Outcomes in Critically Ill Patients Aged 90 Years and Older: A Scoping Review

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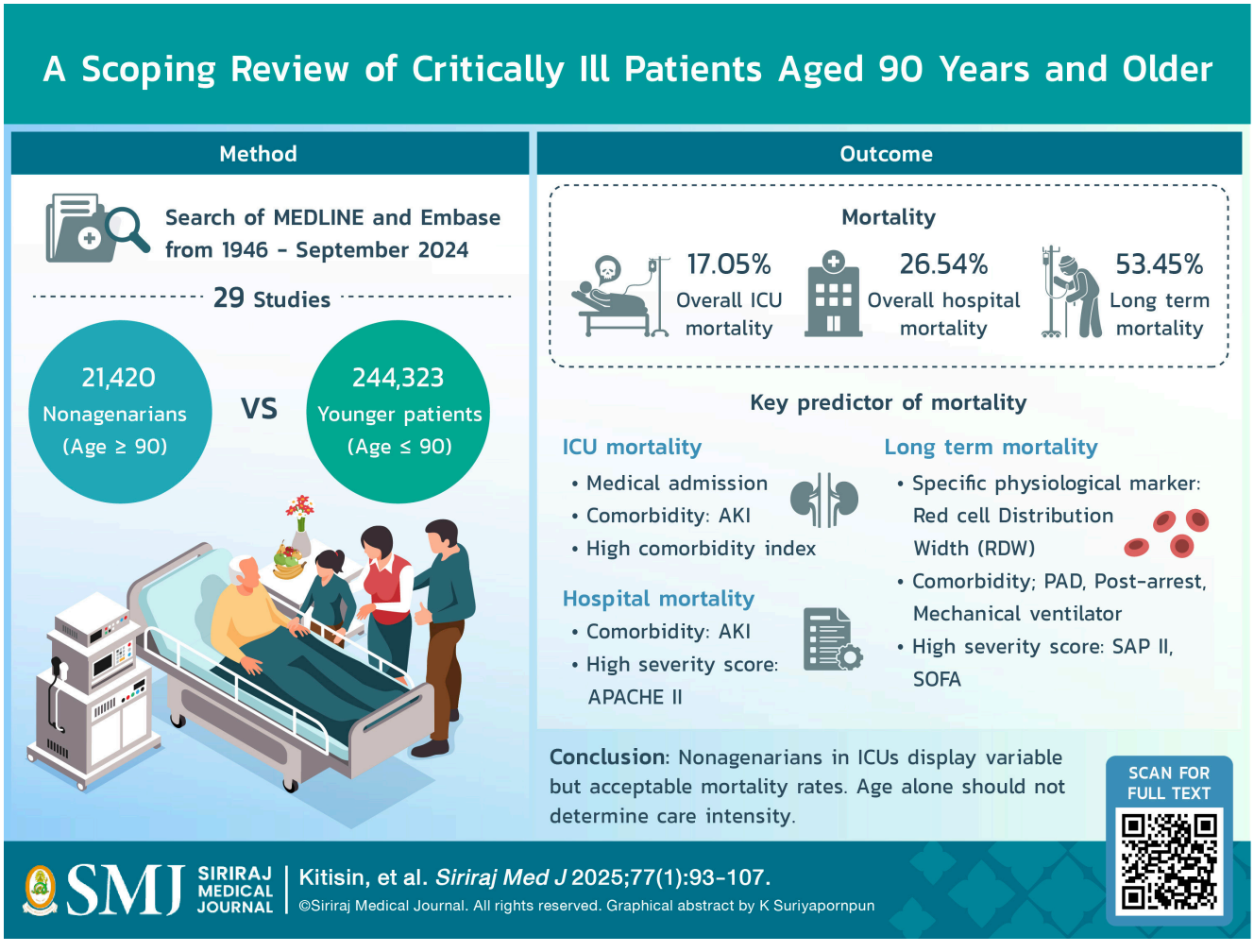

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ABSTRACT

The growing population of nonagenarians has led to increased intensive care unit (ICU) admissions among elderly patients. However, evidence on their outcomes and optimal management strategies remains limited and fragmented. This scoping review aimed to explore mortality outcomes, factors associated with mortality, and treatment intensity in nonagenarians, comparing them to younger patients. A systematic search of MEDLINE and Embase from 1946 to September 2024 identified studies reporting ICU, in-hospital, and long-term mortality in nonagenarians. Twenty-nine studies involving 21,420 nonagenarians and 244,323 younger patients were included. ICU mortality among nonagenarians ranged from 1.42% to 66.7%, with an overall rate of 17.05% (2,738/16,062). In-hospital mortality ranged from 5.6% to 47%, with an overall rate of 26.54% (5,563/20,962). Long-term (one-year) mortality varied from 19% to 77%, with an overall rate of 53.45% (7,020/13,134). Key predictors of mortality included comorbidities, high severity scores (APACHE II, SAPS II), and less aggressive treatment. Despite these factors, nonagenarians had comparable mortality rates to younger patients when adjusted for illness severity. Nonagenarians in ICUs display variable but acceptable mortality rates, suggesting that age alone should not determine care intensity. Their heightened vulnerability after discharge calls for more effective and personalized post-ICU and post-hospital discharge care plans to better address their ongoing risks.

Keywords: Nonagenarians; Intensive Care Units; Mortality Outcomes; Critical Illness; Elderly Patients; ICU Admission (Siriraj Med J 2025; 77: 93-107)

INTRODUCTION

The global population is aging rapidly, leading to a significant increase in the number of very elderly individuals, particularly nonagenarians. By 2030, more than 30 million nonagenarians are projected to reside in 35 industrialized countries.[1] Alongside this trend, the number of patients aged 80 years and older in intensive care units (ICUs) is steadily increasing[2-5], presenting substantial challenges for healthcare systems, especially in the management of critically ill elderly patients.[6,7] Despite the growing presence of nonagenarians in ICUs, there remains a significant gap in the evidence regarding their specific outcomes and optimal management strategies.

