	676	1.1
6–10 years	13,936	23.6
11–15 years	15,241	25.8
>=16 years	29,114	49.5
Patient Arrival Time		
Weekday	43,377	73.4
Holiday	15,696	26.6
Emergency Department Shift		
Day Shift	30,757	52.1
Night shift	21,274	36
Graveyard shift	7042	11.9

that of the group with the shortest EDLOS (aOR = 2.23, 95% CI = 1.848–2.678). The ≥ 24 and < 48 h group had a 1.73 times higher mortality risk (aOR = 1.73, 95% CI = 1.437–2.073), and the second shortest group had a 1.4 times higher mortality risk than the reference group (aOR = 1.40, 95% CI = 1.163–1.686) (Table 3). This finding was alarming, as over 40% of our study sample had an EDLOS of more than one day, indicating that a significant portion of patients were exposed to high mortality risk, an issue that urgently needs to be addressed.

Discussion

There is a direct correlation between EDLOS and patients' clinical outcomes. Numerous international studies have indicated that prolonged EDLOS increases hospital stay duration, hospitalization costs, and mortality risk [11, 12, 19–21]. Our study found that the average hospital stay for emergency department admitted patients was 9.84 days. Patients with an EDLOS exceeding 24 h had an average hospital stay of 9.95 days, which is 1.1% longer than the average. Those with an EDLOS exceeding 48 h had an average hospital stay of 11.19 days, representing a 13.7% increase compared to the average. After adjusting for other relevant factors, a significant positive correlation was observed between EDLOS and hospital stay duration, consistent with findings in the literature. Possible reasons include the close relationship between hospital bed occupancy rates and EDLOS for emergency admissions. When the bed occupancy rate exceeds 90%, the hospital stay duration increases significantly [17]. According to queueing theory, higher utilization leads to longer wait times for new patients [22]. Emergency department overcrowding forces patients who need admission to wait in the ED for extended periods, affecting their ability to receive appropriate care, thereby increasing the burden on emergency resources and prolonging hospital stay [23–25].

Regarding hospitalization costs, our study found that the average hospitalization cost for emergency department admitted patients was US$2,360, which decreased with longer EDLOS. Patients with an EDLOS ≤ 2 h had the highest average hospitalization cost of US$3,730, while those with an EDLOS exceeding 48 h had an average cost of US$2,519. After adjusting for other relevant

Table 2 Relationship between EDLOS, length of hospital stay, and hospitalization cost

Variable	Length of Hospital Stay(days)				Hospitalization Cost(USD)			
	β	SE	95%CI	*p*-value	β	SE	95%CI	*p*-value
EDLOS								
< 2 h(ref.)								
≧2 and < 6 h	2.01	0.182	(1.654–2.366)	< 0.0001**	-631.76	112.27	(-851.80–411.72)	< 0.0001**
≧6 and < 24 h	1.774	0.173	(1.435–2.113)	< 0.0001**	-951.54	108.36	(-1163.92–739.15)	< 0.0001**
≧24 and < 48 h	2.265	0.177	(1.918–2.612)	< 0.0001**	-1100.20	108.75	(-1313.34–887.06)	< 0.0001**
≧48 h	3.215	0.183	(2.856–3.574)	< 0.0001**	-1211.10	109.78	(-1426.27–995.94)	< 0.0001**

Table 3 Adjusted mortality risk by EDLOS time groups

Variable	aOR	95%CI	*p*-value
EDLOS			
< 2 h			
≧2 and < 6 h	1.4	(1.163–1.686)	< 0.0001**
≧6 and < 24 h	1.415	(1.182–1.694)	< 0.0001**
≧24 and < 48 h	1.726	(1.437–2.073)	< 0.0001**
≧48 h	2.225	(1.848–2.678)	< 0.0001**
Gender			
Female			
Male	1.212	(1.147–1.281)	< 0.0001**
Age (years)			
20–34			
35–49	2.911	(2.432–3.484)	< 0.0001**
50–65	4.142	(3.493–4.911)	< 0.0001**
>=65	4.825	(4.081–5.705)	< 0.0001**
Triage Classification Levels			
Lv.1			
Lv.2	3.75	(2.259–6.225)	< 0.0001**
Lv.3	1.523	(0.919–2.523)	0.102
Lv.4	0.985	(0.595–1.630)	0.952
Lv.5	0.906	(0.532–1.545)	0.718
Way of Arrival to Emergency Department			
Self-Arrival			
Referred Self-Arrival	0.71	(0.663–0.760)	< 0.0001**
119 Ambulance	1.283	(1.173–1.403)	< 0.0001**
Private Ambulance	1.931	(1.625–2.293)	< 0.0001**
Transferred from Outpatient Department	0.948	(0.855–1.050)	0.304
Other	0.565	(0.206–1.545)	0.266
Comorbidity			
Y			
N	1.822	(1.717–1.935)	< 0.0001**
Experience for Specialist Attending Physician			
<=5 years			
6–10 years	1.531	(1.136–2.065)	0.005**
11–15 years	1.814	(1.347–2.443)	< 0.0001**
>=16 years	2.075	(1.545–2.787)	< 0.0001**
Patient Arrival Time			
Weekday			
Holiday	0.983	(0.925–1.045)	0.581
Emergency Department Shift			
Day Shift			
Night shift	0.898	(0.847–0.952)	< 0.0001**
Graveyard shift	0.845	(0.774–0.923)	< 0.0001**

