Acta Anaesth. Bel., 2026, 77 (3): *207-217*

Original study

Very Old Intensive Care Patients Across Two Eras: A Retrospective Cohort Study Comparing Outcomes Between 2005–2009 and 2015–2019

De Pauw L.[1], De Keukeleere E.[2], Quisquater M.[3,4], De Grauwe T.[3,4], Pauwels J.[3], Koch A.[4], Mignolet K.[3,4], Temmerman W.[4], Pannier E.[3,4], Sarens T.[4], Termote E.[3,4], Swinnen W.[3]

[1]Department of Anesthesiology, Leuven University, Leuven University Hospitals, Leuven, Belgium; [2]Department of Anesthesiology, Ghent University, Ghent University Hospital, Ghent, Belgium; [3]Department of Anesthesiology, AZ Sint-Blasius, Dendermonde, Belgium; [4]Department of Intensive Care, AZ Sint-Blasius, Dendermonde, Belgium.

Corresponding author: W. Swinnen, Department of Anesthesiology, AZ Sint-Blasius, Kroonveldlaan 50, 9200 Dendermonde, Belgium. Email: walter.swinnen@azsintblasius.be

Abstract

Background: Over the past two decades, the proportion of very old intensive care patients (VIPs; aged ≥ 80 years) admitted to intensive care units has significantly increased. Despite advances in critical care, outcomes for this vulnerable population remain variable and poorly understood across different eras in medical practice.

Objectives: This study aimed to compare the one-year outcomes of VIPs admitted to the ICU between 2005–2009 (05–09) and 2015–2019 (15–19), assess shifts in demographics and case mix, and evaluate outcomes for time-sensitive admission diagnoses.

Design and Setting: Single-center retrospective cohort study conducted in a 12-bed mixed medical-surgical ICU at Sint-Blasius General Hospital, Belgium.

Methods: All ICU admissions of VIPs during the two periods were analyzed. Patients with missing data or non-retrievable patient files were excluded. For patients with repeated ICU admissions within one year, only data from the last admission were considered. Propensity Score Matching (PSM) was applied to adjust for age, sex, SAPS II score, and APACHE IV admission diagnosis. ICU Length of Stay (LOS) was additionally explored as an indirect surrogate for end-of-life decision-making. Kaplan-Meier survival analysis and statistical tests were used to compare outcomes up to 1 year after ICU admission.

Results: A total of 885 VIPs were admitted between 05–09 versus 1267 between 15–19. After exclusion, 747 and 1066 ICU admissions from the 05–09 and 15–19 periods, respectively, were analyzed. ICU admissions of VIPs increased among the 15–19 group, with older patients exhibiting lower SAPS II scores. Over time, the top 25 APACHE IV diagnoses showed significant changes. Medical admissions were predominant, whereas planned surgical admissions decreased in 15–19. Despite these shifts, the overall mortality rate remained unchanged. However, there was a notable improvement in ICU LOS in 15–19. PSM was employed to adjust for biases and create two well-balanced cohorts of 506 patients, revealing no significant differences in overall mortality. For time-sensitive conditions, such as AMI, CVA, and sepsis, ICU mortality and LOS improved significantly in 15–19, whereas outcomes for less time-sensitive conditions, such as CHF, COPD exacerbation, and pneumonia, remained unchanged. The reduction in ICU LOS in the later period was primarily driven by shorter ICU stays among survivors (PSM analysis), as suggested by an exploratory surrogate analysis.

Conclusion: Despite an older and more complex ICU population in 15–19, adjusted survival outcomes remained

Preliminary data for this study were presented as a poster presentation at the Euroanaesthesia 2025 meeting in Lisbon, on May 25-27, 2025.

The study was approved by the Committee for Medical Ethics of AZ Sint-Blasius (AZ Sint-Blasius, Kroonveldlaan 50, 9200 Dendermonde, chairperson Dr. Sabine Serry, approval number BB012201941151) on August 20, 2019. EU-GDPR requirements were met.

stable. Improvements in early recognition and standardized treatment protocols have likely contributed to better outcomes for specific acute conditions. However, missing frailty data and residual confounding limit the ability to draw definitive conclusions. Further prospective studies are warranted.

Key words: **Intensive Care Units, Critical Care, Very Old Patients, Survival, Propensity Score Matching, Time-Sensitive Diagnoses.**

Introduction

Over the past few decades, intensive care medicine has undergone profound transformations. As global life expectancy increases and chronic disease management improves, adults aged ≥ 80 years, referred to as very old intensive care patients (VIPs), now represent a growing proportion of ICU admissions worldwide[1]. These patients often present with increased frailty, multimorbidity, and diminished physiological reserve, resulting in a more complex response to critical illness and greater variability in outcomes than younger cohorts[2].

Despite significant advances in diagnostics, therapeutics, and ICU protocols, improving survival and long-term outcomes in VIPs remains a formidable challenge. Previous studies have shown that mortality rates in this population are higher, and survivors frequently experience functional decline, cognitive impairment, and reduced quality of life[3]. However, the extent to which medical progress has resulted in better outcomes for VIPs remains unclear. Few studies have systematically compared ICU outcomes for VIPs across distinct periods of clinical practice, making it difficult to determine whether improvements in care have helped reduce the unique risks faced by this age group[4,5].

The criteria for ICU admission have become more stringent, with stricter triage and treatment limitation policies to avoid non-beneficial interventions[6]. These changes may have led to a more selective ICU population, potentially influencing severity scores and case mix over time. Additionally, the use of standardized treatment protocols and early warning systems for time-sensitive conditions, such as acute myocardial infarction (AMI), cerebrovascular accident (CVA), and sepsis, may have improved early mortality and ICU efficiency, although long-term survival remains unchanged. Understanding these trends over time is crucial for guiding ICU triage, allocating resources, and developing care protocols tailored to different age groups.

