Survival after out-of-hospital cardiac arrest in nursing homes – A nationwide study

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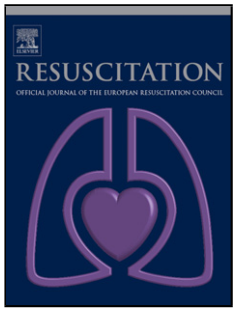

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Survival after Out-of-Hospital Cardiac Arrest in Nursing Homes – A Nationwide Study

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Abstract (249 /max 250 words)

Background

Survival among nursing home residents who suffers out-of-hospital cardiac arrest (OHCA) is sparsely studied. Deployment of automated external defibrillators (AEDs) in nursing home facilities in Denmark is unknown. We examined 30-day survival following OHCA in nursing and private home residents.

Methods

This register-based, nationwide, follow-up study identified OHCA-patients ≥18 years of age with a resuscitation attempt in nursing homes and private homes using Danish Cardiac Arrest Register data from June 1, 2001 to December 31, 2014. The primary outcome measure was 30-day survival. Multiple logistic regression analyses were used to assess factors potentially associated with survival among nursing and private home residents separately.

Results

Of 26,999 OCHAs, 2,516 (9.3%) occurred in nursing homes, and 24,483 (90.7%) in private homes. Nursing home residents were older (median 83 (Q1-Q3: 75-89) vs. 71 (Q1-Q3: 61-80) years), had more witnessed arrest (55.4% vs. 43.4%), received more bystander cardiopulmonary resuscitation (CPR) (49.7% vs. 35.3%), but less pre-hospital defibrillation (15.1% vs. 29.8%). Registered AEDs increased in the period 2007-2014 from 1 to 211 in nursing homes vs. 1 to 488 in private homes. Average 30-day survival in nursing homes was 1.7% [95%CI: 1.2-2.2%] vs. 4.9% [95%CI: 4.6-5.2%] in private homes (P<0.001). If bystanders witnessed the arrest, performed CPR, and pre-hospital defibrillation was performed, 30-day survival was 7.7% [95%CI: 3.5-11.9%] vs. 24.2% [95%CI: 22.5-25.9%] in nursing vs. private home residents.

Conclusions

Average 30-day survival after OHCA was very low in nursing home residents, but those who received early resuscitative efforts had higher chance of survival.

Keywords: Out-of-Hospital Cardiac Arrest, Resuscitation, Survival, Nursing Home, Defibrillation

Introduction

Nursing home residents are often of high age and have significant comorbidity burden [1–4]. As a consequence, it is often debated whether resuscitative efforts and placement of automated external defibrillators (AEDs) in nursing homes are futile [5–9]. Nursing homes are often located in community centers with 24/7 accessibility. Placement of AEDs in nursing homes can potentially benefit both nursing home and private home residents, as well as out-of-hospital cardiac arrests (OHCAs) occurring in public.

During the past decades, a shift has been made towards treating serious illnesses in the very old, offering intensive care treatment and invasive medical treatments to patients above 80 years of age [10, 11]. Increasing age is associated with lower 30-day survival after OHCA [1–4, 12, 13]. In Denmark, 30-day survival after OHCA among patients ≥80 years was 2.0% by 2011 [1], and failed to increase significantly despite increasing bystander cardiopulmonary resuscitation (CPR) [1, 14–16].

Survival after OHCA in nursing homes is not reported on a nationwide scale. Older studies report similar survival rates between nursing home residents and persons living in the community [7, 17, 18]. Recent studies from Osaka, Hong Kong, and Copenhagen report 30-day survival rates from 0.3% to 9% [12, 19, 20].