Existing studies provide some insights, but the evidence remains limited and fragmented. For example, Garrouste-Orgeas et al.[8] found that nonagenarians received fewer interventions, such as arterial line monitoring and renal replacement therapy, than octogenarians. However, their ICU and hospital mortality rates were similar. Likewise, Bruno et al.[9] also reported that nonagenarians had ICU mortality rates comparable to octogenarians, despite greater frailty and fewer organ support interventions. After adjusting for confounders, there was no significant increase in risk of 30-day mortality. These findings suggest that nonagenarians might have outcomes similar to those of slightly younger elderly patients, even with less intensive care. Still, the limited number and scope of these studies leave questions about the best way to care for nonagenarians in ICUs.

Recent data suggest improvements in long-term survival rates for nonagenarians.[10] Yet, few comprehensive analyses have explored how advances in medical care and treatment strategies have contributed to these outcomes. This gap in research leaves healthcare providers with insufficient guidance on optimizing care for this growing patient population.

This scoping review aims to explore the outcomes of nonagenarians in ICUs, focusing on mortality rates and comparing them to younger age groups. Additionally, the review will identify key risk factors for death in critically ill nonagenarians and evaluate how the intensity of treatment affects outcomes. Treatment is categorized based on its intensity, such as less aggressive (involving limited use of invasive catheters, mechanical ventilation, vasopressors, inotropes, and renal replacement therapy) or more aggressive. By synthesizing the literature, this study seeks to provide a clearer understanding of survival factors and offer guidance for optimizing care for this unique patient population.

METHODOLOGY

This scoping review adhered to the Cochrane and Joanna Briggs Institute (JBI) methodologies for scoping reviews, with reporting following Preferred Reporting Items for Systematic Reviews and Meta-analyses extension for scoping reviews (PRISMA-ScR) guidelines.[11] It focused on collecting data on mortality rates, factors associated with mortality, and treatment intensity among critically ill nonagenarian ICU patients.

Eligibility Criteria

Inclusion

- Studies involving nonagenarian patients (aged ≥90 years old)admitted to ICUs.
- Studies reporting on mortality (e.g., 30-day mortality, ICU mortality) and other relevant clinical outcomes.

Exclusion

- Studies without ICU-specific outcomes (e.g., those focused solely on quality of life).
- Studies focused exclusively on patients younger than 90 years of age, unless nonagenarian-specific data could be extracted.
- Studies not published in English
- Reviews, letters, commentaries, correspondence, conference abstracts, expert opinions, and editorials were excluded.

Information sources

Searches were conducted in MEDLINE Ovid ALL and Embase Ovid Classic the period from 1946 to September 18, 2024.

Search strategy

We performed preliminary searches in MEDLINE and Embase to identify relevant studies, indexing terms, and keywords (e.g., nonagenarian, aged over 90, very elderly, extreme aged, mortality, intensive care). Next, we conducted a comprehensive search using all indexed terms and keywords across the selected databases, without applying any limits or filters (as detailed in Appendix II: Search strategy). Finally, we manually reviewed the references from the included studies and assessed those that met the eligibility criteria for inclusion in the review.

Selection of evidence

We uploaded all citations to Covidence and removed duplicates. Two independent reviewers (NK and NR) screened the titles and abstracts based on the inclusion criteria. Any disagreements during the full-text screening were resolved through discussion.

Data extraction

The two reviewers (NK and NR) created a data extraction table to record key variables. These included study details, publication year, design, the mean or median age of the nonagenarian group, and mortality outcomes, with comparisons to younger cohorts when available.

RESULTS

Search results and included studies

The search strategy identified 303 references from two databases: MEDLINE (n = 178) and Embase (n = 125). Two additional studies were found through citation searching, yielding a total of 305 articles. After the removal of 45 duplicates via Covidence, 260 studies remained for screening. Following title and abstract screening as well as full-text review, 29 publications met the inclusion criteria for the final analysis (Fig 1).

Types of Included Papers

The selected publications spanned from 1984 to September 18, 2024, with a noticeable increase in studies in recent years. Among the 29 publications, 4 (13.8%) were prospective studies[12-15], whereas the remaining 25 (86.2%) were retrospective cohort studies.[3,6,8-10,16-35] The types of ICUs represented were diverse and included mixed ICUs, surgical ICUs, cardiac ICUs, respiratory ICUs, nephrology ICUs, and trauma and surgical ICUs (Table 1).

Among these publications, 58.6% (17 studies) reported mortality outcomes specific to ICU settings[6,8-10,12,13,17,20-24,27,28,31-33], while others addressed in-hospital mortality, long-term mortality, or ICU-related complications. Several studies focused on specific medical conditions affecting nonagenarians, such as acute kidney injury[16,32], peripheral vascular disease[27], and postoperative outcomes following major surgeries, particularly cardiac surgery.[18,19]

Most of the publications incorporated various illness severity risk scores to predict mortality outcomes, including the Acute Physiology and Chronic Health Evaluation (APACHE)[13,17,23,25,28,31], Simplified Acute Physiology Score (SAPS II)[8,10,12,21,22,31,33], Sequential Organ Failure Assessment (SOFA)[8-10,22,33], Charlson Comorbidity Index (CCI)[10,16,22,24,27,30,32,33], Elder Risk Assessment (ERA)[29], Global Registry of Acute Coronary Events (GRACE)[36], New York Heart Association (NYHA) Functional Classification[18], Clinical Frailty Scale (CFS)[9], and Mortality Probability Model (MPM).[35] These scores are used to assess the severity of illness and guide clinical decisions concerning critically ill nonagenarians, with the APACHE II, SAPS II and CCI scores being the most commonly used scores.