We hypothesized that survival outcomes for VIPs would improve over time because of advances in critical care, particularly for time-sensitive diagnoses. Therefore, the primary objective of this study was to compare one-year survival rates of VIPs admitted to the ICU between 2005-2009 (05-09) and 2015-2019 (15-19). Secondary objectives included assessing shifts in demographics and case mix and evaluating outcomes for VIPs with time-sensitive APACHE IV admission diagnoses.

Methods

Setting and study design

We conducted a retrospective single-center cohort study using data from a 12-bed mixed medical-surgical ICU at Sint-Blasius General Hospital in Dendermonde, Belgium. The study was approved by the Medical Ethics Committee of AZ Sint-Blasius (AZ Sint-Blasius, Kroonveldlaan 50, 9200 Dendermonde; Chairperson: Dr. Sabine Serry; approval no. BB012201941151) on August 20, 2019, and complied with all the EU-GDPR regulations.

Data collection

Intensivists collected data on demographics, length of hospital and ICU stay, Acute Physiology And Chronic Health Evaluation IV (APACHE IV) admission diagnoses, and Simplified Acute Physiology Score II (SAPS II). Physiological data were obtained from paper records. Demographic and laboratory data were collected electronically. An ICU database search (Mediscore ICU; Itémedical, Tiel, The Netherlands) identified all VIPs admitted between 05-09 and 15-19. Cross-referencing with the Belgian National Register provided vital status or date of death.

Inclusion and exclusion criteria

All ICU admissions of VIPs from January 1, 2005, to December 31, 2009, and from January 1, 2015, to December 31, 2019, were included. VIPs were defined as patients aged ≥ 80 years. To prevent bias from multiple readmissions, all data concerning admissions and readmissions in the 1-year period before the last (re)admission were excluded. Patients with missing data or non-retrievable patient files were excluded.

Plan of investigation

This study compared the ICU admission volume, case mix, and outcomes of VIPs during two distinct

periods (05–09 and 15–19), reflecting major temporal changes in critical care practice (including improvements in cardiovascular interventions, sepsis management, noninvasive ventilation, organ support, and chronic disease treatment), admission policies, and population demographics. We focused on three clinically relevant endpoints: ICU length of stay (LOS), in-hospital mortality, and 12-month survival rates.

To minimize bias from differences in baseline characteristics and case mix, we applied the Propensity Score Matching (PSM) method. The cohorts were matched based on age, sex, SAPS II, and APACHE IV admission diagnoses. This resulted in two statistically comparable cohorts, allowing us to assess the differences in outcomes more accurately.

Recognizing the importance of timely intervention in older patients with limited physiological reserves, we performed subgroup analyses of VIPs admitted with time-sensitive conditions. Six frequent time-sensitive ICU pathologies were selected and divided into two subgroups. The first subgroup included AMI, CVA, and sepsis, as these conditions have established treatment protocols developed in the past decades and narrow therapeutic windows. The second subgroup included conditions with less standardized acute management, including congestive heart failure (CHF), COPD exacerbations, and pneumonia.

Another relevant temporal change to consider is how end-of-life (EoL) decision-making or policy has evolved and how this affects the endpoints of this study. Because detailed and reliable data on withholding or withdrawal of life-sustaining treatment were unavailable for a substantial part of the study period, ICU LOS was additionally analyzed as an indirect surrogate indicator of EoL decision-making in the total population and after PSM. ICU LOS was compared between survivors and non-survivors within each period and between the periods. Shorter LOS among non-survivors was explored descriptively as a potential indicator of earlier treatment limitation.

In summary, by integrating demographic shifts, severity scores, and diagnosis-specific outcomes, this investigation aimed to clarify whether advances in ICU care have translated into improved survival and care efficiency for VIPs and to identify areas in which further improvements are required.

Statistical analysis

The null hypothesis (H0) posits that there is no difference in the results between the two study periods, whereas the alternative hypothesis (H1) indicates a difference between them. Statistical analyses were conducted using the XLStat software (Lumivero (2024). XLSTAT statistical and data analysis solution. New York, USA. https://www.xlstat.com), Statskingdom (https://www.statskingdom.com), VassarStats (http://www.vassarstats.net), MedCalc (https://www.medcalc.org), and Social Science Statistics (https://www.socscistatistics.com). Groups were compared using the Shapiro-Wilk test for normality. We compared non-normal distributions using the Mann-Whitney U test and reported the median and interquartile range (IQR). For normal distributions, we used Student's t-test and reported the mean and standard deviation. Categorical data were compared using the chi-square or Fisher's exact test. Odds ratios (ORs) with 95% confidence intervals (CI) were used to compare the differences in the top 25 APACHE IV admission diagnoses.

Model fit was assessed using R^2 (Cox and Snell) and the Hosmer-Lemeshow statistic. PSM was used to adjust for biases related to sample size, age, sex, APACHE IV admission diagnosis, and SAPS II score. The Mahalanobis distance algorithm with one-to-one and caliper-matching techniques was applied. The maximum permissible distance was established as 0.10 of the pooled standard deviation of the logit of the propensity score with a confidence level of 95%. The highest acceptable difference in the propensity score was 0.001. The model incorporated covariates such as age, sex, APACHE IV admission diagnosis, and SAPS II score. The corresponding author can be contacted for a comprehensive account of the PSM results. To determine whether the PSM cohorts were similar, we measured the effect size using Cohen's d for the logit of the propensity score. A small effect size was pursued, as it indicated better matching and thus, similar cohorts.

Kaplan-Meier survival analysis with the log-rank test was performed to assess survival rates up to 12 months after ICU admission for both the total population and PSM cohorts. The relative risk of mortality was calculated using a 95% CI. Statistical significance was set at $p < 0.05$.