Using Danish national administrative registries, we aimed to examine survival after OHCA in nursing homes in relation to private residential locations during 2001-2014. Although nursing home residents differ from patients in residential areas regarding demographic and clinical characteristics, they are more comparable than OHCA-patients in public locations [21]. In recognition of the differences between nursing home and private home residents, we analyzed the data from the two locations separately, analyzing factors associated with survival in each location. Following recent AED dissemination in Denmark, we assessed annual changes in newly registered AEDs in nursing homes and residential locations during 2007-2014 to put defibrillation rates in context to AED coverage in nursing home and other private locations. Finally, we examined 30-day

survival in an optimized scenario where bystanders witnessed the arrest, performed CPR, and bystanders and/or Emergency Medical Services (EMS) personnel delivered pre-hospital defibrillation. We compared the results to the opposite worst-case scenario (unwitnessed arrest, no bystander CPR, and no pre-hospital defibrillation), since these factors are commonly used in clinical practice when considering termination of resuscitation [9].

Methods

Study setting

Nationwide OHCA-data between June 1, 2001 and December 31, 2014 was used. The Danish population consisted on average of 5.6 million inhabitants. The OHCA incidence rate was 59 per 100.000 citizens in 2014 [16, 22]. The EMS-system is tax-financed and dispatched to all emergencies, including OHCAs, covering the entire country. Ambulances staffed with emergency medical technicians and paramedics are able to perform basic and advanced life support. The EMS personnel are obliged to initiate resuscitation, except cases with obvious signs of death or if patients have an active Do-Not-Attempt-Resuscitation (DNAR)-order. To terminate resuscitation in cases without DNAR-orders, EMS personnel are legally required to consult the emergency physician. Mobile emergency care units staffed with a physician or paramedic can rendezvous with the ambulances. Resuscitation treatment was given in accordance with latest international guidelines at the given time throughout the study period [23, 24].

Mandatory CPR-training was implemented in elementary schools in 2005, and when acquiring a driver's license in 2006 [14]. Dispatcher-assisted CPR was provided when contacting the emergency medical dispatch center in the greater Copenhagen Area in 2009, and extended to a national level in 2011. The first publicly accessible AED was registered in the Danish AED Network in 2007, and since 2011, bystanders were able to locate the nearest registered AED using a free smartphone application, or when calling the emergency medical dispatch center [25–27].

Recording of OHCAs

The Danish Cardiac Arrest Register [16] covers OHCAs where bystanders (layperson or healthcare worker) and/or EMS personnel initiate a resuscitation attempt, except cases with obvious signs of death. By contractual agreement, EMS personnel are obliged to complete a short case report form for every OHCA making case ascertainment close to complete.

Study population

We included patients with OHCA in nursing homes and private homes. We excluded patients with OHCA occurring in public or unknown locations, patients <18 years of age, and EMS-witnessed arrests.

Study design and data sources

We linked data from several national registries through each citizen's unique civil personal registration number used in all emergency, healthcare and social contacts in Denmark, and were able to follow each citizen through the registries.

From the Danish Cardiac Arrest Register we included information on date; time; location; whether bystanders witnessed the collapse, performed CPR or defibrillated the patient; time interval between the collapse (based on time of emergency call and/or bystander interview) and first rhythm analysis by EMS; EMS first recorded heart rhythm (shockable or non-shockable), EMS defibrillation, and whether return of spontaneous circulation was achieved before hospital arrival. Due to a low number of bystander defibrillations, we combined bystander defibrillation and EMS defibrillation as pre-hospital defibrillation.

From the Danish AED Network [27] we included AED-registration date and information on AED-location. If the AED was located in a nursing home or elderly housing, the AED was categorized in nursing homes. If the AED

was located in private residential areas, apartment complexes, student and support housing, or other residential areas, the AED was categorized in private homes. We report the annual number of newly registered AEDs from 2007 to 2014.

From the Danish Civil Registration System [28] we included, and verified, information on patient age, sex, vital- and migration-status.

Comorbidities 10 years prior to OHCA were assessed using both the Danish National Patient Registry [29], collecting discharge diagnosis codes of selected comorbidities (ischemic heart disease, heart failure, chronic obstructive pulmonary disease, diabetes, renal disease, cancer, stroke and dementia), and using the Danish National Prescription Registry [30], collecting information on redeemed prescriptions for antidiabetic drugs.