Demographics and geographic distribution of the studies

Most studies were conducted in Germany (34.5%, 10 studies)[6,10,16,18,22,24,27,28,33,34], followed by the United

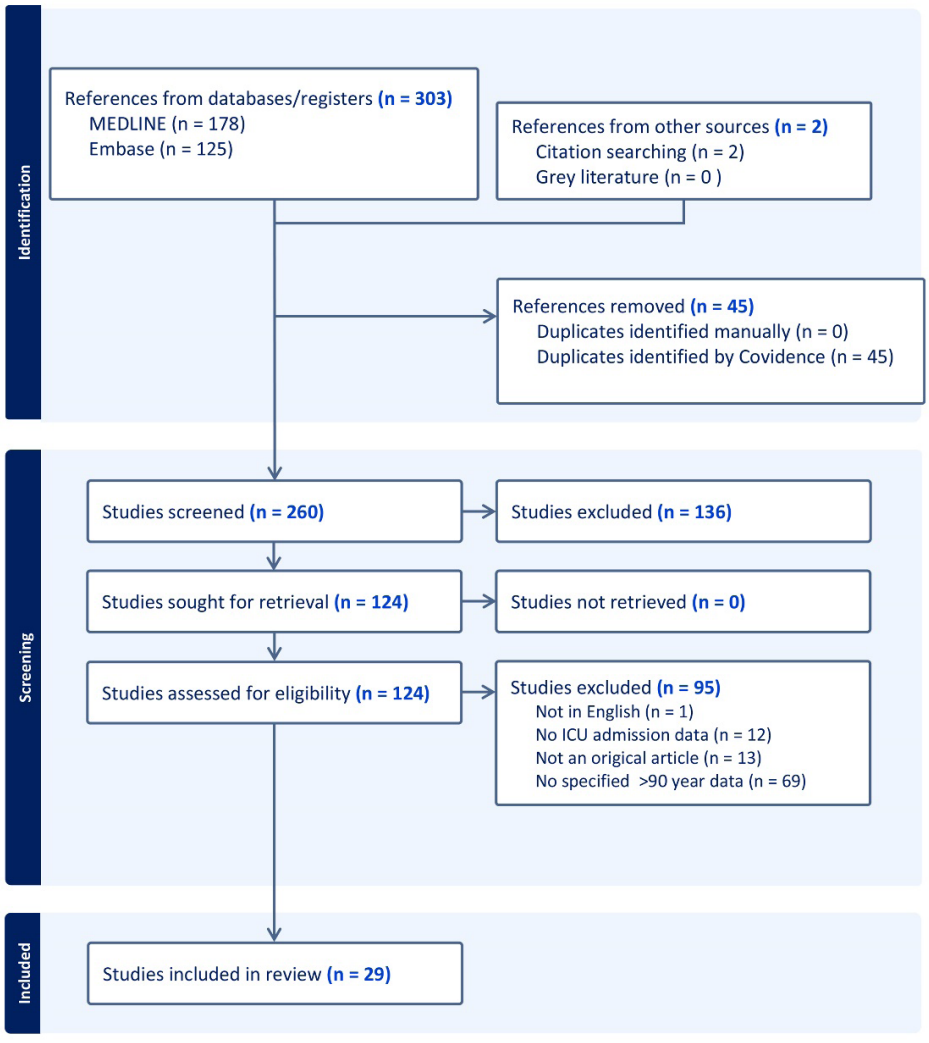

Fig 1. PRISMA flow diagram

TABLE 1. Study characteristics.

Author, Year, Country	Study design	Population	Type of ICU	Age (years)	Comparison	Nonagenarian mortality	Younger group mortality
Michel, 1984, United States[26]	Retrospective cohort study	225 nonagenarian who underwent major surgeries	Surgical ICU	92.1	Nonagenarian: Elective surgery vs Emergency surgery	In-hospital mortality: 17/225 (7.5%)	Not reported
Margulies, 1993, United States[12]	Prospective data collection	5,792 surgical ICU patients - Nonagenarians: 140 - Aged < 90: 5,652	Surgical ICU	92.1 (0.2)	Nonagenarians vs. Younger patients (< 90 years)	SICU mortality: 6/140 (4.3%) In-Hospital mortality: 24/140 (17.1%)	SICU mortality: 130/5652 (2.3%) In-hospital mortality: 298/5652 (5.3%)
Bacchetta,2003, United States[19]	Retrospective analysis	42 nonagenarian patients who underwent open-heart procedures	Cardiac surgical ICU	91.2	Not determined	In-hospital mortality: 3/42 (7%) Long-term mortality (mean 2.53 years, range: 0.16 to 7.1 years): 19%	Not reported

TABLE 1. Study characteristics. (Continue)