Results

05-09 versus 15-19 before Propensity Score Matching

Patient characteristics

Patient characteristics and case mix are shown in Table I. Sex did not differ between the two groups ($p = 0.086$). Patients were significantly older ($p = 0.022$) and had a lower SAPS II score ($p = 0.031$) in the 15–19 group. Medical admissions

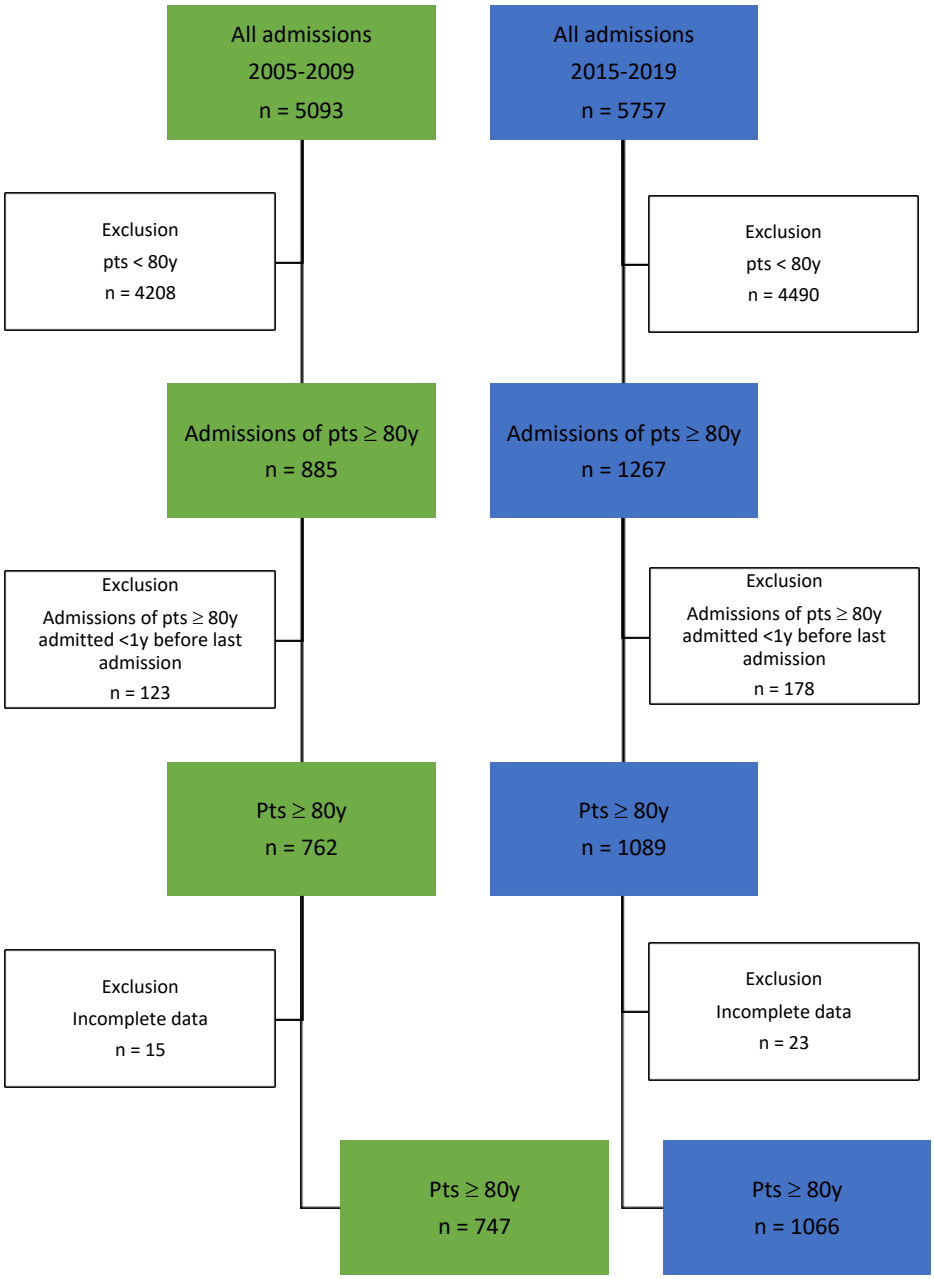


Fig. 1 — Consort Diagram.

represented the majority of admissions during both study periods. The number of planned surgical admissions was significantly lower in the 15–19 group ($p < 0.0001$).

Evolution of case mix and Apache IV admission diagnoses

Figure 2 shows the evolution of the top 25 APACHE-IV admission diagnoses of VIPs over a 15-year period. The increase in VIP admissions over time was accompanied by a pronounced shift in the ICU case mix, as reflected by changes in the distribution of APACHE IV admission diagnoses. Between 05–09 and 05–19, several diagnoses became markedly more prevalent, whereas others declined, reflecting broader changes in clinical practice, patient selection, and underlying population health. The diagnoses with increased odds ratios for ICU admission in the 15–19 cohort included medical diagnoses, such as cardiac rhythm disturbances ($p < 0.0001$), pneumonia ($p = 0.045$), and acid-base electrolyte disturbances ($p = 0.034$). Conversely, diagnoses with reduced odds ratios for ICU admission included several postoperative admissions, such as surgery for colon/rectal cancer ($p = 0.006$), total hip replacement ($p = 0.014$), and pelvic trauma ($p < 0.0001$). Medical admissions with reduced odds ratios included sepsis and septic shock ($p = 0.027$), emphysema/bronchitis ($p = 0.005$), myocardial infarction ($p < 0.0001$), and cardiogenic shock ($p = 0.011$). Interestingly, some diagnoses remained relatively stable across both periods, suggesting consistent ICU admission patterns for certain conditions, regardless of temporal or