Presumed cardiac etiology of arrest was assessed by retrieving information on death certificates from the Danish Registry of Causes of Death [31], and discharge diagnosis codes from the index hospitalization from the Danish National Patient Registry. Patients with cardiac disease, unknown disease, or an unexpected collapse were categorized as presumed cardiac etiology. Patients with other medical conditions than mentioned above were defined as non-cardiac cause of arrest.

Since 1994 Statistics Denmark registered the home address of all citizens in Denmark, including nursing home admission date, and nursing home departure date [32]. Statistics Denmark uses a validated approach for identifying citizens in different types of nursing homes, both municipal and private. Briefly, addresses of all Danish residents aged ≥80 years is identified, and if more than six people aged ≥80 years are living on the same address, the address is linked to a registry of nursing home addresses under Statistics Denmark. If the address is not matched by this procedure, the number of persons <60 years of age living on the address is estimated. If the ratio of elderly versus younger patients is above 4:1, the address was further searched on Google in order to check whether it matched a nursing home address [32].

Outcomes

Primary outcome measure was 30-day survival after OHCA. Secondary outcome measures were 30-day survival in the best-case and worst-case scenarios.

Ethics

The study was approved by the Danish Data Protection Agency (2007-58-0015, GEH- 2014–017, I-Suite-nr. 02735). In Denmark, retrospective register-based studies do not require ethical approval. For further information, visit https://www.isrctn.com/ISRCTN14261134.

Statistical analyses

Descriptive data are summarized using frequencies and percentages for categorical variables, and medians with 1st-3rd quartiles (Q1-Q3) for continuous variables. All analyses were performed separately in data from nursing homes and private homes. The average 30-day and 1-year survival chances were estimated using exact binomial confidence limits. Univariate logistic regression was used to test for linear trends according to calendar year.

Missing values in data were examined, and the main analyses are based on complete cases only. Secondary analyses are based on 400 multiple imputations (Substantive Model Compatible Fully Conditional Specification [33]).

Multiple logistic regression was used to associate 30-day survival with age (18-69, 70-79, 80-89, ≥90 years), sex, selected comorbidities (ischemic heart disease, heart failure, chronic obstructive pulmonary disease, diabetes, renal disease, cancer, stroke and dementia), time interval (0-10 minutes and >10 minutes), witnessed arrest, bystander CPR, and pre-hospital defibrillation. Reported were odds ratios (ORs) with 95% confidence limits (CIs), and predicted 30-day survival chances of best-case (witnessed arrest, bystander CPR, and pre-hospital defibrillation) and worst-case (unwitnessed arrest, no bystander CPR, and no pre-hospital defibrillation) scenarios.

A 2-sided *P* value <0.05 was considered statistically significant. Data management and statistical analyses were done using SAS version 9.4 (SAS Institute Inc) and R statistical software package version 3.3.3 [34].

Results

Patients and characteristics

Of 45,293 OHCAs, we included 26,999 OHCAs, where 2,516 (9.3%) occurred in nursing homes and 24,483 (90.7%) in private homes (Figure 1). Patient characteristics according to OHCA location are presented in Table 1. Compared to private home residents, nursing home residents were older (median 83 (Q1-Q3: 75-89) vs. 71 (Q1-Q3: 61-80) years), more frequently of female sex (58.2% vs. 37.0%), and more likely to have: 1) chronic obstructive pulmonary disease (COPD) (21.9% vs. 17.9%); 2) previous stroke (29.9% vs. 12.0%); 3) dementia (26.1% vs. 3.0%); 4) witnessed arrest (55.4% vs. 43.4%); and 5) bystander-initiated CPR (49.7% vs. 35.3%). In nursing vs. private homes, bystander defibrillation with an AED was performed in 1.1% vs. 0.9% of OHCAs, a shockable heart rhythm upon EMS arrival was observed in 7.6% vs. 17.0%, and EMS life support treatment resulted in EMS defibrillation in 14.4% vs. 29.4% of OHCAs.

Registered AEDs increased in the period 2007-2014 from 1 to 211 in nursing homes vs. 1 to 488 in private homes (Table 2).