Author, Year, Country	Study design	Population	Type of ICU	Age (years)	Comparison	Nonagenarian mortality	Younger group mortality
Demoule, 2005, France[21]	Case-control	108 ICU patients - Aged ≥90 years: 36 - Aged 20-69 years: 72	Respiratory ICU	92.8 (2.4)	Patient aged ≥90 years vs. Age 20-69 years	ICU mortality: 10/36 (28%) In-hospital mortality: 17/36 (47%)	ICU mortality: 13/72 (18%), In-hospital mortality: 20/72 (27%)
Rellos, 2006, Greece[13]	Prospective Cohort Study	5,505 ICU patients - Nonagenarians: 60 - Aged < 90 years: 5445	Mixed ICU	92 (2.8)	Nonagenarians vs. Age <90 years	ICU mortality: 12/60 (20%) In-hospital mortality: 24/60(40%)	ICU mortality: 365/5445 (6.7%), In-hospital mortality: 485/5445 (8.9%)
Nathanson, 2011, United States[35]	Retrospective cohort study	124,885 ICU patients - Aged ≥90 years: 2,576 - Aged < 90 years: 122,309	Mixed ICU	Not specified	18-29 years vs. 30-39 years vs. 40-49 years vs. 50-59 years vs. 60-69 years vs. 70-79 years vs. 80-89 years vs. ≥90 years	In-hospital mortality: 716/2576 (27.8%)	In-hospital mortality: 18-29 years: 505/8709 (5.8%) 30-39 years: 648/9523 (6.8%) 40-49 years: 1449/15928 (9.1%) 50-59 years: 2275/19960 (11.4%) 60-69 years: 3165/22933 (13.8%) 70-79 years: 4722/27941 (16.9%) 80-89 years: 3757/17315 (21.7%)
Yayan, 2012, Germany[34]	Retrospective cohort study	8,554 ICU patients - Aged ≥90 years: 212 - Octogenarians: 1,715	Mixed ICU	92.7 (6.98)	Patient aged ≥90 years vs. Octogenarians	In-hospital mortality rate: 3/212 (1.42%)	In-hospital mortality rate: 44/1715 (2.57%)
Assmann, 2013, Germany[18]	Retrospective data analysis	49 nonagenarians who underwent cardiac surgery	Cardiac surgical ICU	91.2 (3.1)	Not determined	In-hospital mortality: 5/49 (10%)	Not reported
Becker, 2015, Germany[6]	Retrospective observational study	372 critically ill patient ≥90 years	Mixed ICU	92.2 (91–94.3)	Patient aged ≥90 years: ICU-survival vs. ICU-non-survival	ICU mortality: 68/372 (18.3%) In-hospital mortality: 115/372 (30.9%) 1-year mortality: 242/372 (34.9%)	Not reported

TABLE 1. Study characteristics. (Continue)

Author, Year, Country	Study design	Population	Type of ICU	Age (years)	Comparison	Nonagenarian mortality	Younger group mortality
Sim, 2015, Korea[31]	Single-centre retrospective cohort study	155 critically ill patient ≥90 years	Mixed ICU	92 (91–94)	Patient ≥90 years: ICU survival vs. Non-survival	ICU Mortality: 50/155 (32.3%) In-hospitality mortality: 52/155 (33.5%)	Not reported
Garrouste-Orgeas, 2016, France[8]	Retrospective observational, multicentre study	2,419 ICU patient age ≥80years, matching compared nonagenarian vs octogenarians - Age >90 years: 176 - Age 80-90 years: 176	Mixed ICU	92 (90.8-93.7)	Patient age >90 years vs. 80-90 years old	ICU mortality: 44/176 (25%) In-hospital mortality: 36/176 (39.8%)	ICU mortality: 36/176 (20.5%) In-hospital mortality: 64/176 (36.4%)
Lai, 2016, Taiwan[25]	Retrospective cohort study	510 patients who required prolonged mechanical ventilation (PMV) for over 21 days - Patient ≥90 years: 41 - Octogenarians: 469	Mixed ICU	91.6 (1.6)	Patient ≥90 years vs. Octogenarians	In-hospital mortality: 7/41 (17.1%) (22.2%)	In-hospital mortality: 104/469
Rosenbaum, 2017, United States[29]	Retrospective cohort study	453 nonagenarians (age ≥90 years) admitted to or transferred to the Cardiac Intensive Care Unit (CICU)	Cardiac Intensive Care Unit	92 (2)	Nonagenarian: Elder Risk Assessment (ERS) score: 4-8 vs. 9-15 vs. ≥16	Overall in-hospital Mortality: 70/453 (15%) - ERS 4-8: 34/109 (18%) - ERS 9-15: 28/227(12%) - ERS≥16: 22/117 (19%) Overall 30-day mortality: 104/453 (23%) Overall 6-month mortality: 181/453 (40%) Overall 1-year mortality: 213/453 (47%)	Not reported
Roedl, 2018, Germany[28]	Single-centre retrospective cohort study	48 nonagenarian (age ≥90 years) who suffered from cardiac arrest (CA) and achieved return of spontaneous circulation	Mixed ICU	91.7 (90.7-92.6)	Nonagenarian: Postcardiac arrest survival vs. Postcardiac arrest non-survival	ICU Mortality: 26/48 (54%) In-hospital mortality: 30/48 (62.5%) 1-year mortality rate:37/48 (77%)	Not reported

TABLE 1. Study characteristics. (Continue)

Author, Year, Country	Study design	Population	Type of ICU	Age (years)	Comparison	Nonagenarian mortality	Younger group mortality
E.M.Haas, 2020, Netherlands[23]	Retrospective national cohort study	104,754 critically ill patients - Aged ≥90 years: 9,495 - Octogenarians: 95,259	Mixed ICU	Not specified	Aged ≥90 years vs. Octogenarians	ICU mortality: 1310/9495 (13.8%) In-hospital mortality: 2478/9495 (26.1%) 3-month mortality: 4092/9495 (43.1%) 1-year mortality: 5222/9495 (55%)	ICU mortality: 15337/95259 (16.1%) In-hospital mortality: 24482/95259 (25.7%) 3-month mortality: 32102/95259 (33.7%) 1-year mortality: 40676/95259 (42.7%)
Sousa, 2020, Brazil[32]	Retrospective cohort study	436 nonagenarians (age ≥90 years) hospitalized patients - ICU admitted: 333 - Ward admitted: 103	Mixed ICU	93.5 (3.3)	Nonagenarian: with AKI vs. without AKI	Overall ICU mortality: 170/333 (51.1%) - AKI: 124/173 (71.7%) - Non-AKI: 46/160 (28.8%) Overall hospital mortality (ICU and ward mortality): 188/436 (43.1%) - AKI: 131/196 (66.8%) - Non-AKI: 57/240 (23.8%)	Not reported
Kochlya, 2020, France[36]	Retrospective cohort study	403 patients admitted to ICU with acute coronary syndrome (ACS) - Age ≥90 years: 92 - Octogenarians: 311	Cardiac Intensive Care Unit	92.6 (2.2)	Age ≥90 years vs. Octogenarians	In-hospital mortality rate: 14/92 (15.2%) 5-year overall mortality: 34/92 (37%)	In-hospital mortality: 29/311 (9.3%) 5-year overall survival: 84/311 (27%)
Arikan, 2020, Turkey[17]	Retrospective observational study	107 critically ill nonagenarians (age ≥90 years)	Mixed ICU	92.65 (2.36)	Nonagenarian: Medical vs. Surgical patients	Overall ICU Mortality: 68/107 (63.55%) - Surgical: 4/25 (16%) - Medical: 64/82 (78.04%)	Not reported

