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REVIEW

The outcome of in- and out-hospital cardiopulmonary arrest in the older population: a scoping review

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Key summary points

Aim We aimed to collect the available evidence on outcome regarding survival and quality of life after CPR following both IHCA and OHCA in the older population.

Findings Hospital survival rates following IHCA and OHCA in the older population improved in the recent decade, though do not exceed 28.5% and 11.1%, respectively. The effect of age on outcome remains controversial and age should not be used as the sole decision criterium whether to initiate CPR.

Message Future research should study frailty and resilience as an independent predictor regardless of age, and add broader, extensive QoL measures as outcome variables.

Abstract

Purpose We aimed to collect the available evidence on outcome regarding survival and quality of life after cardiopulmonary resuscitation (CPR) following both in-hospital cardiac arrest (IHCA) and out-of-hospital cardiac arrest (OHCA) in the older population.

Methods A scoping review was performed studying published reviews after 2008, focusing on outcome of CPR in patients aged ≥ 70 years following IHCA and OHCA. In addition, 11 (IHCA) and 19 (OHCA) eligible studies published after the 2 included reviews were analyzed regarding: return of spontaneous circulation, survival until hospital discharge, long-term survival, neurological outcome, discharge location or other measurements for quality of life (QoL).

Results The survival until hospital discharge ranged between 11.6 and 28.5% for IHCA and 0–11.1% for OHCA, and declined with increasing age. The same trend was seen regarding 1-year survival rates with 5.7–25.0% and 0–10% following IHCA and OHCA, respectively. A good neurological outcome defined as a Cerebral Performance Category (CPC) 1–2 was found in 11.5–23.6% (IHCA) and up to 10.5% (OHCA) of all patients. However, the proportion of CPC 1–2 among patients surviving until hospital discharge was 82–93% (IHCA) and 77–91.6% (OHCA). Few studies included other QoL measures as an outcome variable. Other risk factors aside from age were identified, including nursing home residency, comorbidity, non-shockable rhythm, non-witnessed arrest. The level of frailty was not studied as a predictor of arrest outcome in the included studies.

Conclusions Hospital survival rates following IHCA and OHCA in the older population improved in the recent decade, though do not exceed 28.5% and 11.1%, respectively. The effect of age on outcome remains controversial and age should not be used as the sole decision criterium whether to initiate CPR. Future research should study frailty and resilience as an independent predictor regardless of age, and add broader, extensive QoL measures as outcome variables.

Keywords Age · CPR · Functional state · Neurological outcome · Quality of life · Survival

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Introduction

A cardiopulmonary arrest can be defined as the cessation of cardiac mechanical activity as confirmed by the absence of signs of circulation [1]. When this condition occurs in a hospital setting, it is referred to as an in-hospital cardiac arrest (IHCA). An out-of-hospital cardiac arrest (OHCA) takes place in prehospital environments.

Cardiac arrests are more frequently seen in people with advanced age. A study in Japan reported that patients aged 65 years and older accounted for more than 80% of all patients with OHCA [2]. In view of the rapid, worldwide expansion of this older section of the population, a higher rate of cardiac arrests can be expected [3].

Cardiopulmonary resuscitation (CPR) can be lifesaving for persons with cardiopulmonary arrest. However, patients who survive the initial resuscitation are at risk of anoxic brain damage [4, 5]. In addition, significant emotional disorders such as anxiety, depression and post-traumatic stress disorder (PTSD) are frequent in those who survive [6]. Therefore, in some cases, the use of CPR may lead to prolongation of the dying phase and suffering without adding to quality of life.

As such, it is important that resuscitation attempts occur in accordance with the preferences of the well-informed patient [7–9]. The driving force for their decision regarding resuscitation is quality of life post-resuscitation. Many patients are unrealistically optimistic about the results of CPR and thus make uninformed choices. Relevant and correct information, once provided, influences the final decision considerably [10]. It is up to the healthcare professional to explain the success rate and possible harmful effects of CPR to the patient and their family [11].

To provide accurate information and make the optimal decision for each individual, it is important for healthcare professionals to identify those subgroups with good chances of a satisfactory post-arrest quality of life [12, 13].

In this scoping review, we aimed to collect all available and recent evidence on outcome regarding survival and quality of life after CPR following both IHCA and OHCA in the older population, including indicators of poor prognosis.

Methodology

Search strategy

A search was conducted to find the most recent systematic reviews concerning survival and quality of life following IHCA and OHCA in patients 70 years or older. Subsequently, a search was conducted to find all primary studies published after these systematic reviews to acquire the most recent available evidence. This was done separately for IHCA and OHCA, using analogous search entries.

Review selection The MEDLINE, EMBASE, PubMed and Google Scholar databases were electronically searched in October 2018 to find reviews concerning CPR outcomes in the older population. The search strategy cross-referenced 'elderly', 'resuscitation' and 'functional outcome' using appropriate synonyms, medical subject headings (MeSH), keywords and filters (Appendix 1 in ESM). The references from relevant reviews were also scanned for additional studies. The remaining titles were scanned to exclude other study types (such as randomized controlled trials, observational studies, editorials, case reports, case-series, and narrative reviews), duplicates and articles in a language different from Dutch or English or of which no free full text could be obtained.

Other reasons for exclusion were reviews that lacked relevant outcomes, focused on the effect of a specific treatment or specifically investigated the association with a pathology (such as malignancies or pneumonia). Reviews with irrelevant study populations (too young) or conditions (such as victims of avalanches) were also excluded (Fig. 1). Indistinct cases were discussed and resolved by consensus with RP, NVDN and PD.

Two systematic reviews were found using the search strategy mentioned above, concerning IHCA and OHCA, respectively [14, 15].

Primary study selection To find complementary primary studies published after these systematic reviews, a search was conducted by cross-referencing 'elderly', 'resuscitation', 'functional outcome' and 'in-hospital' or 'out-of-hospital', using appropriate medical subject headings (MeSH), keywords and filters in MEDLINE, EMBASE and PubMed to find observational studies and RCTs (Appendix 2 in ESM). The search period for the primary studies was determined by the end of the search period of the two included reviews: November 2012 to October 2018 concerning IHCA, and from May 2011 until October 2018 concerning OHCA. Older publication dates, unrelated articles, duplicates and articles in a language different from Dutch or English were excluded. Other reasons for exclusion were articles that focused on irrelevant outcomes, populations or contexts; comparisons of scores, guidelines, measurement tools or models, and the effect of a specific pathology or treatment on outcome (Figs. 2, 3). In total, 11 articles were included concerning IHCA [16–26] and 19 articles concerning OHCA [27–45].

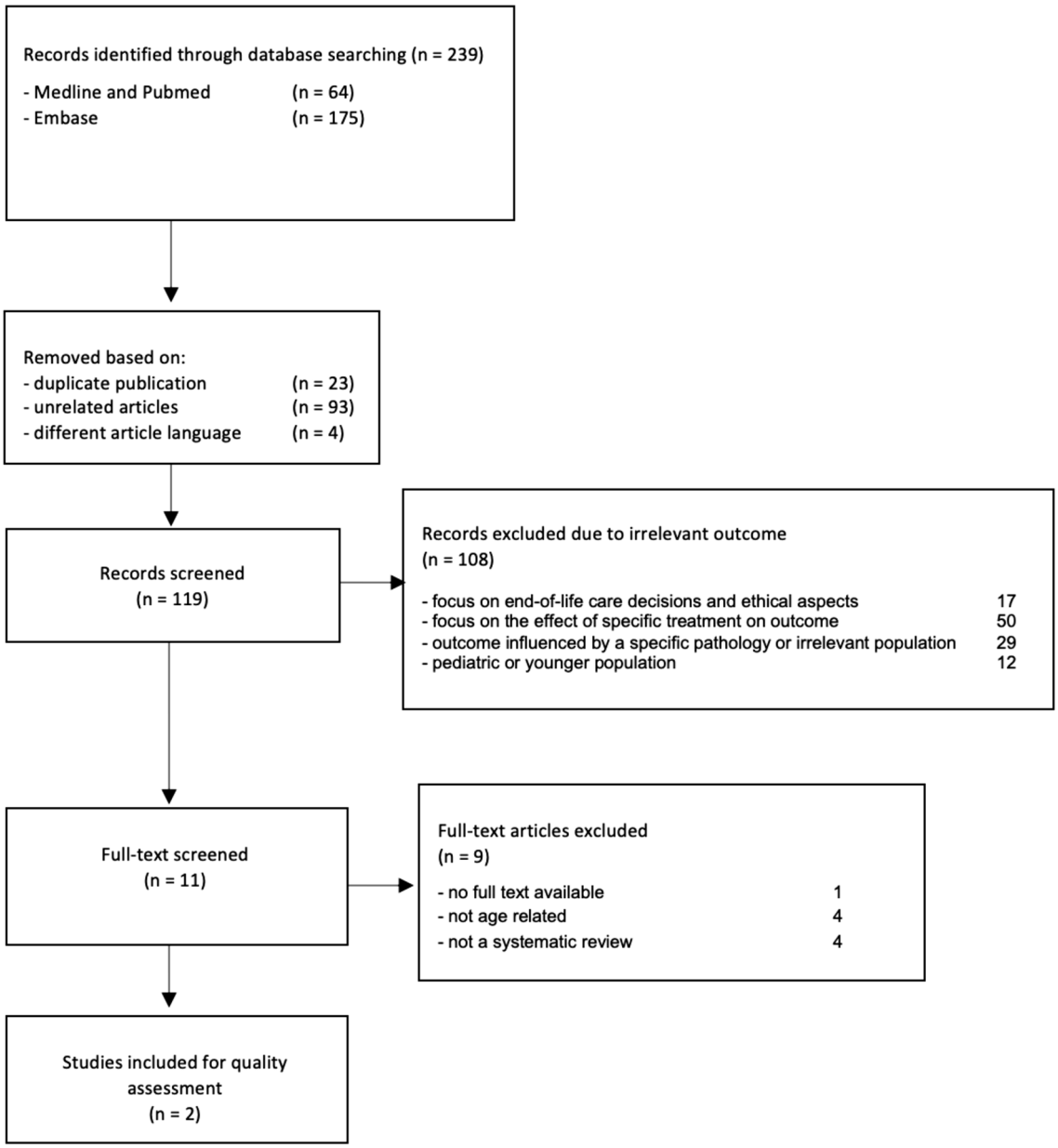

Fig. 1 Search and study selection: systematic reviews

Quality assessment

For quality assessment of the reviews, the AMSTAR measurement tool was applied. This checklist consists of 11 items. A review was considered to be of low, moderate or high quality when, respectively, ≤ 5, 6–8, or ≥ 9 of the requirements were fulfilled. Both reviews proved to be of moderate quality (Appendix 3 in ESM).