Trends in characteristics and survival from 2001 to 2014 are presented in Table 2. A total of 89 of all 2,516 resuscitation attempts in nursing homes (3.5%) occurred in 2002 versus 414/2,516 (16.5%) in 2014. Correspondingly, 1,491 of all 24,483 resuscitation attempts in private homes (6.1%) occurred in 2002 versus 2,375/24,483 (9.7%) in 2014 (Table 2).

Survival and factors associated with survival

Thirty-day survival was 1.7% [95%CI: 1.2-2.2%] and one-year survival was 1.2% [95%CI: 0.8-1.7%] for nursing home residents compared to 4.9% [95%CI: 4.6-5.2%] and 4.3% [95%CI: 4.1-4.6%] for private home residents (Table 3).

Independent factors associated with 30-day survival were (nursing home vs. private home): witnessed arrest (OR 4.07 [95%CI: 1.17-14.13] vs. 3.28 [95%CI: 2.77-3.89]), bystander CPR (OR 3.87 [95%CI: 1.39-10.77] vs. 2.57 [95%CI: 2.23-2.95]), and pre-hospital defibrillation (OR 5.59 [95%CI: 2.40-13.01] vs. 6.76 [95%CI: 5.68-8.03]), see Figure 2. Results were similar after multiple imputation (Supplement eFigure 1).

Best- and worst-case scenarios in relation to survival

In nursing home residents, 135 patients met the best-case scenario criteria (witnessed arrest, bystander CPR, and pre-hospital defibrillation), and predicted probability of 30-day survival was 7.7% [95%CI: 3.5-11.9%]. For private home residents, the best-case scenario was met in 2,096 patients, and predicted probability of 30-day survival was 24.2% [95%CI: 22.5-25.9%] (Figure 3). The opposite worst-case scenario (unwitnessed arrest, no bystander CPR, and no pre-hospital defibrillation) was met in 282 nursing home residents and 6,363 private home residents, and predicted probability of 30-day survival was 0.1% [95%CI: 0.0-0.2%] vs. 0.4% [95%CI: 0.3-0.5%] in the respective groups.

Data were complete on all three parameters for 2,063 (82.0%) in nursing homes, and 22,430 (91.6%) in private homes. Results of the multiple imputation analyses showed similar predicted probabilities of 30-day survival (nursing home vs. private home): 9.3% [95%CI: 5.0-13.7%] vs. 24.8% [95%CI: 23.1-26.4%] in best-case scenarios, and 0.1% [95%CI: 0.0-0.3%] vs. 0.4% [95%CI: 0.3-0.5%] in worst-case scenarios.

Discussion

This Danish nationwide study investigated survival after OHCA between 2001 and 2014 in nursing homes and private homes. The study had three main findings: 1) significantly lower 30-day survival among nursing home

residents with only 42 of 2,516 (1.7%) surviving thirty days compared to 1,201 of 24,483 (4.9%) in private homes; 2) increasing number of registered AEDs from 1 in 2007 to 211 in 2014 in nursing homes compared to 1 to 488 in private homes; and 3) in the best-case scenario (witnessed arrest, bystander CPR, and pre-hospital defibrillation), 30-day survival was 7.7% in nursing homes compared to 24.2% in private homes, whereas survival in the worst-case scenario was limited to 0.1% vs. 0.4% in the respective groups.

We found 30-day survival in nursing home residents to be 1.7%, which is substantially higher than 0.3-0.5% found in other studies reporting 30-day survival after OHCA in nursing home facilities [12, 20]. In contrast, Søholm et al. found 30-day survival among nursing home residents in the Capital Area of Denmark to be 9% [19], which is considerably different from our result (1.7%), other nursing home studies (0.3-0.5%), and studies on all OHCA-patients ≥80 years (2.0-4.4%) [1, 4, 7, 13, 35]. The study by Søholm et al. includes an urban cohort with short EMS response times, and only OHCAs treated by a pre-hospital consultant anesthesiologist, who can refrain from initiating treatment in the pre-hospital setting in contrast to paramedics and ambulance technicians with more restricted prerogatives. This may in part explain the difference in the 30-day survival rate found by Søholm et al. and the national 30-day survival rate we report.