factors, a significant negative correlation was observed between EDLOS and hospitalization costs, contrary to previous literature [13, 26, 27]. Recent studies have shown that overcrowding in emergency departments can lead to treatment delays, requiring hospitals to allocate more resources to save patients. However, these studies did not clarify whether the additional resources were utilized in the emergency department or during subsequent inpatient care, leaving room for further investigation [25]. Since the study subjects were patients awaiting a definite diagnosis and admission, most were complex and critically ill, requiring extensive testing in the ED before admission [28]. The longer these patients stayed in the ED, the more emergency medical costs were incurred, leaving fewer new procedures or tests for specialists to perform during the hospital stay, thus relatively lowering hospitalization costs. This result warrants further investigation in future research.

The mortality risk results showed that the mortality rate for emergency department admitted patients was 12.3%. Patients with an EDLOS of 24–48 h had a mortality rate of 12.5%, while those with an EDLOS exceeding 48 h had a mortality rate of 16.0%, representing increases of 1.6% and 30.1%, respectively, compared to the overall mortality rate. After adjusting for other relevant factors, a significant positive correlation was observed between EDLOS and mortality risk, consistent with findings in the literature. Studies have indicated that prolonged EDLOS increases mortality rates [29], and that mortality rates within 7 days and 30 days post-admission are associated with emergency and hospital overcrowding [15]. Recent findings suggest that both extremely short EDLOS and EDLOS exceeding 24 h are associated with in-hospital mortality (IHM), emphasizing the need to minimize prolonged ED stays while also paying special attention to patients admitted after a very short ED stay [30]. The continuity of care for patients waiting for admission in the ED may be affected by frequent shift changes, with priority given to the evaluation of new patients, potentially diverting attention from those waiting for admission [10]. This situation increases the risk of medical errors and adverse events [31]. The risk of adverse events increases with prolonged EDLOS, and short-term mortality risk for emergency department admitted patients is higher [32]. In summary, prolonged EDLOS increases the risk of mortality for patients.

Additionally, insufficient human resources may be another fundamental factor contributing to prolonged EDLOS and higher mortality rates. Hospitals in Taiwan face the dual challenge of increasing emergency department patient volumes and strained medical personnel capacity. Previous studies have proposed three key strategies to address these issues. First, staff scheduling should be adjusted based on peak ED hours, including the establishment of flexible stations and dynamic allocation of staff. Second, time window arrangements can be estimated based on the distribution of patient visits and subsequently adjusted according to the progress of patient flow. Finally, manpower allocation should be dynamically adjusted according to the waiting times at each station to optimize resource utilization effectively.

ED overcrowding, in addition to its impact on mortality risk, negatively affects the timing and process of

triage, leading to prolonged patient wait times and a decline in service quality, which delays diagnosis and the initiation of treatment. This condition may also cause more patients to abandon overcrowded EDs without receiving appropriate medical care [33]. Furthermore, overcrowding places significant stress and burnout on healthcare providers [34], representing another serious consequence. Additionally, overcrowding may reduce the time patients spend with physicians, potentially compromising the quality of interactions. Separately, overcrowding can also increase the likelihood of adverse medical events due to the strained healthcare environment [35, 36].

From a policy perspective, reducing EDLOS should be a top priority to improve patient outcomes and optimize resource allocation. Strategies such as enhancing emergency department staffing, streamlining admission processes, and investing in infrastructure to expand capacity and manage patient flow more efficiently are essential. By addressing EDLOS-related challenges, healthcare systems can improve clinical outcomes, reduce mortality, and ensure equitable access to care. Future research should evaluate the effectiveness of these interventions in diverse healthcare settings to provide more comprehensive insights.