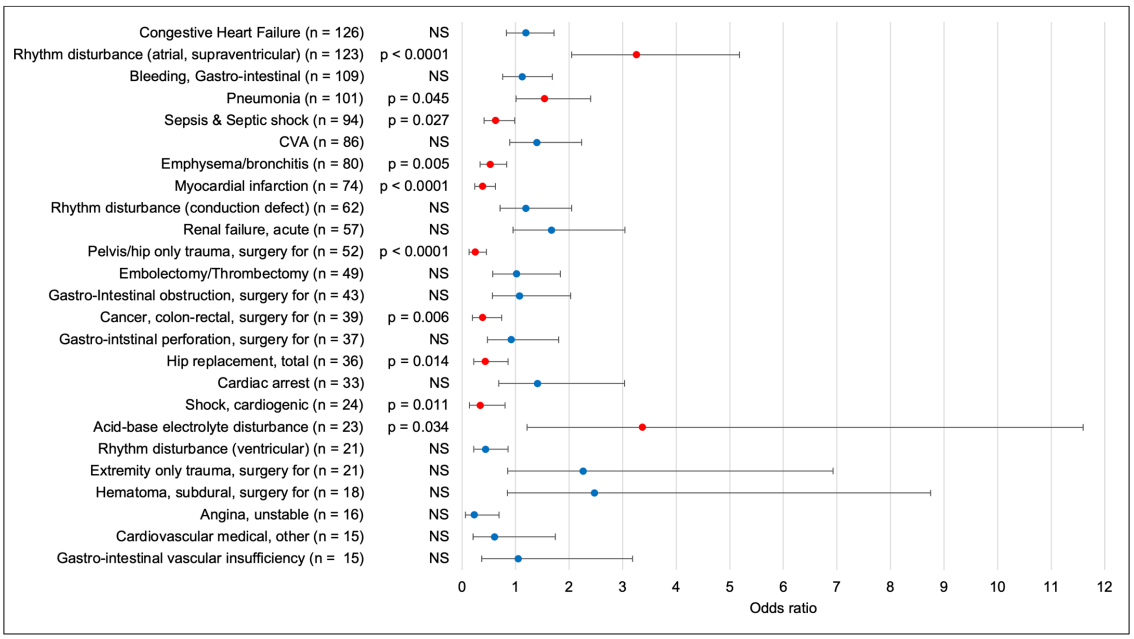
Table I. — Demographic data of the original cohorts and after Propensity Score Matching.

ORIGINAL COHORTS	05-09	15-19	
Admissions >80 years (n)	747	1066	p < 0.0001
Age (years, median, (IQR))	83 (4)	84 (5)	p = 0.022
Sex (M/F)	333/414	511/555	p = 0.086
SAPS II (median, (IQR))	36 (20)	35 (17)	p = 0.031
LOS ICU (days, median, (IQR))	3 (2)	2 (2)	p < 0.0001
Hospital Admission Type: Emergency Surgery / Planned surgery / Medical (n)	91/169/487	119/150/797	p < 0.0001
Hospital Mortality: Death in ICU / Death in hospital after ICU / Discharged alive) (n)	75/116/556	105/140/821	p = 0.334
Survival up to 12 months after ICU admission (%)	59.6	61.6	p = 0.373
AFTER PROPENSITY SCORE MATCHING	**05-09**	**15-19**	
Admissions >80 years after PSM (n)	506	506	
Age (years, median, (IQR))	83 (5)	83 (5)	p = 0.607
Sex (M/F)	227/279	224/282	p = 0.849
SAPS II (median, (IQR))	36 (IQR 20)	36 (IQR 16)	p = 0.857
LOS ICU (days, median, (IQR))	3 (IQR 3)	2 (IQR 2)	p = 0.0001
Hospital Admission Type: Emergency Surgery / Planned surgery / Medical (n)	24/82/400	38/70/398	p = 0.128
Hospital Mortality: Death in ICU / Death in hospital after ICU / Discharged alive) (n)	46/84/376	57/74/375	p = 0.405
Survival up to 12 months after ICU admission (%)	59.1	57.9	p = 0.658

IQR: Interquartile range; SAPS: Simplified Acute Physiology Score; LOS ICU: Length of Stay in ICU.

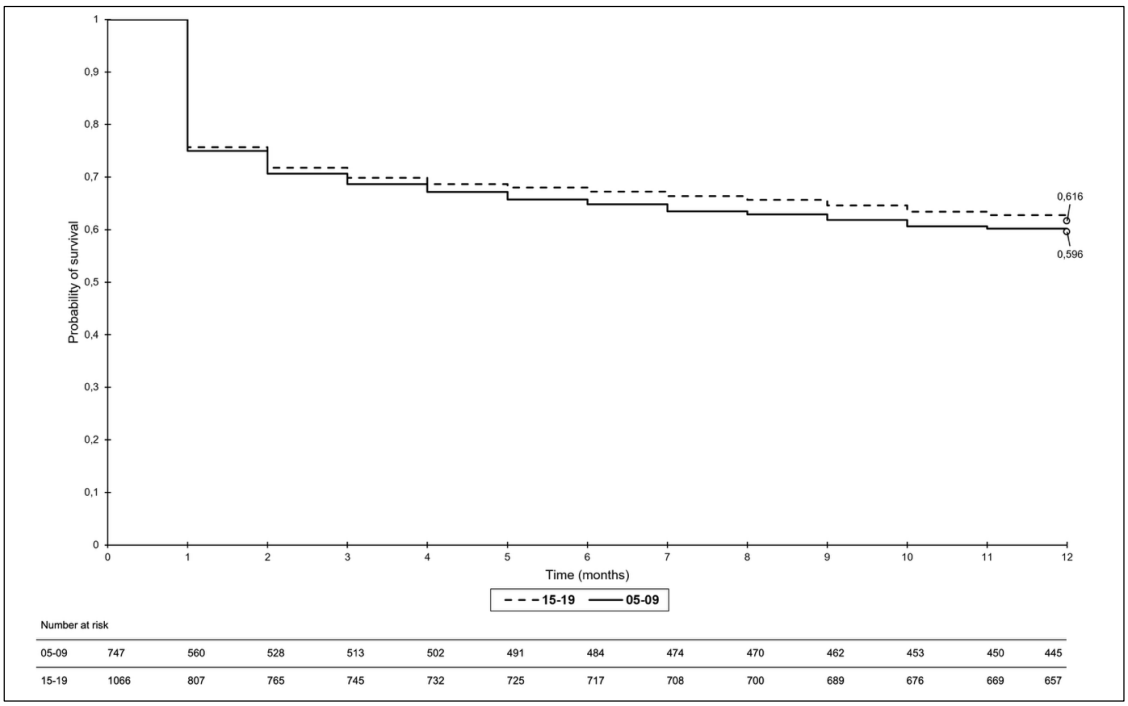
demographic shifts. These included medical and surgical neurological diagnoses (CVA, subdural bleeding, surgery for subdural hematoma), surgical and medical gastrointestinal (GI) diagnoses (GI surgery for obstruction or perforation, GI vascular insufficiency), several cardiac diagnoses (congestive heart failure, cardiac arrest, unstable angina, and other medical cardiovascular admission diagnoses), and peripheral vascular surgery (embolectomy/thrombectomy).