During the study period, the number of nursing home facilities in Denmark remained constant [32], but the frequency of OHCAs with a resuscitation attempt in nursing homes quadrupled from 3.5% in 2002 to 16.5% in 2014. This finding potentially represents a change of attitude towards offering resuscitative efforts regardless of advancing age, severe comorbidity, or whether the person lives in a nursing home.

We found that nursing home residents had more witnessed arrest and received more bystander CPR, representing favorable factors for 30-day survival. Because nursing homes are staffed with several healthcare workers, it is likely that CPR was initiated immediately after recognition of arrest, and performed with a higher quality than by an elderly spouse in private homes. At the same time, nursing home residents had less primary shockable heart rhythm upon EMS arrival, and received less EMS defibrillation. Nursing home residents were older, and had a higher comorbidity burden than private home residents, representing unfavorable factors for

OHCA-survival. We have no information on disease severity of different comorbidities, but it is very likely that disease severity and frailty among nursing home residents were higher. Although our data only demonstrates that advancing age is associated with lower chance of survival in nursing homes, it could be argued that a DNAR-order should be considered in cases where advancing age, severe comorbidity, and low physical abilities make resuscitation futile. It is often debated whether discussion of a DNAR-order should be made between the general practitioner and the nursing home resident when entering a nursing home. At this point, the general practitioners have no recommendation to follow.

Increasing AED deployment in nursing homes in Denmark raise the debate on whether it is futile to place AEDs in nursing homes, where the majority of residents are fragile, elderly citizens, for whom resuscitation may be regarded as futile. Nursing home facilities are high-risk areas for OHCAs, and resuscitation attempts are being offered increasingly over the years. Two issues regarding AED deployment in nursing homes are essential; an AED is only useful in case of shockable heart rhythms, which we found to be limited to 7.6% of the nursing home population, and AEDs in nursing homes can be used on employees, visitors and community residents outside nursing homes, because nursing homes have 24/7 accessibility. We found that only 1.1% of the nursing home residents had received a shock from an AED before EMS arrival. It is widely accepted that the proximity of an AED will lead to increasing use and earlier defibrillation in cases of shockable heart rhythm, which in turn increases survival [26, 36–38]. Nonetheless, placement of AEDs in nursing homes underscores the importance of DNAR-orders to avoid futile resuscitation attempts.

Under the best circumstances, 30-day survival in nursing home residents with both witnessed arrest, bystander CPR, and pre-hospital defibrillation was 7.7% vs. 24.2% in private home residents. This supports AED deployment in nursing homes as well as private residential areas, although we emphasize the need for an active standpoint regarding DNAR-orders, especially in nursing homes. Conversely, if the arrest was unwitnessed, no bystanders performed CPR before EMS arrival, and no pre-hospital defibrillation was possible (non-shockable rhythm), chances of 30-day survival in both nursing homes and private homes were extremely low (0.1% vs. 0.4%), and termination of resuscitation seems appropriate in such circumstances.

Limitations

Our study has several limitations. First, the observational study design prevents us from drawing causal conclusions from the associations we found. Second, the Danish Cardiac Arrest Register does not contain data on quality nor length of bystander CPR, and some variables had missing values, especially pre-hospital defibrillation. However, we have no reason to assume that data with missing values were not missing at random. Results of multiple imputation analyses did not differ substantially from complete case analyses. Third, we did not have access to data regarding cerebral performance status before and after OHCA, or information on disease severity of comorbidities and individual frailty, which could have provided further insights to the outcome and dilemma of resuscitating nursing home residents. We had insufficient data on in-hospital care factors including therapeutic hypothermia and other post-resuscitation treatments that also may influence 30-day survival. We only had data on registered AEDs, the actual number of available AEDs in both locations may be higher. Finally, information on DNAR-orders in nursing home and private home residents was not available.