TABLE 1. Study characteristics. (Continue)

Author, Year, Country	Study design	Population	Type of ICU	Age (years)	Comparison	Nonagenarian mortality	Younger group mortality
Bardak, 2021, Netherland[20]	Retrospective cohort study	176 critically ill patients - Nonagenarians (age ≥90 years): 18 - Octogenarians: 70 - Elderly patients (65-79 years): 88	Nephrology ICU	92.8	Nonagenarians vs. Octogenarians vs. Elderly (65–79 years)	ICU mortality: 12/18 (66.7%) 1-month mortality rate post-discharge: 40%	ICU mortality - Octogenarians: 34/70 (48.6%) - Elderly 33/88 (37.5%) 1-month mortality rate post-discharge - Octogenarians: 18.6% - Elderly: 11.4%
Bruno, 2021, England[9]	Retrospective cohort study	7,900 critically ill patients - Nonagenarians (age ≥90 years): 790 - Octogenarians: 7110	Mixed	91 (90-94)	Nonagenarians vs. Octogenarians	ICU Mortality: 213/790 (27%) 30-Day Mortality: 337/790 (45%)	ICU Mortality: 1921/7110 (27%) 30-Day Mortality: 2743/7110 (40%)
Higuchi, 2023, Japan[14]	Prospective observational analysis	2,242 critically ill patients - Nonagenarians: 197 - Octogenarians: 655 - Patient < 80 years: 1,390	Cardiac Intensive Care Unit	92.5 (2.5)	Nonagenarians vs. Octogenarians vs. Patient <80 years	In-hospital: 11/197(5.6%) 1-Year Mortality: 37/197 (19%)	In-hospital/ 30-day Mortality - Octogenarians: 25/655 (3.8%) - Patient < 80 years: 28/1390 (2%) 1-Year Mortality - Octogenarians: 79/655 (11.9%) - Patient < 80 years: 57/1390 (4.1%)
Roedl, 2023, Germany[27]	Retrospective cohort study	1,108 critically ill nonagenarian and centenarian (age ≥90 years)	Mixed	92.3 (91-94.2)	Nonagenarian and centenarian: PAD vs. without PAD	Overall ICU mortality: 201/1108 (18%) - PAD: 62/391 (23%) - Non-PAD: 139/717 (16%) Overall in-hospital mortality: 311/1108 (30%) - PAD: 108/391 (41%) - Non-PAD: 223/717 (26%)	Not reported

TABLE 1. Study characteristics. (Continue)

Author, Year, Country	Study design	Population	Type of ICU	Age (years)	Comparison	Nonagenarian mortality	Younger group mortality
Theile, 2023, Germany[33]	Retrospective cohort study	863 critically ill nonagenarians (age ≥90 years) with available RDW measurements	Mixed	92.2 (90.0-94.0)	Nonagenarians: ICU survival vs. Non-survival	Overall ICU Mortality: 132/863(15%) - Low RDW (≤14.5%): 34/327 (10%) - High RDW (>14.5%): 98/536 (18%) Overall in-hospital mortality: 275/863 (32%) - Low RDW (≤14.5%): 66/327 (20%) - High RDW (>14.5%): 179/536 (33%) Overall 1-year mortality: 361/863 (42%) - Low RDW (≤14.5%): 148/327 (45%) - High RDW (>14.5%): 339/536 (63%)	Not reported
Bruoha, 2023, Israel[15]	Prospective study	3,807 patients admitted to the Intensive Coronary Care Unit (ICCU) - Nonagenarians (age ≥90 years): 178 - Younger patients (age < 90 years): 3,629	Cardiac Intensive Care Unit	92.5 (2.5)	Nonagenarians vs. younger patients	In-hospital mortality: 10/178 (5.6%) 310 days after discharge mortality: 30%	In-hospital mortality: 91/3629 (2.5%) 310 days after discharge mortality: 14%
Schmidt, 2024, Germany[16]	Retrospective cohort study	1,054 critically ill nonagenarian (aged ≥90 years)	Mixed	92.3 (IQR 3.1)	Nonagenarian: with AKI vs. without AKI	Overall in-hospital mortality: 304/1054 (28.84%) - AKI 129/257 (50.19%) - Non-AKI 175/797 (21.96%)	Not reported
Daniels, 2024, Germany[10]	Retrospective observational cohort study	1,108 critically ill nonagenarian (aged ≥90 years) patients	Mixed	92.3 (91-94.2)	1st period: Nonagenarians in ICU during January 1, 2008 – August 30, 2013 vs. 2nd period: Nonagenarians in ICU during September 1, 2013 – April 30, 2019	Overall ICU mortality: 201/1108 (18.14%) - 1st period: 72/391 (18.41%) - 2nd period: 129/717 (17.99%) Overall in-hospital mortality: 311/1108 (29.87%) - 1st period: 123/391 (31.46%) - 2nd period: 208/717 (29.01%) Overall 1-year mortality: 635/1108 (57.31%) - 1st period: 237/391 (60.61%) - 2nd period: 398/717 (55.51%)	Not reported

TABLE 1. Study characteristics. (Continue)