Despite the substantial increase in VIP ICU admissions and the pronounced evolution in case mix, overall mortality remained unchanged, underscoring a critical insight: an evolving case



APACHE: Acute Physiology And Chronic Health Evaluation; NS: not significant; CVA: cerebrovascular accident

Fig. 2 — Evolution of Top 25 APACHE IV admission diagnoses.



15-19: Patients ≥ 80 years admitted between 2015-2019 (n = 1066); 05-09: Patients ≥ 80 years admitted between 2005-2009 (n = 747); Log-rank test: 0.974; p = 0.373

Fig. 3 — Kaplan-Meier Survival distribution function – original cohorts.

mix alone does not necessarily translate into improved outcomes.

Length of stay (LOS)

The ICU LOS was significantly lower in the 15–19 group (Table I). ICU LOS differed significantly between survivors and non-survivors in both the study periods. In 05–09, non-survivors (n = 190) had a median ICU LOS of 3 days (IQR 4), whereas survivors (n = 557) had a median LOS of 3 days (IQR 2) (p = 0.003). In 15–19, non-survivors (n = 245) had a median LOS of 3 days (IQR 3), while survivors (n = 821) had a significantly shorter LOS of 2 days (IQR 1) (p = 0.0005). When comparing periods, LOS among non-survivors remained largely unchanged between 05–09 and 15–19 (median 3 days in both periods), although the distribution differed slightly (IQR 4 vs. 3; p = 0.038). In contrast, LOS among survivors decreased significantly over time, from a median of 3 days (IQR 2) in 2005–2009 to 2 days (IQR 1) in 2015–2019 (p < 0.0001).

These findings suggest that the reduction in overall LOS observed in the later period was primarily driven by shorter ICU hospitalization among survivors, while LOS among non-survivors remained stable.

Mortality

In-hospital mortality did not differ significantly between the groups (Table I). There were no differences between patients who died in the ICU, those who died during hospitalization, and those who were discharged alive.

Survival up to 12 months after ICU admission

The Kaplan-Meier survival distribution function is presented in Figure 3. Survival after 12 months did not differ significantly: 59.57% in the 05–09 group versus 61.63% in the 15–19 group. The relative risk for mortality in the 15–19 versus the 05–09 group was 0.949 (95% CI: 0.85–1.07; p = 0.375). The log-rank observed value was 0.794 (p = 0.373). Most patients died within the first 30 days after ICU admission.

05–09 versus 15–19 after Propensity Score Matching

The model fit for the logistic regression analysis before PSM showed an R^2 (Cox and Snell) of 0.499, and the Hosmer-Lemeshow test before PSM was statistically significant (p < 0.0001), indicating that the model may be statistically moderate to strong; however, its predictions may not be reliable across all patient profiles because of the presence of confounding variables and changes in case mix. PSM was performed to overcome these biases. PSM, using age, sex, APACHE IV admission diagnosis, and SAPS II score as covariates, resulted in two well-balanced groups of 506 patients each. The means of the logit of the propensity score and standard deviations were comparable (-0.104 ± 0.261 [05–09] vs. -0.108 ± 0.259 [15–19], 95% CI [-0.028; 0.036]), resulting in Cohen's d = 0.015,

indicating a very small effect size and thus nearly identical groups in terms of the covariates.

Patient characteristics

Table I presents the results after PSM. Because PSM accounted for the covariates, no significant differences were observed between the covariates.

Length of stay (LOS)

The ICU LOS was significantly longer in the 05–09 group (Table I). Within the PSM cohorts, ICU LOS differed significantly between survivors and non-survivors in both study periods. In 05–09, non-survivors (n = 130) and survivors (n = 376) had a similar median ICU LOS of 3 days, but LOS distributions differed significantly (IQR 4 vs. 2; p = 0.0003). In 15–19, ICU LOS was shorter in survivors (median 2 days, IQR 1; n = 375) than in non-survivors (median 3 days, IQR 3; n = 131; p = 0.029). When comparing periods, ICU LOS among survivors decreased significantly from 05–09 to 15–19 (median 3 days [IQR 4] vs. 2 days [IQR 1]; p = 0.016). In contrast, the median ICU LOS among non-survivors remained unchanged (median 3 days in both periods), although the LOS distribution differed modestly between 05–09 (IQR 2) and 15–19 (IQR 3) (p = 0.027), reflecting differences in distribution rather than a shift in median ICU LOS. Overall, the reduction in ICU LOS over time was primarily driven by shorter ICU stays among survivors, whereas the ICU LOS among non-survivors remained stable in median terms.

Mortality

In-hospital mortality did not differ statistically after PSM; there were no differences between patients who died in the ICU, died during hospitalization, or were discharged alive (Table I).