The STROBE checklist was used to assess the quality of the primary studies. A review was considered to be of low, moderate or high quality when, respectively, ≤ 10, 11–16, or ≥ 17 of the requirements were fulfilled. For the primary articles concerning IHCA and OHCA, all included studies proved to be of high quality after assessment (Appendix 4 in ESM). In 7 IHCA articles and 14 OHCA articles, Utstein-style guidelines were used to report the data.

Data extraction

Data extraction was performed by RZ and subsequently verified by RP, NVDN and PD. These data concerned: author, place and research period, study design, sample size, sample characteristics, study characteristics and outcomes of interest. We collected both unadjusted

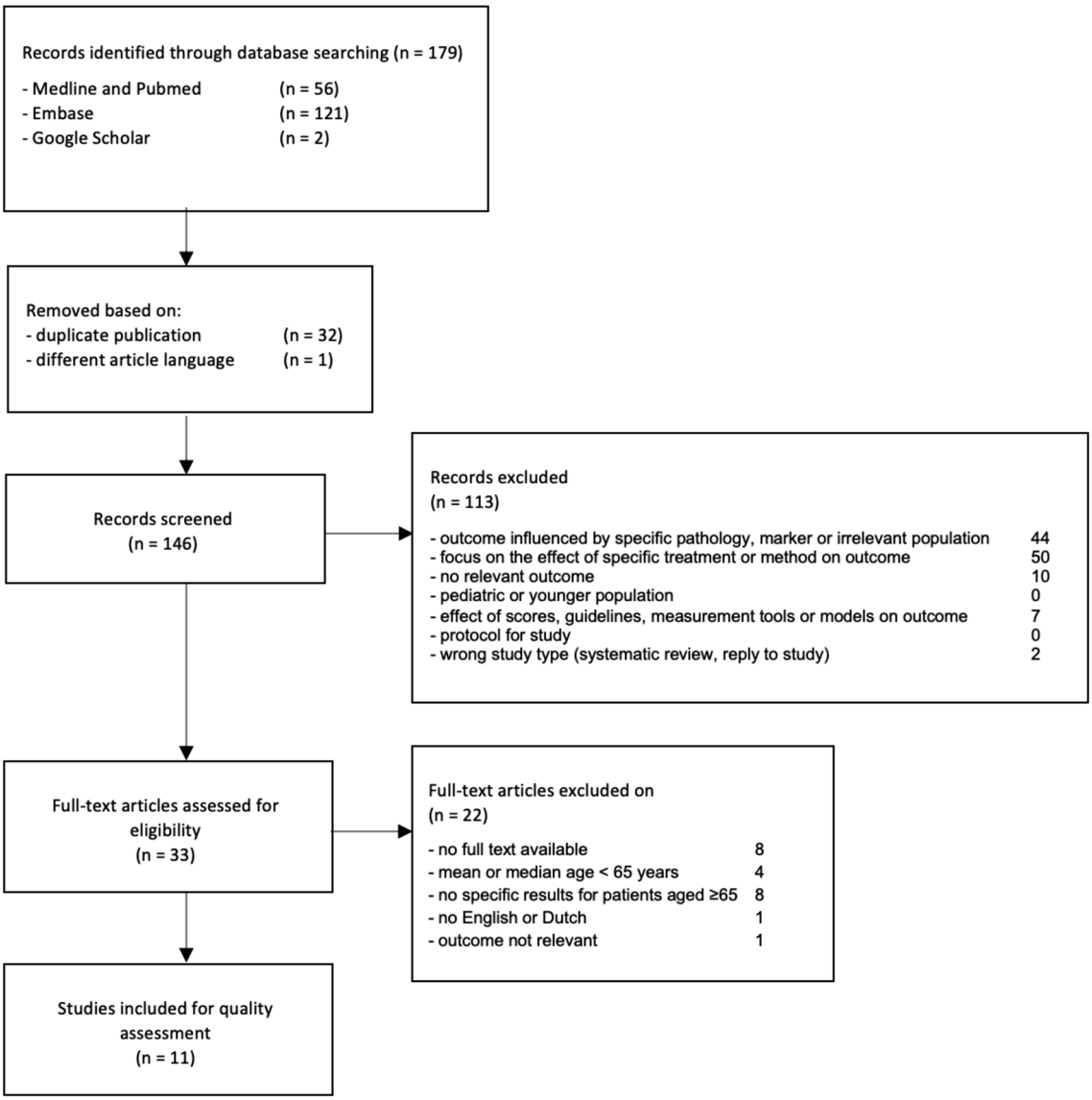

Fig. 2 Search and study selection: primary studies IHCA

and adjusted data. Outcomes were chosen a priori, and consisted of: return of spontaneous circulation (ROSC), survival until hospital discharge, long-term survival (≥ 6 months following the event), discharge location and other quality of life measurements. These outcomes were structured and presented separately for the IHCA review (Table 1), the OHCA review (Table 2), the primary IHCA articles (Table 3) and the primary OHCA articles (Table 4), and additionally according to age (Table 5).

Secondary variables concerning the condition and location of the arrest such as initial cardiac rhythm, type of ward, witnessed event, bystander-initiated CPR and emergency medical services (EMS) response time were reported when registered specifically for the older population. Risk factors positively or negatively associated with survival or quality of life outcomes were also documented.

Post-resuscitation neurological and functional state were mostly analyzed using the Cerebral Performance Category scale (CPC scale) [46]. This measurement tool uses a score of 1–5 for the categories: 1: "good cerebral performance"; 2: "moderate cerebral disability"; 3: "severe cerebral disability"; 4: "coma or vegetative state" and 5: "dead or brain death" [47]. In this review, scores of 1 or 2 are considered to be good neurological outcomes.

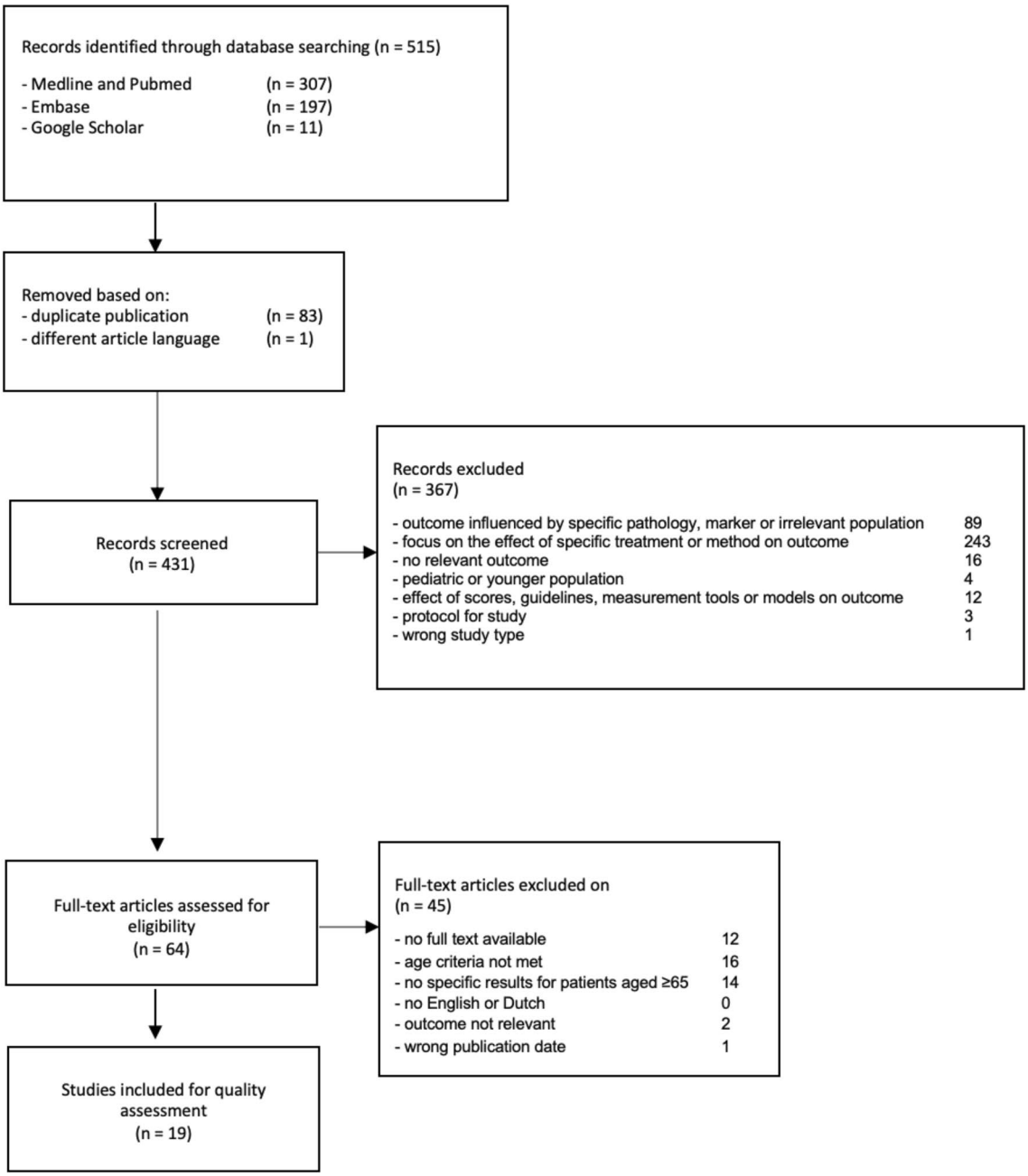

Fig. 3 Search and study selection: primary studies OHCA

Results

Survival rates

The systematic review concerning IHCA consisted of 29 studies. An overall ROSC was found in 38.6% of the resuscitated patients. Overall survival rates were lowest in the category of 90 years and older (11.6%), followed by octogenarians (15.4%), and highest in patients aged 70–79 years (18.7%). Long-term survival (6 months to 1 year) varied between 5.7 and 20.9% concerning patients aged 70 years and older.