Author, Year, Country	Study design	Population	Type of ICU	Age (years)	Comparison	Nonagenarian mortality	Younger group mortality
Heuer, 2024, Germany[24]	Retrospective cohort study	145 nonagenarians (aged ≥90 years) with proximal femur fracture (PFFs) or periprosthetic femur fractures	Trauma and surgical	94.1 (3.0)	Nonagenarians: 365-day survival vs. decreased before 365-days	ICU mortality: 14/145 (9.66%) In-hospital mortality: 32/145 (22.07%) 1-year mortality: 81/145 (56%)	Not reported
Sarma,2024, United States[30]	Retrospective cohort study	239 nonagenarians (aged ≥90 years) admitted to the cardiac intensive care unit (CICU) with acute coronary syndrome (ACS) - No CAG: 103 - CAG/No PCI: 46 - PCI= 90	Cardiac Intensive Care Unit	92.3 (91.0-94.4)	Nonagenarians: No CAG vs. CAG/No PCI vs. CAG/PCI	Overall in-hospital mortality: 50/239 (20.8%) - No CAG: 22/103 (21.4%) - CAG/No PCI: 10/46 (21.3%) - CAG/PCI: 18/90 (20.0%) Overall 1-year mortality: 133/239 (55.6%) - No CAG: 63/103 (61.2%) - CAG/No PCI: 24/46 (52.2%) - CAG/PCI: 52/90 (57.8%)	Not reported
Haar, 2024, Germany[22]	Retrospective analysis	1,108 nonagenarians (aged ≥90 years) critically ill patients	Mixed	92.3 (91.0-94.2)	Nonagenarians: ICU-cardiac arrest vs. No ICU-cardiac arrest (CA)	Overall ICU mortality: 201/1108 (18.14%) - ICU-CA: 22/25 (88%) - No ICU-CA: 179/1083 (17%) Overall in-hospital mortality: 311/1108 (29.87%) - ICU-CA: 25/25 (100%) - No ICU-CA: 306/1083 (28%)	Not reported

The data is presented in Mean (Standard deviation) or Median (interquartile range)

Abbreviations: AKI = Acute kidney injury, ACS = acute coronary syndrome, CA = Cardiac arrest, CAG = Coronary angiography, CICU = cardiac intensive care unit, ERS = Elder Risk Assessment, ICU = Intensive Care Unit, IQR = Interquartile range, PAD = Peripheral vascular disease, PCI = Percutaneous coronary intervention, RDW = Red Cell Distribution width, SICU = Surgical ICU

States (20.69%, 6 studies)[12,19,26,29,30,35] and France (10.3%, 3 studies).[8, 21,36] Other contributing countries included the England[9], Netherlands[20,23], Japan[14], Israel[15], Korea[31], Brazil[32], Taiwan[25], Greece[13], and Turkey[17], each accounting for 3.45% to 6.9% of all contributing countries.

Regarding temporal distribution, there has been a notable increase in publications in recent years, with 27.6% of the studies published in 2024[10,16,22,24,30] and 20.7% in 2023.[14,15,27,33] This trend reflects a growing interest in the outcomes of very elderly patients, particularly nonagenarians, in critical care settings.

Mortality

A total of 29 studies involving 21,420 nonagenarians and 244,323 younger patients (aged less than 90 years) were included, examining outcomes related to ICU mortality, in-hospital or 30-day mortality, and 1-year or long-term mortality (Fig 2).

ICU mortality

ICU mortality was reported in 17 of 29 studies[6,8-10,12,13,17,20-24,27,28,31-33], with rates among nonagenarians showing considerable variation, ranging from as low as 1.42%[34] to as high as 66.7%.[20] The overall ICU mortality rate across all studies was 17.05% (2,738 out of 16,062 patients).

Comparisons between nonagenarians and younger groups have produced mixed results. Margulies et al.[12] reported a slightly higher ICU mortality rate for nonagenarians (4.3%) compared to patients younger than 90 years old (2.3%) in United States (U.S.) surgical ICUs. Demoule et al.[21] observed higher ICU mortality among nonagenarians (28%) than patients aged between 20–69 years (18%) in French respiratory ICUs. Conversely, Bruno et al.[9] found equal ICU mortality rates of 27% for both nonagenarians and octogenarians in England. Across all studies that reported ICU mortality rates, the mortality rate for patients younger than 90 years old was 15.61% (17,766 out of 244,093 patients), slightly lower than that of nonagenarians (17.05%).

In-hospital mortality

In-hospital or 30-day mortality was reported in 26 of 29 studies[6,8-10,12-16,18,19,21-31,33-36], with rates among nonagenarians ranging from 5.6% to 47%. Michel et al.[26] documented a 7.5% in-hospital mortality rate for nonagenarians undergoing major surgeries in the United States. Margulies et al.[12] observed a higher in-hospital mortality rate for nonagenarians (17.1%) compared to patients younger than 90 years of age (5.3%) in surgical ICUs. Demoule et al.[21] reported an in-hospital mortality rate of 47% among nonagenarians, significantly higher than the 27% seen in patients aged 20–69 years.

Comparative studies with octogenarians presented various findings. Garrouste-Orgeas et al.[8] reported similar in-hospital mortality rates between nonagenarians (39.8%) and octogenarians (36.4%) in French mixed ICUs. Higuchi et al.[14] reported an in-hospital mortality rate of 5.6% among nonagenarians in a Japanese cardiac care