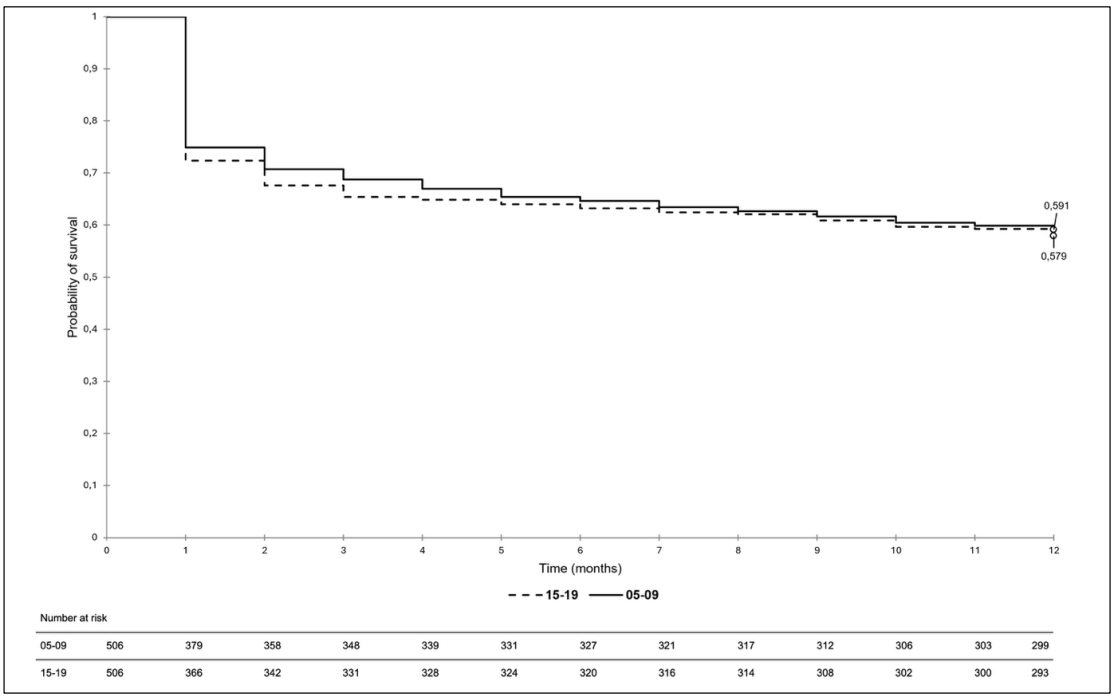
Survival up to 12 months after ICU admission

The Kaplan-Meier survival distribution function is presented in Figure 4. Survival after 12 months did not differ significantly: 59.09% in the 05–09 group versus 57.91% in the 15–19 group. The relative risk for mortality in the 15–19 versus the 05–09 group was 1.03 (95% CI: 0.89–1.19; p = 0.702). The log-rank observed value was 0.196 (p = 0.658). Most patients died within the first 30 days after ICU admission.

Outcomes of time-sensitive pathologies

Table II presents the outcomes of time-sensitive pathologies. In the original cohorts, patients in the 15–19 group were statistically older, although this was not clinically reflected. Patients in the 05–09 group appeared to be significantly sicker, with median SAPS II scores of 41 compared to 37. However, these differences did not influence the ICU LOS or mortality.

After stratification of time-sensitive versus less time-sensitive pathologies, statements regarding age and SAPS II remained, while ICU LOS



15-19: Patients ≥ 80 years admitted between 2015-2019 (n = 506); 05-09: Patients ≥ 80 years admitted between 2005-2009 (n = 506); Log-rank test: 0.196; p = 0.658

Fig. 4 — Kaplan-Meier Survival distribution function after Propensity Score Matching.

Table II. — Trends in time-sensitive pathologies.

ORIGINAL COHORTS	05-09	15-19	
Admissions > 80 years (n)	258	300	
Age (years, median, (IQR))	83 (4)	84 (5)	P = 0.006
Sex (M/F)	128/130	141/159	P = 0.538
SAPS II (median, (IQR))	41 (23)	37 (13)	P < 0.0001
LOS ICU (days, median, (IQR))	3 (3)	3 (2)	P = 0.025
Hospital Mortality: Death in ICU / Death in hospital after ICU / Discharged alive (n)	29/58/171	22/67/211	P = 0.266
AFTER STRATIFICATION	**05-09**	**15-19**	
AMI, CVA & Sepsis			
Admissions > 80 years (n)	124	127	
Age (years, median, (IQR))	83 (5)	84 (6)	P = 0.018
Sex (M/F)	61/63	52/75	P = 0.849
SAPS II (median, (IQR))	37 (24)	35 (16)	P = 0.0007
LOS ICU (days, median, (IQR))	3 (3)	2 (1)	P = 0.023
Hospital Mortality: Death in ICU / Death in hospital after ICU / Discharged alive (n)	19/23/82	7/26/94	P = 0.039
CHF, COPD-exacerbation & Pneumonia			
Admissions > 80 years (n)	134	173	
Age (years, median, (IQR))	83 (4)	83 (6)	P = 0.090
Sex (M/F)	67/67	89/84	P = 0.801
SAPS II (median, (IQR))	42 (19)	37 (11)	P = 0.0002
LOS ICU (days, median, (IQR))	4 (3)	3 (3)	P = 0.124
Hospital Mortality: Death in ICU / Death in hospital after ICU / Discharged alive (n)	10/35/89	15/41/117	P = 0.848

IQR: Interquartile range; SAPS: Simplified Acute Physiology Score; LOS ICU: Length of Stay in ICU; AMI: acute myocardial infarction; CVA: cerebrovascular accident; CHF: congestive heart failure; COPD; chronic obstructive pulmonary disease.

appeared to be significantly longer in 05–09 for the time-sensitive pathologies with established treatment protocols (AMI, CVA, and sepsis) (p=0.023). For less time-sensitive pathologies (CHF, COPD exacerbation, and pneumonia), there was no significant difference between the two timeframes (p=0.124). ICU mortality was significantly higher in 05–09 for time-sensitive pathologies (p=0.039) than for less time-sensitive pathologies (p=0.848).