In the complementary IHCA studies, overall survival until hospital discharge was systematically higher and varied

Table 1 Review in-hospital

First author Year Country	Study design Methods Population Setting	Sample size (*n*)	Inclusion	ROSC	Survival to discharge Long-term survival	Quality of life
Van Gijn, M. et al 2014 The Netherlands [14]	**Study design** Systematic review 1968–2012 **Methods** 29 studies included Retrospective 17 Prospective: 12 **Setting** General hospital: 13 Tertiary hospital: 8	417 190	All patients 70 years or older	10 studies investigated the ROSC for patients aged 70 years and older The rate of ROSC varied between 20.8 and 57.9%, with a pooled rate of 38.6%	**Survival to discharge (pooled or average)** Including all wards: 17.3% (6 studies) Including all wards except emergency settings: 18.7% (4 studies) Including geriatric wards: 14.8% (1 study) Patients between 70 and 79 years old: 18.7% (range 8.2–35.7%) (11 studies) Patients between 80 and 89 years old: 15.4% (range 4.0–31.0%) (10 studies) Patients aged 80 years and older: 10.5% (1 study) Patients aged 90 years and older: 11.6% (range 0–50.0%) (9 studies) **Long-term survival** 1-week survival: 8.4% 1-month survival: 7.0% 6-month survival: 5.7% 6-months survival after CPR for patients ≥ 80 years who survived CPR: 6.1% 1-year survival of 234 patients ≥ 70 years: 15.4–20.9% 1-year survival of 86 patients ≥ 75 years: 7.0% 2-year survival of 78 patients ≥ 70 years: 18.5% 3-year survival of 78 patients ≥ 70 years: 17.3%	**Functional status** One study showed that all successfully resuscitated patients of 70 years and older (n = 7) enjoyed a level of independence similar to their level before the resuscitation, measured 1 month after the resuscitation Another study with 42 successfully resuscitated patients of 70 years and older (54% of total) also found that there were no significant differences in the functional level of the survivors at the time of hospital discharge compared with their pre-arrest status In a study with 24 patients older than 80 years, only 20% of the survivors were capable of independent functioning outside of institutionalized care **Discharge location** *In one study of 50 patients who survived to hospital discharge*: 19 were discharged home 9 were placed in a nursing home 12 were admitted to a rehabilitation or psychiatric facility 10 were transferred to a chronic care hospital with ventilator capabilities

Table 2 Primary studies in-hospital

First author Year Country	Study design Methods Population Setting	Sample size (*n*)	Inclusion	Conditions Location	ROSC	Survival from ICU Survival until discharge Long-term survival	Quality of life Neurological state Discharge destination
Al-Dury, N. et al 2017 Sweden [16]	**Study design** Prospective study using the National quality register of OHCA and IHCA 69 hospitals included 2007–2014 **Mean age (years)** 72.7 (13.4) **Age categories (years)** ≥ 65 **Men (%)** 62.4	14,933	**Inclusion** Patients who suffered a cardiac arrest and underwent CPR within the hospital perimeter **Exclusion** Patients younger than 18 years	**Conditions ≥ 65 years** Witnessed: 79.2% Initial VT/VF: 30.0% **Location ≥ 65 years** Monitored ward: 43.1% General wards: 52.8% Lab, radiology department: 3.6% Other: 2.2%	–	**Survival until hospital discharge and 30 days after** Patients ≥ 65 years: 24.2% (2777/11 474)	**Good neurological state (CPC 1–2)** *At hospital discharge*: Survivors ≥ 65: 93.1% All patients ≥ 65: 20.1%
Chan P. S. et al 2013 USA [21]	**Study design** Prospective study using Get With The Guidelines (GWTG)-Resuscitation registry 2007–2010 **Methods** They randomly selected 2/3 of the study population for the derivation cohort and 1/3 for the validation cohort **Mean age (years)** 65.6 (16.1) **Age categories** 60–69 years 70–79 years ≥ 80 years **Men (%)** 58.3	48,841	**Inclusion** Patients 18 years of age or older with an index IHCA enrolled in GWTG-Resuscitation **Exclusion** Patients with do-not-resuscitate (DNR) orders	**Conditions** Not available for patients aged ≥ 65 years	–	**Survival until hospital discharge** *Derivation cohort*: 60–69 years: 21.9% 70–79 years: 23.2% 80–89 years: 21.9% *Validation cohort*: 60–69 years: 21.8% 70–79 years: 23.3% 80–89 years: 21.5%	–

Table 2 (continued)

First author Year Country	Study design Methods Population Setting	Sample size (*n*)	Inclusion	Conditions Location	ROSC	Survival from ICU Survival until discharge Long-term survival	Quality of life Neurological state Discharge destination
Chan P. S. et al 2013 USA [26]	**Study design** Study using the national Get with the Guidelines Resuscitation registry of inpatient cardiac arrests and Medicare files 523 acute care hospitals 2000–2008 **Mean age (years)** 75.8 (±7) **Age categories** 65–74 years 75–84 years ≥85 years **Men (%):** 55.5	6972	**Inclusion** Patients 65 years of age or older who survived to hospital discharge after IHCA **Exclusion** Patients younger than 65 years of age Patients with do-not-resuscitate orders For patients who had a cardiac arrest during multiple hospitalizations, we used the first hospitalization as the index hospitalization	**Initial rhythm** Asystole: 24.5% PEA: 29.1% VF: 30.5% PVT: 15.9%	–	**Survival rate of survivors to discharge** At 30 days: 82.0% At 3 months: 72.0% At 1 year: 58.5% At 2 years: 49.6% **1-year survival of survivors to discharge** Risk-adjusted: 65–74 years: 63.7% 75–84 years: 58.6% ≥85 years: 49.7% Risk-adjusted based on CPC score at discharge: CPC1: 72.8% CPC2: 61.1% CPC3: 42.2% CPC4: 10.2%	**Good neurological state (CPC 1–2)** *Survivors at hospital discharge:* CPC1 = 48.1% CPC2 = 34.3% **Discharge location** *Among survivors*: Inpatient skilled nursing facility: 55.3% Home: 40.0% Hospice: 4.8% *Readmission* At 1 year: 65.6% At 2 years: 76.2%
DeVoe B. et al 2016 USA [22]	**Study design** Retrospective cohort study A large tertiary care hospital in a metropolitan area, focusing on two units, Cardiac Care and Cardiothoracic Telemetry Cardiac patients 2007–2013 **Age categories (years)** 65–84.9 years 85–100 years **Median age (years)** 75 (21–98) **Men (%)** 61	417	**Inclusion** Patients 18 years and older, who experienced IHCA and were treated with ACLS were included in the study **Exclusion** Patients who were under do not resuscitate (DNR) or do not intubate (DNI) orders, admitted to the ICU, or treated in the operating suites or emergency department If a patient had more than one CA on the floor during the hospitalization, only the first event was included	**Conditions** Not available for patients aged ≥65 years	**ROSC > 20 min** 65–84.9: 61% 85–100: 50%	**Survival until hospital discharge** 65–84.9 years: 18% (45/247) 85–100 years: 12% (8/64)	–

Table 2 (continued)

First author Year Country	Study design Methods Population Setting	Sample size (*n*)	Inclusion	Conditions Location	ROSC	Survival from ICU Survival until discharge Long-term survival	Quality of life Neurological state Discharge destination
Gershengorn, H. B. et al 2012 USA [17]	**Study design** Retrospective cohort study The Project IMPACT (Cerner Corporation, Kansas City, Mo) database 2001–2008 **Age categories (years)** 65–84 years ≥ 85 years **Men (%)** 58	6518	**Inclusion** Patients who survived to admission and received CPR while in the ICU **Exclusion** Patients younger than 20 years old at ICU admission Patients cared for in a separate neurologic unit Patients who had a do-not-resuscitate (DNR) order at the time of in-ICU CPR	**Conditions** Not available for patients aged ≥ 65 years	–	**Survival until hospital discharge** 65–84 years: 16.2% (476/2941) ≥ 85 years: 11.3% (52/461)	**Discharged destination** *Among all patients*: Home, independent: 3.3% Home, dependent: 1.5% Facility, independent: 0.1% Facility, dependent: 8.2% *Among survivors to discharge*: Home: 33.6% Functionally independent: 20.1% Partially dependent: 45.8% Fully dependent: 34.1%
Hessulf F. et al 2017 Sweden [23]	**Study design** Retrospective study using The Swedish Register of Cardiopulmonary Resuscitation (SRCPR) 66 Swedish hospitals with cardiac arrest teams (CATs) participated 2006–2015 **Median age (years)** 75 (48%) **Men (%)** 61	18,069	**Inclusion** All unique (i.e., the first occasion for those with multiple CAs during the study period) IHCAs in patients 18 years of age or older	**Conditions** Not available for patients aged ≥ 65 years	**ROSC during resuscitation** 61% **Alive when resuscitation was terminated** 50%	**Survival until hospital discharge** 28.5% (5150/18 069) **30-day survival** 28.3% (5114/18 069) **1-year survival** 25.0% (4517/18 069)	**Good neurological state (CPC 1–2)** *Among all patients*: 23.6% (4262/18 069) *At hospital discharge*: 93.0% (4790/5150)

Table 2 (continued)