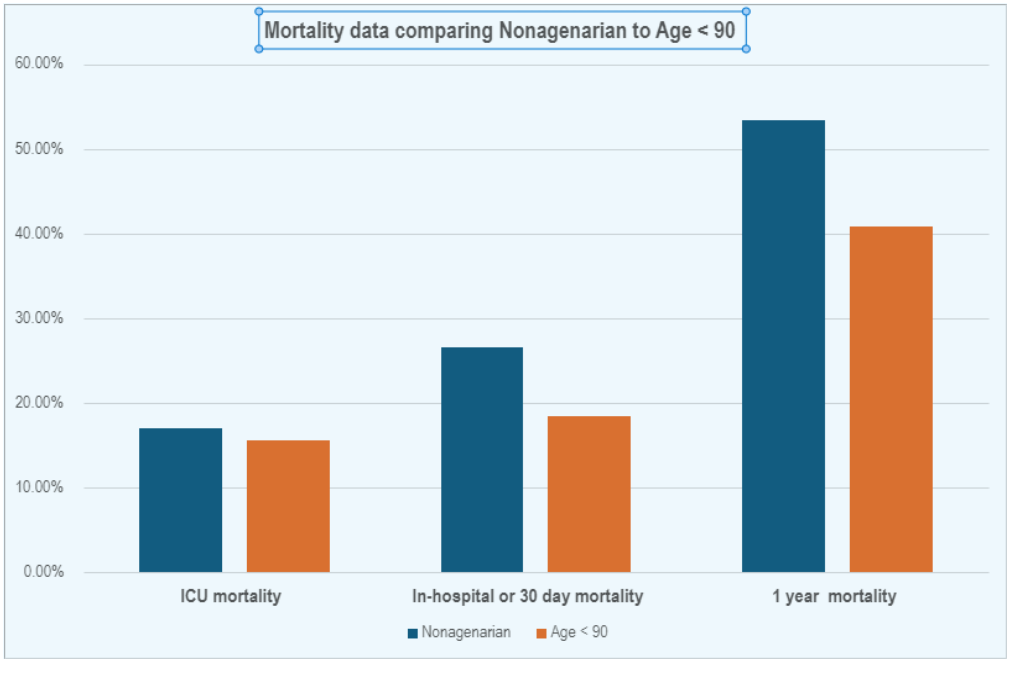

Fig 2. Comparison of Mortality Rates (%) between Nonagenarians and Patients under 90 Years of Age in ICU, In-Hospital, and 1-Year Outcomes

unit, which was slightly higher than the 3.8% observed in octogenarians and the 2% reported in patients younger than 80 years of age. Bruoha et al.[15] reported in-hospital mortality rates of 5.6% for nonagenarians versus 2.5% for younger patients in Israeli intensive coronary care units. When considering studies that reported in-hospital or 30-day mortality, the pooled overall rate for nonagenarians was 26.54% (5,563/20,962 patients), which was higher than the rate for patients younger than 90 years of age, at 18.4% (44,914/244,093 patients).

Long-term mortality

One-year mortality was reported in 12 studies [6,10,14,15,19,23,24,28-30,33,36], consistently showing higher rates among nonagenarians relative to younger age groups: 53.45% (7,020/13,134 patients) for nonagenarians versus 40.88% (41,260/100,933 patients) for those under 90 years of age. Becker et al.[6] reported a one-year mortality rate of 34.9% in Germany, while Rosenbaum et al.[29] observed a rate of 47% among nonagenarians admitted to U.S. cardiac intensive care units. Roedl et al.[28] reported the highest one-year mortality rate, at 77%, among German nonagenarians who had suffered cardiac arrest. Daniels et al.[10], who compared mortality between two periods, reported a one-year mortality rate of 57.31% among nonagenarians in German ICUs, with a slight decrease in recent years, reflecting improvements in ICU care for this population over time.

Comparative analyses consistently indicated higher long-term mortality among nonagenarians. Haas et al.[23] reported a one-year mortality of 55% for nonagenarians in the Netherlands, compared with 42.7% for octogenarians. Higuchi et al.[14] reported a one-year mortality rate of 19% for nonagenarians, which was higher than the 11.9% reported for octogenarians and the 4.1% reported for patients younger than 80 years old.

Factors associated with mortality

Various studies have reported that factors such as the type of admission, comorbidities, severity scores, and specific physiological markers influence ICU, in-hospital, and long-term mortality rates in nonagenarians.

Of the 29 studies, 17 were conducted in mixed ICUs, which included both surgical and medical patients, with ICU mortality rates ranging from 1.42% to 63.55%.[6,810,13,16,17,22,23,25,27,28,31-35] Other studies varied: 5 studies were in cardiac ICUs with mortality rates between 5.6% and 20.8%[14,15,29,30,36], 1 in a nephrology ICU[20], 1 in a respiratory ICU[21], and 5 in surgical ICUs[12,18,19,24,26], of which 2 focused on post-cardiac surgery patients[18,19] and 1 focused on trauma.[24]

ICU mortality is primarily influenced by the type of admission, comorbidities and illness severity. Arikan et al.[17] reported a 63.55% ICU mortality rate among nonagenarians in Turkey, with significantly higher rates in medical patients (78.04%) than surgical patients (16%). Similarly, Sousa et al.[32] found that nonagenarians with acute kidney injury (AKI) had a much higher ICU mortality rate (71.7%) than those without AKI (28.8%). The Charlson Comorbidity Index (CCI) was also independently associated with ICU mortality, highlighting the impact of comorbidities.[32]

In-hospital mortality is closely associated with comorbidities and illness severity. Nonagenarians with AKI had significantly higher in-hospital mortality, as reported by Schmidt et al.[16] and Sousa et al.[32], relative to those without AKI (50.19% vs. 21.96% and 66.8% vs. 23.8%, respectively). Additionally, elevated severity scores, such as the Acute Physiology and Chronic Health Evaluation II (APACHE II), were consistently linked to increase in-hospital mortality.[25]

Long-term mortality is influenced by similar factors, including specific physiological markers, comorbidities, and illness severity. Theile et al.[33] found that nonagenarians with elevated red cell distribution width (RDW) had a one-year mortality rate of 63%, compared to 45% in those with lower RDW. Comorbidities such as peripheral vascular disease[27] and cardiac arrest during ICU stay[22] were also associated with higher mortality rates. Higher SAPS II scores[10,17,24] and SOFA scores[24], along with the need for mechanical ventilation and inotropic support[10,17], were linked to increased long-term mortality. However, Margulies et al.[12] found no significant difference in mortality between nonagenarians and younger patients after adjusting for SAPS scores, indicating that illness severity, rather than age alone, plays a more critical role in mortality outcomes.