Conclusion

Survival after OHCA in nursing homes is low despite more bystander resuscitative efforts. A reason for this might be older age and higher comorbidity burden. An active standpoint regarding Do-Not-Attempt-Resuscitation in elderly, frail citizens is essential because of increasing resuscitation attempts in nursing home residents in recent years, concurrent with increasing AED deployment in nursing homes. In cases of witnessed arrest where bystanders performed CPR and pre-hospital defibrillation was delivered, 30-day survival was 7.7% in nursing home residents versus 24.2% in private home residents.

Conflict of interests

None.

Acknowledgments

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Table and figure legends

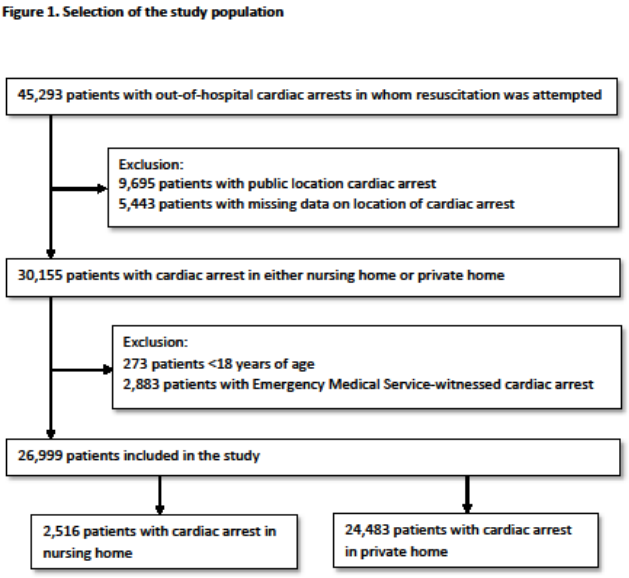
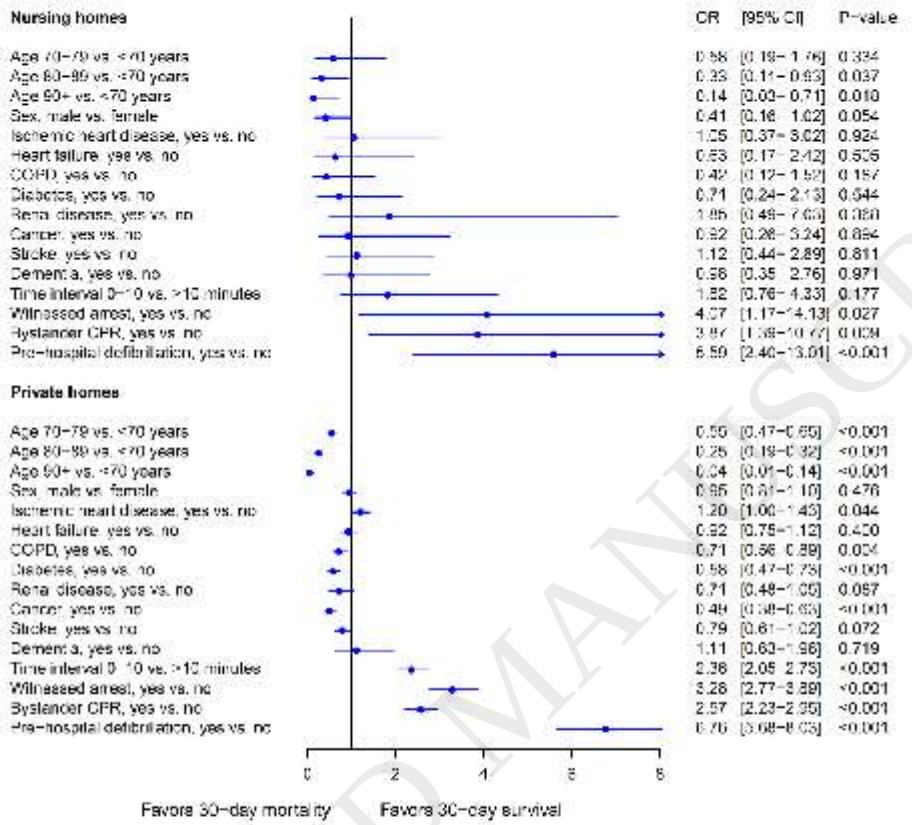