First author Year Country	Study design Methods Population Setting	Sample size (*n*)	Inclusion	Conditions Location	ROSC	Survival from ICU Survival until discharge Long-term survival	Quality of life Neurological state Discharge destination
Hirlekar, G. et al 2017 Sweden [18]	**Study design** Retrospective observational cohort study The Swedish Cardiopulmonary Resuscitation Registry 2007–2015 73 hospitals **Age categories (years)** 70–79 years = 28% 80–89 years = 20% ≥ 90 years = 14% **Men (%)** 70–79 years: 64.3 80–89 years: 55.6 ≥ 90 years: 43.8	11,396	**Inclusion** Patients at least 70 years of age who had an IHCA Patients with multiple IHCAs during the study period were only included once (the first occasion)	**VF/VT as initial rhythm** 70–79 years: 31.3% 80–89 years: 26.5% ≥ 90 years: 21.7% **Witnessed** 70–79 years: 81.3% 80–89 years: 76.7% ≥ 90 years: 75.3% **Monitored wards** 70–79 years: 35.9% 80–89 years: 28.4% ≥ 90 years: 19.5% **Emergency department** 70–79 years: 8.7% 80–89 years: 8.7% ≥ 90 years: 12.3% **General ward** 70–79 years: 49.4% 80–89 years: 57.8% ≥ 90 years: 63.1%	–	**Survival until hospital discharge** 70–79 years: 27.9% (1460/5232) 80–89 years: 20.1% (1036/5156) ≥ 90 years: 15.1% (152/1008) ≥ 90 years with VF/VT: 41% **30-day survival** 70–79 years: 27.9% (1460/5232) 80–89 years: 20% (1005/5156) ≥ 90 years: 14% (142/1008)	**Good neurological state (CPC 1–2)** *Among all patients*: 70–79 years: 22.7% (1188/5232) 80–89 years: 16.5% (851/5156) ≥ 90 years: 11.5% (116/1008) *At hospital discharged*: 70–79 years: 92% (1343/1460) 80–89 years: 93% (963/1036) ≥ 90 years: 88% (134/152)
Kazaure H. S. et al 2013 USA [25]	**Study design** Retrospective analysis of The Nationwide In patient Sample 2000–2009 **Age categories** 65–74 years 75–84 years ≥ 85 years **Mean age (years)** 2000–2001: 68.7 (0.04) 2008–2009: 67.1 (0.04) **Median age (years)** 2000–2001: 72 (59–80) 2008–2009: 69 (57–80) **Men (%)** 2000–2001: 54.3 2008–2009: 55	813,493	**Inclusion** Adult patients (≥ 18 years) who underwent CPR (ICD-9 code: 99.60) during their hospitalization were abstracted **Exclusion** Patients who had cardiopulmonary arrest as a primary diagnosis were excluded to avoid including patients who experienced an out-of-hospital event in our analyzes	–	–	**Survival until hospital discharge** *In 2000–2001*: 65–74 years: 21.3% (6887/32 364) 75–84 years: 19.2% (7510/39 081) ≥ 85 years: 15.3% (2843/18 625) *In 2008–2009*: 65–74 years: 28.1% (12 229/43 506) 75–84 years: 24.1% (11 648/48 304) ≥ 85 years: 19.0% (4842/25 241)	–

Table 2 (continued)

First author Year Country	Study design Methods Population Setting	Sample size (*n*)	Inclusion	Conditions Location	ROSC	Survival from ICU Survival until discharge Long-term survival	Quality of life Neurological state Discharge destination
Menon, P. R. et al 2014 USA [19]	**Study design** Epidemiological study using Medicare Provider Analysis and Review (MedPAR) 1992–2005 **Age categories (years)** 65–69 years 70–74 years 75–79 years 80–84 years 85–89 years ≥90 years **Men (%)** 50.6	421,394	**Inclusion** Patients ≥ 65 years who underwent CPR during the study period **Exclusion** Patients with incomplete CPR claims data Those with incoherent data concerning time of death and/or hospital discharge	**Conditions** Not available for patients aged ≥ 65 years	–	**Survival until hospital discharge** One CPR event: 17.7% (73 172/413 403) Multiple CPR events: 8.8% (703/7991) 1 × CPR (%) / Multi (%) 65–69 years: 21.8 / 8.9 70–74 years: 21.8 / 9.3 75–79 years: 18.4 / 9.0 80–84 years: 16.3 / 7.1 85–89 years: 14.3 / 7.8 ≥90 years: 11.3 / 5.3	**Discharged destination** *Home*: One CPR event: 43.7% (31 976/73 172) Multiple CPR events: 34% (239/703) *Skilled nursing facility*: One CPR event: 22.8% (16 683/73 172) Multiple CPR events: 21.8% (153/703) *Another hospital*: One CPR event: 31.6% (23 122/73 172) Multiple CPR events: 42.6% (299/703)
Thompson L. E. et al 2017 USA [24]	**Study design** Observation of The Guidelines-Resuscitation Registry 2000–2011 **Mean age (years)** 77.2 (7.4) **Age categories (years)** 65–74 years 75–85 years > 85 years **Men (%)** 55.5	45,567	**Inclusion** Patients aged 65 years or older with cardiac arrests occurring in an intensive care unit or inpatient ward who received CPR **Exclusion** Patients with arrests that occurred in operating rooms, procedural suites, or emergency departments, as cardiac arrests in these settings have distinct clinical circumstances and outcomes Patients with do-not-resuscitate orders Among patients with multiple in-hospital cardiac arrests (n = 5130), the analysis was restricted to the index event	**Initial rhythm** VF: 12.5% PVT: 7.8% PEA: 42.2% Asystole: 37.6% **Location** ICU: 53.6% Monitored: 25.3% Non-monitored: 21.2%	–	**Survival until hospital discharge** Unadjusted: 16.6% (7564/45 567) **30-day survival** 13.6% (6200/45 567) **1-year survival** 9.4% (4283/45 567)	–

Table 3 Review out-of-hospital

First author Year Country	Study design Methods Population Setting	Number of participants	Inclusion	Conditions	Survival to discharge Long-term survival	Quality of life
Van de Glind, E. M. et al 2013 The Netherlands [15]	**Study design** Systematic review 1980–2011 **Methods** All retrospective cohort studies of chart reviews and one case–control 23 studies included **Age and gender** Range 33–99 years Patients ≥ 70 years (4 studies) Mean age ≥ 70 years (5 studies) Subgroups provided (14 studies) **Location** 14 USA 8 Europe	44,582	**Exclusion** Age below 70 or no separate subgroup with participants > 70 years The examination of In-hospital CPR only	**Most studies include arrest factors such as**: Witnessed arrest Bystander arrest Shockable rhythm	**Pooled survival to discharge** Patients aged 70 years or older: 4.1% Patients in a nursing home: 0–5.1% All studies but one reported survival to discharge **Long term outcome** 7 reported long-term outcome No results were mentioned	**Functional status** 7.5% of the patients for whom resuscitation was attempted survived neurologically intact to 1 year (2 studies) In patients that did not achieve ROSC in the field, only 0.6% survived to discharge neurologically intact Other studies that included only patients over 70 years showed that although the overall survival was low, the majority of the survivors displayed moderate to good cerebral performance The study of Pleskot et al. showed no difference between younger and older survivors in cerebral performance (but the number of survivors was insufficient to identify significant differences) In the Horsted study, survivors rated two of the eight quality of life aspects of the SF-36 scale as significantly worse than the age-matched normative scores (no specification for age was made)

Table 4 Primary studies out-of-hospital

First author Year Country	Study design Methods Population Setting	Number of participants	Inclusion	Conditions Location	ROSC	Survival to admission Survival to ICU/hospital discharge Long-term survival	Quality of life
Abrams H. C. et al 2011 USA [30]	**Study design** A retrospective study 2004–2007 **Age categories (years)** <50: 19.1% 50–60: 20.3% 60–70: 20.2% 70–80: 20.6% >80: 18.6% **Men** (%) 66.6	1156	**Inclusion** All arrests of presumed cardiac etiology where resuscitation was attempted by EMTs or paramedics EMS, or by first responders	**Witnessed bystander**: 46; 8% **Initial rhythm** VF/VT: 32.9% Asystole: 24% **Location** Home: 53.1% Public place: 22.3% Other: 18.6%	**Pre-hospital ROSC** 32% (374/1156)	**Survival until hospital discharge** *Among all patients*: 11.1% (128/1156) *In patients with pre-hospital ROSC*: 32.9% (128/374) *In the age group of*: 60–70 years: 15% (35/234) 70–80 years: 9.2% (21/238) >80 years: 2.8% (6/215)	–
Andersen, L.W. et al 2015 USA [42]	**Study design** Retrospective, observational, cohort study 2006–2013 **Mean age (years)** 66 (54–78) **Age categories** 65–69 years 70–74 years 75–79 years 80–84 years 85–89 years 90–94 years 95–99 years >100 years **Men** (%) 61	101,968	**Inclusion** Patients with OHCA of presumed cardiac etiology **Exclusion** Patients aged 16 or younger Patients where no CPR was attempted in the prehospital setting Patients where resuscitation efforts were terminated based on a DNR designation Patients with missing data on the exposure (age), covariates or outcomes	**Conditions** Not Available for patients ≥ 65 years	**ROSC achieved** 65–69: 32.5% 70–74: 32% 75–79: 31.5% 80–84: 29% 85–89: 28.5% 90–94: 28% 95–99: 23.5% >100: 25%	**Survival until hospital discharge** 65–69: 10.5% 70–74: 8.5% 75–79: 7.5% 80–84: 5% 85–89: 4% 90–94: 3.5% 95–99: 1.7% >100: 3.9%	**Good neurological state (CPC 1–2:** *At discharge*: 65–69: 9% 70–74: 7% 75–79: 6% 80–84: 4% 85–89: 3% 90–94: 2% 95–99: 1% >100: 2%

Table 4 (continued)

First author Year Country	Study design Methods Population Setting	Number of participants	Inclusion	Conditions Location	ROSC	Survival to admission Survival to ICU/hospital discharge Long-term survival	Quality of life
Andrew, E. et al 2018 Austria [27]	**Study design** Retrospective analysis of Victorian Ambulance cardiac arrest registry data 2010–2016 **Mean age (years)** 75.0 (SD 7.4) **Age category** 65–74: 51.8% 75–84: 35.6% ≥85: 12.6% **Men (%)** 75.7	20,103	**Inclusion** Survivors to hospital discharge aged ≥65 years after OHCA	**Residence** At home: 92.0% No additional care: 65.9% **Witnessed** Public: 48.4% EMS: 41.4% **Bystander** CPR: 78.2% **Initial rhythm** VF/VT: 76.0% PEA: 14.9% Asystole: 9.0% **Location** Private: 50.6% Facility: 2.9% Public: 29.7% Other: 16.9%	–	**Survival until hospital discharge** All patients: 9.7% (876/9016) In an aged care facility: 2.2% (57/2575) **1-year survival** 65–74: 64.6% 75–84: 62.6% ≥85: 72.7% **1-year survival** In an aged care facility: 1.0%	**GOSE** *Good upper and lower recovery*: 65–74: 72.4% (262/363) 75–84: 63.3% (143/227) ≥85: 41% (25/61) *Moderate upper and lower recovery*: 65–74: 16.6% (60/363) 75–84: 13.3% (30/227) ≥85: 14.8% (9/61) *Severe upper and lower disability*: 65–74: 10.8% (39/363) 75–84: 23.4% (53/227) ≥85: 44.3% (27/61) *Vegetative state*: 65–74: 0.3% (1/363) 75–84: 0% (0/227) ≥85: 0% (0/61) *In an aged care facility*: 1/8 patients were in a vegetative state 7/8 had a lower severe disability **Mean SF-12** *Mental component summary*: 65–74: 56.5 75–84: 56.7 ≥85: 56.3 *Physical component summary*: 65–74: 46.3 75–84: 43.6 ≥85: 36.2 **Median EQ-5D** *Index score*: 65–74: 0.85 75–84: 0.81 ≥85: 0.73 *VAS*: 65–74: 80 75–84: 70 ≥85: 70 **Good 1-year functional recovery** 4.8% (42/876) **Returned to work if working prior** 65–74: 62.6% (67/107) 75–84: 0.81 (8/8) ≥85: 0.73 (0/1) **Discharge location** Home: 77.9% Rehabilitation: 16.2% Aged care facility: 5.9%