The impact of ICU treatment intensity was notable. Some studies found that nonagenarians often received less aggressive treatments, such as invasive arterial catheter and renal replacement therapy, yet had mortality rates comparable to younger cohorts.[8] Additionally, Bruno et al.[9] reported that nonagenarians were more likely to have treatment limitations but did not face an increased risk of care withdrawal compared to octogenarians.

Detailed data on factors associated with mortality and treatment intensity are provided in Appendix I: Supplemental Table.

DISCUSSION

This scoping review highlights several important themes relevant to clinical practice and future research.

Key findings

Across 29 studies, ICU mortality among nonagenarians averaged 17.05%, slightly higher than the 15.61% observed in younger patients. In-hospital mortality was 26.54%, exceeding the 18.4% rate in younger groups, while one-year mortality reached 53.45%, compared to 40.88% in younger patients. Key factors influencing mortality included comorbidities, illness severity (e.g., APACHE II, SAPS II, SOFA), and acute conditions like AKI. Although nonagenarians often received less aggressive interventions, they still achieved comparable outcomes to younger patients in some instances, suggesting that age alone should not dictate the intensity of care.

Progressive increase in mortality rates

Mortality rates among nonagenarians increase progressively from ICU admission through to hospital discharge and over the long term. These results are consistent with those from the largest cohort study by Haas et al.[23] which reported ICU, in-hospital, and 1-year mortality rates of 16.1%, 25.7%, and 42.7%, respectively, in a cohort of 9,495 nonagenarian ICU patients. This progressive increase emphasized the ongoing vulnerability of critically ill nonagenarians even after ICU discharge, suggesting that they require more comprehensive care and follow-up to improve long-term outcomes.

Variability and factors associated with mortality

There is significant variability in mortality rates across different studies, reflecting differences in patient populations, healthcare systems, and ICU practices worldwide. Mortality rates for ICU admissions among nonagenarians varied widely, which can be attributed to factors such as geographic location, type of ICU, patient comorbidities, and illness severity. Medical admissions were linked to higher mortality rates compared to surgical admissions[10,17,35], suggesting that the underlying cause for ICU admission has a major impact on patient outcomes.

In nonagenarians, mortality is driven by factors other than age, including the severity of illness, comorbidities, and the reason for ICU admission. Specific physiological markers, such as red cell distribution width (RDW), have also been linked to higher mortality, reflecting the need for a comprehensive assessment of health status. While nonagenarians generally had higher mortality rates compared to younger patients, some studies reported similar outcomes after adjusting for illness severity[12], suggesting that age alone may not determine mortality in the ICU. Severity scores, such as APACHE II[13,17,23,25,28,31,] SAPS II [8,10,12,21,22, 31,33], and CCI[10,16,22,24,27,30,32,33], play a crucial role in assessing physiological reserve and comorbidities. These tools allow for more nuanced and individualized decision-making for both nonagenarians and younger patients, guiding clinical care and optimizing treatment strategies for this vulnerable population.

Less aggressive interventions and mortality rates

Nonagenarians often receive less aggressive interventions, such as mechanical ventilation or renal replacement therapy[8], and a higher likelihood of treatment limitations but did not face an increased risk for withdrawal of care.[9] However, their mortality rates remained within acceptable ranges. This may result from various factors, including patient or family preferences for less invasive care, concerns about the risks of aggressive treatments, or clinical judgments regarding the benefits of such interventions. The acceptable mortality rates, despite less aggressive care, suggest that a more tailored approach—one that weighs the risks and benefits of interventions—may be appropriate for nonagenarians.

Strengths and limitations

This research presents several key strengths. It is the first scoping review to systematically explore mortality outcomes for critically ill nonagenarians, addressing a significant gap in the literature while ensuring a geographically diverse and relevant perspective on nonagenarian ICU outcomes. The review offers a comprehensive overview by examining multiple studies across diverse ICU settings, including both surgical and medical ICUs, providing a broad perspective on patient outcomes. Additionally, it identifies critical factors influencing mortality, such as illness severity, comorbidities, and physiological markers like red cell distribution width (RDW). Finally, the research establishes a strong foundation for future studies by identifying knowledge gaps and proposing directions for further investigation, particularly regarding long-term care and post-ICU outcomes, thus contributing to the optimization of care for this growing and vulnerable population.

This review has several limitations. First, the majority of the included studies were retrospective, which may introduce missing data, bias, and variability in mortality reporting. Some studies focused on ICU mortality, others on in-hospital mortality, with only a few addressing long-term outcomes, contributing to heterogeneity. Second, while we did not perform statistical or qualitative analyses or assess the risk of bias across studies, this was intentional, as the review serves as a precursor to a more comprehensive future meta-analysis and systematic review. Third, nonagenarians have only recently become the focus of research, meaning that

additional data and insights are likely to emerge in the coming years, potentially expanding the evidence base. Lastly, the exclusion of non-English studies may limit the generalizability of findings, particularly in regions where non-English research is more common.

Future research direction

There is still a lack of data on the factors that strongly influence outcomes in this patient population. Common severity scores used in general ICU populations, such as SAPS or APACHE, and the frailty index[37], may not fully capture the unique characteristics of nonagenarians and require revalidation in this group. Future prospective studies should focus on protocolized management after ICU discharge, including rehabilitation and nutritional support, to improve long-term outcomes for nonagenarian patients.

CONCLUSION

Critically ill nonagenarians in ICUs experience varied, yet often acceptable, mortality rates, suggesting that age alone should not determine ICU admission or treatment intensity. However, the rise in mortality from ICU discharge to long-term follow-up demonstrates their continued vulnerability and emphasizes the importance of developing comprehensive, individualized care plans that extend beyond the ICU setting.

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The authors confirm that we have no conflicts of interest to declare.

Author Contributions

N.K. and N.R. had the idea for the article, performed the literature search, data extraction and analysis, drafted and critically revised the work, and approved the version to be published. N.T. performed data extraction and approved the version to be published. N. P. approved and revised the version to be published.

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