This study has potential limitations that should be acknowledged. First, the selection of EDLOS < 2 h as the reference group may introduce confounding factors, as patients in this category are often critically ill, requiring urgent interventions and extensive resource utilization. These factors may contribute to higher hospital costs and mortality risk compared to other groups, potentially influencing the interpretation of EDLOS impacts on hospital length of stay, medical costs, and mortality risk. Although we controlled for Triage Classification Levels to adjust for patient acuity, residual confounding may persist. Second, during the course of our analysis, we identified trauma status as a potential factor influencing EDLOS and patient outcomes. Trauma patients often have distinct care pathways, which could impact the relationships observed in this study. While Triage Classification Levels partially account for variations in patient acuity, they may not fully capture differences attributable to trauma status. Future studies should consider incorporating trauma stratification to better understand its role and provide more comprehensive insights into the impact of EDLOS on patient outcomes. Third, our study did not exclude patients who received life-saving interventions, as the database did not include specific markers for such interventions. These patients, who often require immediate and intensive medical care, may exhibit distinct patterns of EDLOS, hospital costs, and mortality risk, which could influence the overall findings. Future research with access to datasets containing detailed information on life-saving interventions is warranted to further refine these results and explore their specific impact.

Method discussion

The methodological approach of this study demonstrates several strengths. The large dataset spanning from January 1, 2012, to December 31, 2016, includes a total of 80,403 individuals, with 59,703 cases meeting the inclusion criteria. This comprehensive dataset ensures robust statistical power and enhances the generalizability of findings within the Taiwanese healthcare context. Furthermore, the application of GEE effectively addresses potential repeated measures in hospitalization data, thereby improving the reliability of the analytical results.

However, this study's methodology also has certain shortcomings. First, the study design relied on secondary data, which limited the availability of specific clinical details, such as markers for life-saving interventions or precise indicators of patient acuity. Second, the categorization of EDLOS into discrete time intervals, while practical, may oversimplify the continuous nature of time data and obscure finer nuances in its relationship with patient outcomes. Third, while GEE is well-suited for handling repeated measures, it assumes a certain structure for the correlation within clusters, which may not fully capture the complexity of the data.

Conclusion

The study reveals a significant positive correlation between EDLOS and both hospital stay duration and mortality risk. Patients with an EDLOS exceeding 24 h experienced significantly longer hospital stays and higher mortality risk. Specifically, patients with an EDLOS of 24–48 h had an extended hospital stay by an average of 2.29 days and an increased mortality risk (OR = 1.73, $P < 0.001$). For those with an EDLOS exceeding 48 h, the hospital stay was prolonged by an average of 3.24 days, and the mortality risk was even higher (OR = 2.23, $P < 0.001$). Additionally, there is a negative correlation between EDLOS and hospitalization costs; the longer the EDLOS, the relatively lower the hospitalization costs, reflecting the excessive consumption of emergency resources. These findings underscore the critical importance of effectively managing EDLOS to improve clinical outcomes for patients.

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Author contributions

K.J.M., Y.C.H., and J.Y.W. designed and conceptualized the study and analyzed the data. K.J.M. and Y.C.H. drafted the first version of the article. W.W.P. contributed to the early-stage database integration, data cleaning, and initial exploratory analysis. W.W.P., M.H.C., W.S.C., and J.Y.W. performed the literature search and reviewed the article. All authors contributed substantially

to the article and approved the final article for submission. All authors are responsible for the integrity, accuracy, and presentation of the data.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
In this study, all the research database involving humans were conducted ethically and in accordance with the Declaration of Helsinki. Our study protocols were reviewed and approved by the Institutional Review Board I&II of the Taichung Veterans General Hospital(CE18030B). To protect the patients' privacy, all personal identification numbers were encrypted by the Taichung Veterans General Hospital before the data were analyzed and released. Therefore, patient informed consent is not required for authorized researchers to access this research database. The researchers of this study are not possible to contact any studied patient for obtaining informed consent. No informed consent form is used in this study. Furthermore, the Institutional Review Board I&II of the Taichung Veterans General Hospital(CE18030B) also specifically waived the requirement of informed consent.

Competing interests
The authors declare that there are no conflicts of interest regarding the publication of this manuscript. The research was conducted independently, without any financial or personal relationships that could be viewed as potential conflicts of interest.

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