Table 4 (continued)

First author Year Country	Study design Methods Population Setting	Number of participants	Inclusion	Conditions Location	ROSC	Survival to admission Survival to ICU/hospital discharge Long-term survival	Quality of life
Beesems, S. G. et al 2015 The Netherlands [45]	**Study design** Prospective community-based cohort study with retrospective collection of comorbidity information 2009–2011 **Age categories:** ≥ 70 years: 100% 70–79 years: 52.5% ≥ 80 years: 47.5% **Men (%):** 65	1332	**Inclusion** All nontraumatic OHCA patients of ≥ 70 years in whom CPR was attempted by EMS personnel were included in the survival analysis **Exclusion** Aborted resuscitation efforts in individuals with a do-not-attempt resuscitation (DNAR) order, patients with signs of prolonged death, patients who live outside the Netherlands, and EMS-witnessed cases	**Initial rhythm** Shockable: 36% Not shockable: 64% **Conditions** Witnessed arrest: 73% Bystander CPR: 68%	**Survival to ER** ≥ 70 years: 55% (736/1332) 70–79 years: 59% (410/699) ≥ 80 years: 52% (326/633)	**Survival to admission** ≥ 70 years: 35% (464/1332) 70–79 years: 39% (273/699) ≥ 80 years: 30% (191/633) **Survival until hospital discharge** ≥ 70 years: 12% (156/1332) 70–79 years: 16% (108/699) ≥ 80 years: 8% (48/633) **1-year survival** ≥ 70 years: 10% (137/1332) 70–79 years: 14% (96/699) ≥ 80 years: 6% (41/633) Of patients discharged alive: 88% **1-year mortality of patients discharged alive** CPC1: 9% (9/100) CPC2: 15% (6/41) CPC3: 36% (4/11)	**Good neurological state (CPC 1–2)** *At discharge*: ≥ 70 years: 90% (140/156) 70–79 years: 92% (99/108) ≥ 80 years: 88% (42/48)
Chan P. S 2016 USA [31]	**Study design** Prospective clinical registry study using the National CARES registry 2005–2010 **Age category (year)** 65 + **Mean age (years)** 75.4 **Men (%)** 58.3	1127	**Inclusion** Adults 65 years or older with an OHCA not occurring in the presence of EMS personnel and enrolled within CARES **Exclusion** Patients younger than 65 years who would not be eligible for a match to Medicare files: Patients who died during the index hospitalization for their cardiac arrest	**Conditions** Witnessed: 70.6% Bystander CPR: 34.3% First responder CPR: 29.5% EMS CPR: 36.1% **Location** Home: 61% Nursing home: 11.7% Public area: 14.3% Hospital facility: 5.3% Other: 7.6%	–	**Survival until hospital admission** 24.2% (3931/16 208) **Survival until hospital discharge** 6.9% (1127/16 208) **Mortality** At 30 days: 12.7% At 1 years: 31.8% At 3 years: 47.2%	**Good neurological state (CPC 1–2)** *Of patients who survived to discharge*: CPC 1: 52.8% (555/1127) CPC 2: 25.2% (265/1127) **1-year mortality rate among those with CPC 1 or 2 at discharge** 21.4% **Discharge location** Home (most without requirement for home health care): 52.6% (592/1127) An inpatient skilled nursing or rehabilitation facility: 38.3% (431/1127) Hospice or another facility: 8.0% (90/1127) Non-home facilities: 1.2% (14/1127) **Readmissions** 638 (56.6%) patients were readmitted during the first year, and 279 (24.8%) were readmitted ≥ 3 times

Table 4 (continued)

First author Year Country	Study design Methods Population Setting	Number of participants	Inclusion	Conditions Location	ROSC	Survival to admission Survival to ICU/hospital discharge Long-term survival	Quality of life
Deasy, C. et al 2012 Austria [40]	**Study design** A retrospective study of The Victorian Ambulance Cardiac Arrest Registry (VACAR) 2000–2009 **Mean age (years)** 70 (52–80) **Men (%)** 66	30,006	**Inclusion** All OHCAs occurring in residential aged care facilities, which were unwitnessed by EMS	**Initial rhythm > 70 years** *At a residential age care facility (RACF)*: Shockable: 7,6% (179/2350) Asystole: 72% (2171/2350) PEA: 20% *At home*: Shockable: 11% Asystole: 77% PEA: 13% **Witnessed for patients > 70 years** At RACF: 36% At Home: 31% **EMS response time for patients > 70 years (min)** At RACF: 7 (6–9) At home: 7.9 (6–10) **Location** 7.8% in a residential aged care facility	**ROSC achieved** OHCA at RACF > 70 years: 24% OHCA at home > 70 years: 32%	**Survived event** *Patients > 70 years*: At RACF: 20% (163/815) At home: 26% (1206/4631) **Survival until hospital discharge** *All patients > 70 years*: 4.3% (232/5389) *OHCAs at RACF > 70 years*: All rhythms: 2.1% (17/810) Shockable: 8.2% (12/146) Non-shockable: 0.9% (6/674) *OHCAs at home > 70 years*: All rhythms: 4.7% (215/4575) Shockable: 9.9% (125/1265) Non-shockable: 2.7% (90/3304)	**Discharge location** A rehabilitation facility: 12% (3/25) Survivors returning to the same level of facility from which they originated: 88% (22/25)
Fan et al 2017 China [32]	**Study design** Retrospective analysis of the prospectively collected data 2012–2013 **Mean age (years)** 80 (66–87) **Age categories (years)** ≥ 65 years: 76.4% **Men (%)** 56	5154	**Inclusion** Patients of all ages were who experienced an OHCA **Exclusion** OHCAs caused by trauma Victims directly transferred to the public mortuary from scene by EMS personnel Patients not using a ground ambulance	**Cases attended by EMS** Home: 51.7% Public place: 10.5% Street: 3.0% HFA: 30.4% On-route to hospital: 4.3% Others: < 0.02% **Witnessed arrest**: 39.5% **Bystander CPR**: 28.8% **Initial rhythm**: VF/VT: 8.7% Asystole: 81.1% PEA: 9.9% Unknown/other: 0.2% **EMS response time (min):** 10 (8–13)	**ROSC on hospital arrival** 3.1% (162/5154)	**Survived to hospital admission** 15.3% (788/5154) **Survival until hospital discharge or 30-day survival** 2.3% (121/5154)	**Good neurological state (CPC 1–2)** *Of all patients at discharge or at 30 days*: 1.5% (78/5154)

Table 4 (continued)

First author Year Country	Study design Methods Population Setting	Number of participants	Inclusion	Conditions Location	ROSC	Survival to admission Survival to ICU/hospital discharge Long-term survival	Quality of life
Fukuda, T. et al 2015 Japan [28]	**Study design** Prospective, population-based clinical registry study using the All-Japan Utstein Registry of the Fire and Disaster Management Agency 2005–2010 **Age categories (years)** 65–84 ≥85 ≥65: 75.1% ≥85: 25.6% **Mean age (years)** 73.1 **Men (%)** 59.4	605,505	**Inclusion** All patients with a confirmed OHCA of all causes and for whom resuscitation is attempted are identified and followed, including those with DNR orders Data collected from 3 sources: 119 dispatch centers, EMS agencies, and receiving hospitals **Exclusion** Patients younger than 18 years of age Patients with missing data (on age) Patients who require an extremely long prehospital time because they have distinct prehospital circumstances and outcomes	**Conditions** Not available for patients ≥ 65 years	**Prehospital ROSC** 2005–2006: 4.5% (8686/191,325) 2007–2008: 5.6% (10,928/194,688) 2009–2010: 6.6% (14,521/219,492)	**30-day survival** 2005–2006: 3.8% (7230/191,325) 2007–2008: 4.2% (8091/194,688) 2009–2010: 4.6% (10 034/219,492)	**Good neurological state (CPC 1–2)** *Of all patients at 1 month: 1.8%* 2005–2006: 1.4% (2627/191,325) 2007–2008: 1.9% (3607/194,688) 2009–2010: 2.1% (4572/219,492)
Grimaldi et al 2014 France [39]	**Study design** A retrospective cohort study 2000–2009 **Age category** 75 + **Median age (years)** 79.5 **Men (%)** 60	225	**Inclusion** Survivors to ICU admission after OHCA aged 75 years and older	**Initial rhythm** VT/VF: 57% **Location** Home: 51% Public place: 28% Other: 21%	–	**Survival of ICU-admitted patients** To discharge: 21.8% (49/225) To 6 months: 19.5% (44/225) To 1 year: 18.5% (42/225) To 5 years: 7.6% (18/225) **Survival of ICU-discharged patients** 1 year: 69.3% (42/60) 28,4 months: 38% (23/60) 5 years: 32.1% (18/60)	**Good neurological state (CPC 1–2)** *At ICU discharge:* 25.3% (57/225) *In long-term survivors (28,4 months)*: CPC1: 91% (21/23) CPC2: 9% (2/23) *In patients who died (35/60) or were lost (2/60) during follow-up*: 75.6% (28/37) **Overall performance category** *In long-term survivors (28,4 months)*: OPC1: 74% (17/23) OPC2: 22% (5/23) OPC3: 4% (1/23) 15% (9/37) were institutionalized during follow-up

Table 4 (continued)