Discussion

Over a 15–year period, ICU admissions of very old patients increased substantially, accompanied by major shifts in case mix and admission diagnoses; nevertheless, the overall survival outcomes for VIPs remained largely unchanged. Consistent with international trends, the net number of ICU admissions for VIPs has increased significantly over the past two decades, reflecting both demographic shifts and evolving clinical practices[7]. This increase can be attributed to increased life expectancy, improved chronic disease management, and broader surgical indications in older adults. Consequently, ICUs are increasingly tasked with managing complex geriatric patients with multimorbidity, frailty, and variable physiological reserve[8]. These changes highlight the need for age-specific triage strategies and outcome assessments that extend beyond traditional severity scores.

The 15–19 cohort was statistically older but exhibited lower SAPS II scores, indicating more selective admission practices and potentially better baseline health. This shift may suggest a change in triage policies that prioritize patients with realistic chances of meaningful recovery. Importantly, the rise in VIP ICU admissions was not uniform across diagnoses but was associated with significant changes in case mix, including a higher proportion of medical admissions, fewer planned surgical admissions, and a redistribution of APACHE IV diagnoses, reflecting the evolving triage policies, surgical practices, and population health characteristics. This may reflect adjustments in triage policies aimed at optimizing resource utilization while considering ethical aspects in the care of VIPs. These changes complicate the interpretation of outcome trends, as the lower severity scores in the 15–19 cohort did not lead to improved mortality rates, suggesting that the

SAPS II score has limited precision in these patients. Therefore, other scores, such as the Clinical Frailty Score (CFS) or the Charlson Comorbidity Index, may be better predictors of mortality[9-12].

We also observed a significantly lower ICU LOS in the 15–19 cohort after PSM, while the overall in-hospital and 12-month mortality rates remained stable. This may indicate improved ICU efficiency and faster recovery trajectories. Indeed, subgroup analyses revealed that ICU mortality and LOS improved significantly for time-sensitive pathologies (AMI, CVA, and sepsis), likely due to earlier recognition, protocol-driven management, and enhanced acute care delivery[9,10]. In contrast, the outcomes for less time-sensitive pathologies (CHF, COPD exacerbation), and pneumonia remained unchanged, underscoring the need for better strategies to manage these conditions. These findings suggest that although broad survival gains may be limited, targeted improvements in acute care pathways can yield meaningful benefits. The concept of a "critical opportunity window" appears particularly relevant for VIPs, whose physiological reserve is limited and whose outcomes depend heavily on timely intervention[13,14]. Consistent with the prior research by Liu et al., our results support the notion that standardized clinical guidelines and early warning systems contribute to diagnosis-specific mortality reductions[15].

In this context, the reduction in ICU LOS over time raises the question of whether evolving EoL decision-making may have contributed to these findings. Using ICU LOS as an indirect surrogate in the propensity-matched cohorts, we observed a significant reduction in ICU LOS among survivors from 2005–2009 to 2015–2019, whereas the median ICU LOS among non-survivors remained stable across periods (with only modest distributional differences). This pattern argues against an earlier or more aggressive withdrawal of life-sustaining treatment as the primary driver of reduced ICU LOS and is more consistent with improved ICU efficiency, faster stabilization, and earlier transfer of recovering patients. Nonetheless, ICU LOS is an imperfect surrogate for EoL decision-making and should be interpreted with caution.

Strengths and limitations

The strengths of this study include the use of established clinical scores and routinely recorded variables to assess outcomes, allowing for reliable comparisons across different cohorts. Additionally, the inclusion of large multi-year cohorts and the application of PSM helped reduce measured confounding factors and improved the validity of temporal comparisons.

However, this study has some limitations. First, the retrospective design of this study may have introduced biases that are inherent in such studies. Second, important geriatric variables that strongly influence outcomes, notably CFS and pre-admission functional status, were not available and therefore not included in the analyses. The CFS was only used for evaluating frailty in ICU patients around 2017, with research demonstrating its predictive value for mortality in older ICU patients, particularly those aged > 80 years[16,17]. Since then, numerous studies have validated that higher CFS scores correlate with increased ICU and hospital mortality, longer ICU stays, and poorer post-ICU outcomes[9,10]. The scale has proven particularly valuable for assessing frailty-related risk independent of traditional severity scores, such as APACHE II or SOFA. By 2026, the CFS is established internationally as a standard tool for frailty assessment in critical care, with cut-off values used to guide ICU admission decisions and predict prognosis[18]. However, the CFS is often omitted in routine practice, which limits the retrospective capture and adjustment for frailty in this study. Third, a subset of acute diagnoses, notably STEMI patients, were often transferred directly from the emergency department to a different hospital for cardiac catheterization and were not captured in our dataset; therefore, these patients were excluded from the analysis and may represent a clinically important group that was omitted from our results. Finally, temporal changes in EoL practices, including the use of do-not-resuscitate (DNR) orders and other treatment-limitation decisions, may have introduced additional bias. Timely and well-documented EoL decisions have been shown to reduce non-beneficial interventions and ICU resource use in older patients without compromising patient-centered outcomes[19]. However, in this retrospective cohort study, structured data on withholding or withdrawal of life-sustaining treatment were not consistently available, precluding direct adjustment for their potential impact. Documentation practices have evolved over time, with the gradual implementation of hospital-wide policies and heterogeneous adoption by clinicians, resulting in incomplete and inconsistent records. To partially address this limitation, the ICU length of stay stratified by survival status was explored as an indirect surrogate for EoL decision-making. While this analysis suggests that reductions in ICU LOS were primarily driven by shorter stays among survivors rather than non-survivors, ICU LOS remains an imperfect surrogate and cannot substitute for prospective, structured EoL data. Therefore, residual confounding cannot be excluded and

should be considered when interpreting the study findings.

Despite these limitations, our study provides valuable insights into patient outcomes and highlights the importance of considering both clinical scores and routinely recorded variables in future studies.