First author Year Country	Study design Methods Population Setting	Number of participants	Inclusion	Conditions Location	ROSC	Survival to admission Survival to ICU/hospital discharge Long-term survival	Quality of life
Kitamura, T 2014 Japan [34]	**Study design** Prospective population-based observational study 1999–2011 **Mean age (years)** 79.4 **Age categories** 65–79: 51.9% 80–89: 34.2% 90 + : 13.9% **Men (%)** 57.1	10,876	**Inclusion** Patients aged ≥ 65 years suffering bystander witnessed OHCA of presumed cardiac origin, who were resuscitated by EMS personnel or bystanders, and were transported to medical institutions EMS providers are not permitted to terminate resuscitation in the field and DNR orders or living wills are not generally accepted in Japan **Exclusion** Cases of decapitation Incineration Decomposition Rigor mortis Dependent cyanosis	**Initial rhythm** VF: 14.8% PEA: 32.5% Asystole: 51.3% Others: 1.4% **Bystander-initiated CPR** Homes: 29.4% Public places: 35.4% Nursing homes: 75.9% **Type of bystander-initiated CPR, n (%)** No CPR: 63.2% Chest compression-only CPR: 20.1% Conventional CPR with rescue breathing: 16.6% **EMS response time (min):** 7.4 (2.7) **Location** *Patients aged ≥ 90 years:* Homes: 12.2% Public places: 2.8% Nursing homes: 37.9% **Mean EMS response time (min, SD):** 7.9 (4.1)	**Achieved ROSC** Overall: 39% (4251/10 876) VF: 59.9% (962/1614) Non-VF: 35.7% (3289/9262)	**Survived to admission** Overall: 30.5% (3316/10 876) VF: 52.9% (854/1614) Non-VF: 26.6% (2462/9262) **30-day survival** Overall: 7.8% (851/10 876) VF: 30.1% (484/1614) Non-VF: 4.0% (367/9262)	**Good neurological state (CPC 1–2)** *At 1 month:* 1999: 1.4% 2011: 4.8% At homes: 2.4% (186/7661) At public places: 11.6% (161/1392) At nursing homes: 1.3% (17/1358) At other locations: 5.9% (27/461) VF: 17.1% (276/1614) Non-VF: 1.2% (115/9262)
Kitamura, T. et al 2012 Japan [33]	**Study design** Prospective, population-based observational study 2005–2009 **Mean age (years)** 72.3 (17.5) **Age categories** 65–79 years: 33.8% 80–89 years: 28.1% ≥ 90 years: 12.2% **Men (%)** 58.0	169,360	**Inclusion** All patients with OHCA of cardiac and noncardiac origins in whom resuscitation was attempted and who were then transported to medical institutions	**Bystander witnessed** 100%	–	**30-day survival** with **CPC 1–2**: *Overall*: 65–79 years: 3.3% (1871/57 236) 80–89 years: 1.1% (538/47 658) ≥ 90 years: 0.5% (101/20 630) *Cardiac origin*: 65–79 years: 4.6% (1538/33 551) 80–89 years: 1.4% (356/26 366) ≥ 90 years: 0.5% (61/11 332) *Non-cardiac origin*: 65–79 years: 1.4% (333/23 685) 80–89 years: 0.9% (182/21 292) ≥ 90 years: 0.4% (40/9298)	–

Table 4 (continued)

First author Year Country	Study design Methods Population Setting	Number of participants	Inclusion	Conditions Location	ROSC	Survival to admission Survival to ICU/hospital discharge Long-term survival	Quality of life
Libungan, B. et al 2015 Sweden [43]	**Study design** Observational study using the Swedish CPR Register 1990–2013 **Age categories** 70–79 years: 53% 80–89: years 40% ≥90 years: 7% **Men (%):** 70–79 years: 70 80–89 years: 62 ≥90 years: 44	36,605	**Inclusion** Patients aged ≥70 years who were reported to the Swedish CPR Register were included	**Bystander witnessed** **Location** 70–79: 57%—Home 80–89: 55% 70–79: 69% ≥90: 54% 80–89: 68% ≥90: 70% **Bystander CPR** 70–79: 45% 80–89: 42% ≥90: 45% **Initial rhythm VF** 70–79: 31% 80–89: 25% ≥90: 16% **EMS response time (min)** 70–79: 7 (5.12) 80–89: 7 (4.11) ≥90: 7 (5.11)	–	**30-day survival** 70–79: 6.7% (1301/19 422) 80–89: 4.4% (647/14 710) ≥90: 2.4% (59/2473) 95–99: 1.7%	**Good neurological state (CPC 1–2)** *At 30-days:* *CPC1* 70–79: 79% (1027/1301) 80–89: 77% (498/647) ≥90: 86% (51/59) *CPC2* 70–79: 15% (195/1301) 80–89: 17% (110/647) ≥90: 14% (8/59) In an aged care facility, 12 months post-arrest, no patient reported a good 12-month functional recovery

Table 4 (continued)

First author Year Country	Study design Methods Population Setting	Number of participants	Inclusion	Conditions Location	ROSC	Survival to admission Survival to ICU/hospital discharge Long-term survival	Quality of life
Okubo M. et al 2017 Japan [35]	**Study design** A 10-year cohort study Nationwide, population-based OHCA registry in Japan 2005–2014 **Age category** ≥75 years **Median age (years)** 76–80	861,756	**Inclusion** All patients aged 75 years or older with OHCA of medical origin in whom EMS attempted CPR and subsequently transported to hospitals **Exclusion** OHCA with unknown age Unknown witness status Arrest witnessed by EMS personnel Unknown first documented rhythm Unknown bystander CPR status Unknown origin Unknown outcome	**Mean arrival time (min)** <70: 8.0 (5.5) ≥70: 8.5 (4.6) **Shockable** 2005: 8.8% 2006: 9.1% 2007: 9.2% 2009: 9.6% 2010: 9.9% 2011: 9.4% 2012: 9.0% 2013: 9.2% 2014: 10.6% **Bystander witnessed** 2005: 34.3% 2006: 35.6% 2007: 35.8% 2009: 35.8% 2010: 35.5% 2011: 36.2% 2012: 35.8% 2013: 36.1% 2014: 37.6% **Median arrival time (min)** <70: 8 ≥70: 7 **Bystander CPR** 2005: 34.9% 2006: 38.1% 2007: 42.5% 2009: 43.9% 2010: 46.9% 2011: 47.0% 2012: 47.1% 2013: 48.5% 2014: 50.6% **Median EMS response time (min. IQR)** 2005: 8 (6–10) 2006: 8 (6–10) 2007: 8 (6–10) 2009: 8 (6–10) 2010: 8 (6–10) 2011: 8 (7–10) 2012: 8 (7–10) 2013: 8 (7–10) 2014: 8 (7–11)	**Pre-hospital ROSC** 6.4% (55,152/861 756)	**30-day survival:** 4.3% (37 055/861 756)	**Good neurological state (CPC 1–2)** *At 1 month*: 2.0% (17,235/861 756)

Table 4 (continued)

First author Year Country	Study design Methods Population Setting	Number of participants	Inclusion	Conditions Location	ROSC	Survival to admission Survival to ICU/hospital discharge Long-term survival	Quality of life
Pape, M. et al 2017 Denmark [38]	**Study design** A register-based, nationwide, follow-up study using the Danish Cardiac Arrest Register 2001–2014 **Mean age (years)** Total: 73 (62–81) Nursing homes: 83 (75–89) Private homes: 71 (61–80) **Men (%)** Total OHCA: 41.8 Nursing homes: 63.0 Private homes: 61.1	26, 999	**Inclusion** Patients with OHCA in nursing homes and private homes **Exclusion** Patients with OHCA occurring in public or unknown locations Patients < 18 years of age EMS-witnessed arrests	**Witnessed arrests** Nursing home: 55.4% Private home: 43.4% **Bystander CPR** Nursing home: 49.7% Private home: 35.3% **EMS response time (min)** 11 (6–18) **Location** 9.3% nursing homes 90.7% private homes	–	**30-day survival:** ≥65 years: 3.0% (560/18 956) ≥80 years: 1.3% (105/8228) Nursing homes: 1.7% (42/2516) Private homes: 4.9% (1201/24 483) ≥65 years Nursing homes: 1.4% (33/2285) Private homes: 3.2% (527/16 671) ≥80 years Nursing homes: 1.1% (17/1562) Private homes: 1.3% (88/6666) **1-year survival** ≥65 years: 2.4% (452/18 956) ≥80 years: 0.8% (69/8228) Nursing homes: 1.2% (29/2516) Private homes: 4.3% (1053/24 483) ≥65 years Nursing homes: 0.9% (20/2285) Private homes: 2.6% (432/16 671) ≥80 years Nursing homes: 0.6% (9/1562) Private homes: 0.9% (60/6666)	–
Pleskot 2011 Czech Republic [36]	**Study design** *Prospective multicenter cohort study* 2002–2004 **Aged range** 16–97 years Median: 69 years Average: 67 **Subgroups** <70 years: 54.8% ≥70 years: 45.2% 60–96 years: 27.3% 70–79 years: 31.3% 80–89 years: 13% 90–99 years: 0.9% **Men (%)** 71.1	718	**Inclusion** Patients aged between 16 and 97 years with suspected OHCA reported to the dispatch center in whom resuscitation was considered **Exclusion** Patients with cardiac arrest occurring in the presence of EMS Patients in whom there was an apparent toxic, traumatic, submersion, or suicidal cause of unconsciousness, including terminal phase of a chronic illness	**Initial rhythm** *Patients ≥ 70 years:* VF: 37% VT: 3% AV block: 3% Asystole: 49% PEA: 8% **Conditions** *Patients ≥ 70 years*: Witnessed: 91% Bystander CPR: 31% **Location** *Patients ≥ 70 years*: Home: 70% Public place: 30%	–	**Long term survival**: 30-day survival: 11.4% (64/560) 1-year survival: 7.5% (42/560) 3-year survival: 6.8% (38/560) 5-year survival: 5.9% (33/560) **30-day survival:** 70–79 years: 7% (13/175) 80–89 years: 1% (1/73) 90–99 years: 0% (0/5) **1-year survival:** 70–79 years: 5% (8/175) 80–89 years: 0% (0/73) **In the age group 70–79 years** 2-year survival: 4% (7/175) 3-year survival: 4% (7/175) 4-year survival: 3% (6/175) 5-year survival: 2% (4/175) None of the patients aged 80 years and over survived 1 year In the subgroup ≥ 70 years 5-year survival: 2%	–

Table 4 (continued)

First author Year Country	Study design Methods Population Setting	Number of participants	Inclusion	Conditions Location	ROSC	Survival to admission Survival to ICU/hospital discharge Long-term survival	Quality of life
Segal, N. et al 2017 France [44]	**Study design** Retrospective cohort study using the French National CA registry (RéAC) 2011–2015 **Median age (years)** 79 (72–85) **Age categories** 65–69 years 70–74 years 75–79 years 80–84 years 85–89 years 90–94 years ≥95 years **Men (%)** 59.8	18,249	**Inclusion** All people > 65 years old with nontraumatic CA on whom at least a resuscitation attempt (i.e., BLS, ACLS, or both) was performed	**Bystander CPR**: 71.8% **Initial rhythm** Asystole: 82.4% PEA: 5.6% VF/pVT: 6.6% **BLS response time (min)** 10 (5.14) **ACLS response time (min)** 19 (13.27) **Location**: Home: 78.4% Public or workplace: 9.9% Institution: 11.6%	**ROSC achieved** 65–69: 27.9% (836/2999) 70–74: 25.6% (711/2777) 75–79: 23.4% (818/3497) 80–84: 18.6% (719/3864) 85–89: 16.3% (520/3189) 90–94: 9.7% (164/1689) ≥95: 7.7% (18/234)	**Survival until hospital admission** 65–69: 22.0% (660/2999) 70–74: 18.9% (525/2777) 75–79: 16.8% (587/3497) 80–84: 12.7% (491/3864) 85–89: 10.9% (348/3189) 90–94: 6.2% (105/1689) ≥95: 7.3% (17/234) **30-day survival:** 65–69: 6.6% (198/2999) 70–74: 3.9% (108/2777) 75–79: 3.2% (587/3497) 80–84: 2.3% (89/3864) 85–89: 2.0% (64/3189) 90–94: 0.9% (15/1689) ≥95: 2.1% (5/234)	**Good neurological state (CPC 1–2)** *1 month survivors*: 65–69: 84.2% (167/198) 70–74: 80.0% (86/108) 75–79: 80.0% (90/112) 80–84: 91.6% (82/89) 85–89: 78.7% (50/64) 90–94: 78.6% (12/15) ≥95: 80.0% (4/5)
SOS-KANTO 2012 Study Group 2015 Japan [29]	**Study design** *Retrospective collection* 2002–2012 **Median age (years)** 77 (IQR 71–84) 80 (IQR 74–86) **Age categories** 65 – 79 years (47.5–59.9%) 80 – 89 years (31.6–39.9%) ≥90 years (8.5–12.6%) **Men (%)** 57.1	8964: 3544 (2002) 5420 (2012)	**Inclusion** Patients aged ≥65 years, who experienced cardiac arrest of cardiac etiology; received CPR administered by EMS providers; and were subsequently transported to the participating institutions **Exclusion** Cases with missing data regarding inclusion criteria or main outcomes (1-month survival, neurological outcome, and ROSC) Onset of cardiac arrest after the arrival of paramedics or after arrival at the hospital Only respiratory arrest at the time of EMS provider arrival Patients from Niigata prefecture from 2002 (no participation)	**Witnessed** 2002: 1.2% 2012: 0% **Bystander CPR** 2002: 25.6% 2012: 35.0% **Initial rhythm** *VF* 2002: 15.5% 2012: 8.5% *PEA* 2002: 19.2% 2012: 19.3% *Asystole* 2002: 65.4% 2012: 67.0% **EMS response time** 2002: 8 min 2012: 9 min **Location** *Home*: 2002: 77.1% 2012: 74.7% *Public indoor*: 2002: 2.4% 2012: 1.9% *Public outdoor*: 2002: 6.2% 2012: 5.6%	**Pre-hospital ROSC** 2002: 3.8% 2012: 5.6% ROSC achieved: 2002: 28.0% 2012: 27.5%	**30-day survival:** 2002: 3.4% 2012: 4.2%	**Pre-hospital CPC 1–2** 2002: 72,5% 2012: 74,6% **Good neurological state (CPC 1–2)** *At 1-month*: 2002: 1.6% 2012: 2.7%

Table 4 (continued)

First author Year Country	Study design Methods Population Setting	Number of participants	Inclusion	Conditions Location	ROSC	Survival to admission Survival to ICU/hospital discharge Long-term survival	Quality of life
Tsurukiri J 2017 Japan [37]	**Study design** Prospective study 2010–2011 **Men (%)** 65	31	**Inclusion** Patients aged ≥ 65 years with OHCA who received BLS and did not achieve ROSC until arrival at the emergency center	–	**ROSC achieved** 25.8% (8/31)	**Survival until hospital discharge:** *Among patients with ROSC*: 10% **Mortality**: 16% died during hospitalization	–
Winther-Jensen, M et al 2015 Denmark [41]	**Study design** Retrospective study 2007–2011 **Mean age (years)** 67 (57–79) **Men (%)** 67	2509	**Inclusion** OHCA of all causes with attempted CPR and/or more advanced resuscitative efforts (intubation, medication with dispatch by the EMS) **Exclusion** Patients < 18 years Patients who were found with obvious signs of death (rigor/livor mortis, decapitation, maceration) with no attempted CPR	**Successfully resuscitated octogenarians** VF/VT: 40% PEA: 24% Asystole: 24% Other/unknown: 12% Bystander witnessed: 87% Bystander CPR: 48% EMS-witnessed OHCA: 7% EMS response time (min): 7 (5–10) **Unsuccessfully resuscitated octogenarians** VF/VT: 14% PEA: 21% Asystole: 54% Other/unknown: 11% Bystander witnessed: 57% Bystander CPR: 28% EMS-witnessed OHCA: 5% EMS response time (minutes): 7 (5–10)	**ROSC upon hospital admission** Octogenarians: 30% (166/588)	**30-day mortality:** *Octogenarians*: 2007: 94% 2011: 93% **Survival of octogenarians with CPC 3 or 4 prior to OHCA:** CPC 3: 19% (8/43) CPC 4: 0%	**Good neurological state (CPC 1–2)** *Prior to OHCA*: Octogenarians: 89% *In successful or ongoing CPR*: Octogenarians: 79% (26/33)

from 16 to 28.5% [28, 29]. Five studies registered an overall 1-month survival ranging from 13.5 to 28% [16, 18, 23, 24, 26]. Three studies found an overall 1-year survival between 9.4 and 25% [23, 24, 26].

The systematic review concerning OHCAs consisted of 23 studies. Four of these studies featured patients of 70 years and up exclusively, while five had a mean age of at least 70 years and the remaining studies provided various age categories. A meta-analysis for survival was performed on 14 studies. In patients aged 70 years or older, the overall survival until discharge was 4.1% (range 0–9%). The probability of survival significantly decreased as age increased, both in univariate and multivariate analyses.

Survival until hospital admission registered in five primary studies was 15.3–30.5% [31, 32, 34, 44, 45]. The survival until hospital discharge was registered in nine additional studies was also slightly higher than the previously published review and varied from 6.9 to 11.1% [32, 35–37, 42, 44, 45, 47, 50]. Twelve studies registered the 1-month survival rate, ranging from 3.8 to 7.8% of all patients [28, 29, 31–36, 38, 41, 43, 44]. Of those who survived until hospital discharge, 1-year survival reached 88% [45]. Two studies found a 3-year survival rate ranging from 6.8 to 52.8% [31, 36]. Survival up to 5 years was also registered in two studies and ranged from 2 to 32.1% [36, 39].

Neurological assessment

The results of both the IHCA and OHCA reviews on quality of life following CPR were scarce and contradictory [14, 15].

In the primary IHCA studies exploring CPC as an outcome, a favorable outcome (CPC 1–2) was found in a mean of 20.1–23.6% of all resuscitated patients [16, 23]. This proved to be 82.4–93.1% of the patients surviving until hospital discharge [16, 23, 26]. In the primary OHCA studies, a CPC 1–2 at discharge or at 1 month was registered in only 1–4.8% of all resuscitated patients [28, 29, 32, 34, 35]. On the other hand, one study saw that of all survivors until hospital discharge aged 90 years or older, a favorable outcome at 1 month (CPC 1 or 2) was found in all patients (100%) [43].

Discharge location

In the IHCA review, the discharge location was registered in only one of the included studies. Out of 50 patients who survived until hospital discharge, 38% were discharged to their homes, 24% were admitted to a rehabilitation or psychiatric facility, 18% to a nursing home and 20% were transferred to a chronic care hospital with ventilator capabilities [14]. The proportion of patients who returned home after hospital discharge was registered in three primary IHCA studies and three OHCA studies, ranging from 4.8 to 40% and 52.6–77.9%, respectively [17, 19, 26, 27, 31, 39]. Concerning one OHCA study, 88% returned to the same type of facility from which they originated [40].

Functional recovery

Furthermore, one study concerning IHCA found that although 74.9% of the survivors were functionally independent at hospital admission only 20.1% remained so after the event. In total, 63.4% of survivors were less functional upon hospital discharge compared to their state at the time of admission [17].

With regard to the OHCA cases, two studies used additional QoL measures such as the Overall Performance Category, SF-12 score, GOSE score, and the EQ-5D score [27, 39].The mean SF-12 mental component summary was 56.5 (SD 6.5). In contrast, the mean SF-12 physical component summary was 44.8 (SD 11.2), and this decreased with increasing age ($p < 0.001$). They found an upper and lower severe disability in 18.4% of the survivors, with the highest proportion in the age category 85 years and older (44.3%) [27].

Age categories

See Table 5.

Risk factors

Nineteen studies analyzed risk factors associated with short-term and long-term survivals following IHCA and OHCA [17–23, 26, 30–32, 36, 38–41, 43–45].

Patient-related factors associated with worse survival rates were increasing age, a previous history of heart failure or chronic obstructive pulmonary disease, malignancy, renal dysfunction, and multiorgan failure and/or septicemia after CPR. Pertaining OHCA, several studies found that increasing age was associated with worse survival outcomes, but a high Charlson Comorbidity Index (CCI ≥ 4) was not significantly associated with survival.

Arrest characteristics repeatedly associated with increased survival included: initial shockable rhythm (ventricular fibrillation and pulseless ventricular tachycardia), witnessed or ECG monitored arrests, cardiac etiology of arrest, monitored hospital location and time of arrest (during working hours on weekdays). The same risk factors were found concerning OHCA. In addition, arrests at public places were associated with increased survival rates, while arrests that occurred in nursing homes and multiple CPR events resulted in lower chances of survival.