Conclusions

Between 2005–2009 and 2015–2019, ICU admissions of patients aged ≥80 years increased significantly, accompanied by substantial shifts in case mix and admission diagnoses. After adjusting for age, sex, severity scores, and admission diagnoses through propensity score matching, there were no significant changes in in-hospital mortality or 12-month survival rates. However, the ICU length of stay decreased notably in the later period, and mortality and length of stay improved for time-sensitive conditions such as AMI, CVA, and sepsis. Reductions in length of stay over time appeared to be driven mainly by shorter hospitalization among survivors, while the length of stay among non-survivors remained stable, arguing against a dominant effect of earlier treatment withdrawal as the primary explanation. These findings suggest that advances in critical care and standardized treatment protocols have enhanced outcomes for specific acute diagnoses, despite managing an older and more complex patient population. Limitations include missing frailty data, data on the impact of end-of-life decisions, and residual confounding, which restricts definitive causal conclusions. Further prospective studies incorporating comprehensive geriatric assessments are needed to validate these results and optimize care strategies for very old ICU patients.

Funding: The authors declare no conflicts of interest related to the publication of this study. There was no external funding. The authors agree to share the data reported in this study.Data can be requested via walter.swinnen@azsintblasius.be

Acknowledgments: Lore De Pauw and Elizabeth De Keukeleere participated equally in the study and should be considered joint first authors. We express our deepest gratitude to the secretaries of the Central Medical Archives of AZ Sint-Blasius. Their assistance in retrieving old paper files was invaluable.

We acknowledge the use of Paperpal (https://paperpal.com) for language editing during manuscript preparation.

References

1. Cobert J, Jeon SY, Boscardin J, Chapman CA, Ferrante LE, Lee S, et al. Trends in geriatric conditions among older adults admitted to US ICUs between 1998 and 2015. Chest. 2022;161(6):1555–1565.
2. Ferrante LE, Szczeklik W. Frailty is crucial in FORECASTing outcomes in critical care. Intensive Care Med. 2024;50:1119–1122.
3. Hongo T, Yumoto T, Inaba M, et al. Long-term, patient-centered, frailty-based outcomes of older critical illness survivors. BMC Geriatr. 2024;24:257.
4. Beil M, Moreno R, Fronczek J, Kogan Y, Moreno RPJ, Flaatten H, et al. Prognosticating the outcome of intensive care in older patients – a narrative review. Ann Intensive Care. 2024;14:97
5. Guidet B, Vallet H, Flaatten H, Joynt G, Bagshaw SM, Leaver SK, et al. The trajectory of very old critically ill patients. Ann Intensive Care. 2024;14:21.
6. Beil M, van Heerden PV, Joynt GM, Lapinsky S, Flaatten H, Guidet B, et al. Limiting life-sustaining treatment for very old ICU patients: cultural challenges and diverse practices. Ann Intensive Care. 2023;13(1):107.
7. Rai S, Brace C, Ross P, Darvall J, Haines K, Mitchell I, et al. Characteristics and Outcomes of Very Elderly Patients Admitted to Intensive Care: A Retrospective Multicenter Cohort Analysis. Crit Care Med. 2023;51(10):1328-38.
8. Vallet H, Arai H, Jacobs JM. Bridging the gap: improving the long-term management of very old patients in intensive care. Eur Geriatr Med. 2025;16:749-51.
9. Guidet B, de Lange DW, Boumendil A, Leaver S, Watson X, Boulanger C, et al. The contribution of frailty, cognition, activity of daily life and comorbidities on outcome in acutely admitted patients over 80 years in European ICUs: the VIP2 study. Intensive Care Med. 2020;46(1):57-69.
10. Haas LEM, Boumendil A, Flaatten H, Guidet B, Ibarz M, Jung C, et al. Frailty is associated with long-term outcome in patients with sepsis who are over 80 years old: results from an observational study in 241 European ICUs. Age Ageing. 2021;50(5):1719-27.
11. Yildiz A, Benli AR. The prognostic role of Charlson comorbidity index for critically ill elderly patients. Eur Res J. 2020;6(1):67-72.
12. Christensen S, Berg Johansen M, Christiansen CF, Jensen R, Lemeshow S. Comparison of Charlson comorbidity index with SAPS and APACHE scores for prediction of mortality following intensive care. Clin Epidemiol 2011;3:203-211.
13. Quisquater M, Swinnen W, Van Paesschen W, Koch A, Pannier E, Mignolet K, et al. Association between timing of medical intensive care unit admission and outcome of emergency department patients: a retrospective cohort study. Acta Anaesth Belg. 2024;75(2):67–79.
14. Molina JA, Seow E, Heng BH, Chong WF, Ho B. Outcomes of direct and Indirect Medical Intensive Care Unit admissions from the Emergency Department of an Acute Care Hospital: A retrospective cohort study. BMJ Open. 2014;4(11):e005553
15. Liu V, Kipnis P, Rizk NW, Escobar GJ. Adverse outcomes associated with delayed intensive care unit transfers in an integrated healthcare system. J Hosp Med. 2011;7(3):224-30.
16. Flaatten H, De Lange DW, Morandi A, Andersen FH, Artigas A, Bertolini G, et al. The impact of frailty on ICU and 30-day mortality and the level of care in very elderly patients (≥ 80 years). Intensive Care Med. 2017;43(12):1820-8.
17. de Lange DW, Soliman IW, Leaver S, Boumendil A, Haas LE, Watson X, et al.; VIP2 study group. The association of premorbid conditions with 6-month mortality in acutely admitted ICU patients over 80 years. Ann Intensive Care. 2024;14:46.

18. Ganesh KM, Krishna B. Utility of Clinical Frailty Scale in Intensive Care Unit. Indian J Crit Care Med. 2025;29(4):289-90.
19. Kent JT, Ghosh R. Quantifying the association between code status discussions and outcomes in critically ill older adults admitted to the intensive care unit (ICU): a retrospective cohort study. Emerg Care Med. 2025;2(2):16.

doi.org/10.56126/77.3.23