Finally, rescue characteristics such as bystander CPR/defibrillation and shorter time to EMS response, defibrillation and ROSC were also associated with better survival outcomes following both IHCA and OHCA.

Eight studies analyzed risk factors associated with neurological and functional outcome following IHCA or OHCA. Increasing age was associated with worse functional outcomes, whereas initial shockable rhythm, cardiac etiology, public location of the arrest or witnessed arrest, and resuscitation factors such as bystander CPR, early EMS response and early use of automated external defibrillator were associated with a favorable neurological outcome [27, 28, 33, 34, 42, 45]. In addition, being functionally dependent before hospital admission and an admission diagnosis of trauma were associated with less optimal functional outcomes [17, 18].

Discussion

This scoping review presents an overview of the survival and quality of life of older patients following IHCA or OHCA. Data regarding the last decennium indicate a slight improvement in the survival until hospital discharge rates at ages 70 years and older following IHCA. Van Gijn et al. (including articles from 1968 to 2012) found an overall survival until hospital discharge of 18.7% for patients between 70 and 79 years old, 15.4% for patients between 80 and 89 years old, and 11.6% for patients of 90 years and older, whereas in more recent primary studies (including articles from 2012 to 2018), these rates were consistently higher (19–28%, 11.3–19% and 11–15%, respectively). The same trend was noted for OHCA with an overall survival rate of 4.1% in the systematic review from 1980 to 2011 versus a survival rate of 4.3–12% in the primary studies from 2011 to 2018, for patients aged 70 years or older.

Neurological outcome of resuscitated patients following IHCA or OHCA was only evaluated in a limited number of studies. Considering all resuscitated patients, the proportion that survived until hospital discharge with a favorable neurological outcome never exceeded 25%. However, considering the subgroup of patients surviving until hospital discharge or 30 days, the proportion with a good neurological outcome was eminently high, namely 82–100% regardless of the age.

Considerations

Possibly partially responsible for these improved survival rates is the increased initiation of CPR and/or defibrillation by bystanders out-of-hospital. Better management of complications and post-resuscitation care in-hospital, a specific task of the geriatrician, could also be an important factor contributing to the improved outcomes [48]. However, favorable results are more often seen following cardiac arrests with shockable rhythms which are only present in a minority of the older population. Consequently, overall survival rates remain low.

The effect of age on outcome remains controversial. While the included systematic reviews found that old age was associated with worsened survival outcomes for both IHCA and OHCA, other previously published studies could not find any association [49–51]. These inconsistent results may partially be explained by differences in patient characteristics, circumstances of the cardiac arrest, post-resuscitation care, cultural practices, do-not-attempt resuscitation policies, and withdrawal of life-sustaining treatment practice [52]. Moreover, the older population is particularly heterogeneous. The prevalence of multi-morbidity is increasing from 35 to 65% in patients aged 60–69 years to 80–99% in octogenarians [53]. In addition, the reduction of the physiological reserve of multiple organ systems with aging, called frailty, results in an increased inability to maintain homeostasis when faced with disease or injury. As such, not chronological age, but the level of frailty, which results in the reduced ability to withstand acute stress situations such as cardiac arrests, may be an important contributing factor for worse

Table 5 Results categorized by age

	70–79 years	80–89 years	≥90 years
IHCA			
Survival until discharge	20.1–27.9% [18, 19, 26]	15.3–21.5% [18, 19, 26]	11–15.1% [18, 19]
One-month survival	27.9% [18]	20% [18]	14% [18]
CPC 1–2 at discharge	22.7% [18]	16.5% [18]	11.5% [18]
	≥70 years	≥80 years	≥90 years
OHCA			
Survival until discharge	4.3–12.0% [30, 40, 45]	2.8–8% [30, 45]	1.7–3.9% [42]
One-month survival	5.4–5.7% [36, 43, 44]	0.9–7% [36, 38, 41, 43, 44]	0–2.4% [36, 43, 44]
CPC 1–2 at discharge/1-month	10.5% [44]	0.9% [33]	0.5–1.8% [28, 33]
One-year survival	3.2–10% [36, 45]	0–6% [36, 38, 45]	0% [36]

survival outcomes [3]. This was confirmed by a recent study published after this review [54]. These results may facilitate clinical decision making regarding whether CPR may be considered futile.

In conclusion, age alone should not be used as the sole criterium to decide whether CPR is a medically appropriate treatment for the older patient. Patient-related factors (age, medical history and frailty), arrest characteristics (initial rhythm, witnessed of monitored, etiology, location and time) and rescue characteristics (bystander CPR/defibrillation and shorter time to EMS response, defibrillation and ROSC) should also be taken into account.

Strengths and limitations

Strengths of this study include giving a comprehensive overview of the most recent available data on outcomes concerning survival, neurological state and quality of life of both in-hospital and out-of-hospital CPR in older patients, by systematically including return of spontaneous circulation (ROSC), survival until hospital discharge, long-term survival (≥ 1 year following the event), discharge location and other quality of life measurements as outcome variables.

This review has several limitations, due to the heterogeneity of classification in the individual studies we were not able to compare outcomes of specific age categories. The age categories were randomly selected, making comparison of outcomes between studies impractical. As a result, no meta-analysis was performed. However, no tools were used to measure the heterogeneity in this review. Furthermore, the pooled odds ratios concerning the risk factors were also not calculated in this study.

In addition, as a result of the inclusion of studies from various regions, different views and regulations concerning CPR performance have been adopted. For example, EMS providers in Japan are not permitted to terminate resuscitation in the field (except in case of decapitation or dissolution), and Do-Not-Resuscitate (DNR) orders are not generally accepted. Therefore, the generalisability of these study results is restricted.

Moreover, the term 'frailty' was only mentioned in one study concerning IHCAs [20]. Four OHCA studies mentioned frailty, but did not include this variable in their analysis. This would, however, allow healthcare providers to better differentiate older patients with poor prognosis from those with a good chance of survival. A multidimensional interdisciplinary diagnostic process is required to determine an older person's medical, psychological and functional capability, such as a comprehensive geriatric assessment. The Clinical Frailty Scale is also a simple bedside assessment that can provide invaluable information when considering treatment escalation plans [54].

Finally, it is also possible that some eligible studies were missed because they did not specifically refer to older patients in the title or abstract. However, by performing an elaborate search and thorough cross-referencing, this risk was reduced to a minimum.

Implication for practice

The review provides an overview of the recent evidence on outcome regarding survival and quality of life after CPR following both IHCA and OHCA in the older population. CPR for patients of advanced age should be seen as a conditional therapy that may be worthwhile in some older patients, but may cause significant harm and suffering when applied in an undifferentiated way [55]. This knowledge can contribute to end-of-life conversations between health care practitioner and patient to make well-informed decisions and promote advance care planning (ACP). In hospitalized, frail or elderly patients, the etiology of the arrests is more likely to be complex due to other pathologies and complications [56]. These patients should be well informed about the overall low chance of survival and a significant possibility of neurological deficits, especially for nursing home residents. On the other hand, all patients with a limited risk profile should be informed of their chances of survival with a good neurological outcome following CPR [57].

Advance care planning in the hospital and in long-term-care facilities such as nursing homes can help avoid unwanted or ill-advised CPR. Results show that the implementation of ACP possibly decreases potentially inappropriate life-sustaining treatment, increases the use of hospice and palliative care and prevents hospitalization. It has also proven useful to include end-of-life choices such as Do-Not-Resuscitate decisions [55, 58].

When cardiac arrests happen outside the hospital, information about possible advance care planning is generally unavailable. Validated rules for prehospital termination of resuscitation (TOR) could be highly valuable in such cases to avoid futile transport and escalation of care. Until now, there is no international agreement on TOR rules neither on how to apply them. Verbeek et al. and Morrison LJ et al. propose the following criteria: arrest unwitnessed by EMS provider, no shock delivered, no prehospital ROSC, unwitnessed by bystander or no bystander CPR in an Advanced Life Support setting [59, 60]. Shibahashi et al. propose the following three criteria: non-shockable initial rhythm, unwitnessed by bystanders, and age ≥ 73 years; this TOR rule provided an excellent positive predictive value (> 99%) for unfavorable 1-month neurological outcome after OHCA [61]. These criteria were validated in North America by Grunau and Glober [62, 63].

Future research

None of the included studies was able to capture a good image of the patients' quality of life broader than the neurological outcome. Most of the studies merely used the CPC scale which is insufficiently attuned to identifying all the impairments of cardiac arrest survivors [46]. In addition, this score excludes return to private homes, participation in society or other aspects of life greatly valued by this category of patients such as the desire to avoid being a burden to their family, suffering pain, the loss of speech, the loss of dignity and the incapacity to think clearly [64]. Only two studies incorporated multiple measurement tools to assess the quality of life, namely the Extended Glasgow Outcome Score (or GOSE), the Overall Performance Category (OPC), the SF-12 score, and the EQ-5D score [27, 29]. More extensive research into quality of life after resuscitation will allow patients to make better-informed decisions and facilitate decision making adopted to the patient's clinical situation.

A core outcome set for cardiac arrest (COSCA) was recently developed for adults that identified survival, neurological function, and health-related quality of life as essential outcomes in cardiac arrest effectiveness trials. They stated that survival until hospital discharge, at 30 days, or both should be reported, accompanied by neurological state. Health-related quality of life should be measured with ≥ 1 tools from the Health Utilities Index-3 questionnaires, Short Form Health survey 36 version 2 or the five-level EQ-5D instruments at 90 days and at periodic intervals up to 1 year after cardiac arrest, if resources allow [65, 66]. Further research should implement this assessment method and determine if it is also optimal for evaluation of the older population. Prospective study designs are preferred, because many potentially relevant prearrest factors or outcome measures cannot be retrieved retrospectively.

Conclusion

Hospital survival rates following IHCA and OHCA in the older population improved in the recent decade, though do not exceed 28.5% and 11.1%, respectively. Several risk factors were identified, among which increasing age and nursing home residency. However, the effect of age on outcome remains controversial and age should not be used as the sole decision criterium whether to initiate CPR. Future research should analyze frailty as an independent variable regardless of age and include more extensive quality of life measures as outcome variables.

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Compliance with ethical standards

Conflict of interest On behalf of all the authors, the corresponding author states that there is no conflict of interest.

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