Figure 1. Selection of the study population

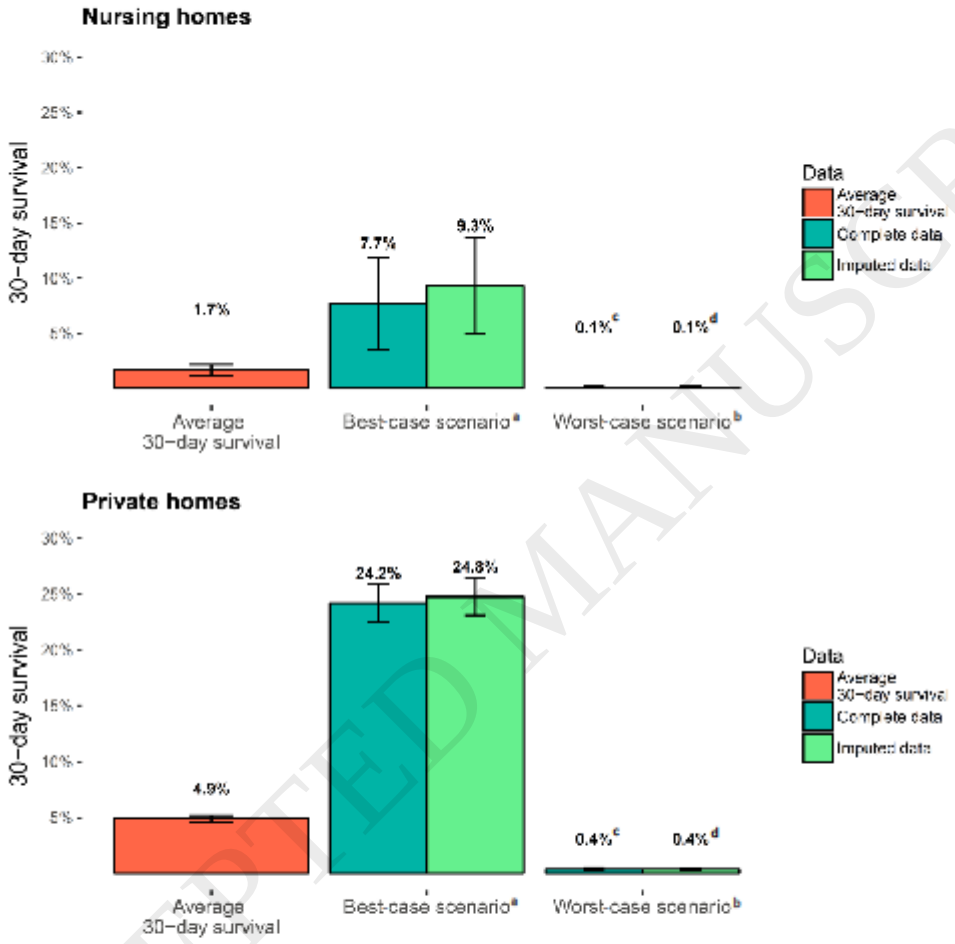
Figure 2. Multiple logistic regression analyses of factors associated with 30-day survival in nursing homes and private homes



Abbreviations: COPD, chronic obstructive pulmonary disease; CPR, cardiopulmonary resuscitation; OR, Odds Ratio; [95% CI], 95% Confidence Interval; Time interval, estimated time interval from recognition of cardiac arrest to first rhythm analysis by the Emergency Medical Services personnel; Pre-hospital defibrillation, defibrillation by bystander and/or Emergency Medical Services personnel.

Figure 2. Multiple logistic regression analyses of factors associated with 30-day survival in nursing homes and private homes

Figure 3. Thirty-day survival and predicted probability of 30-day survival using logistic regression in best-case and worst-case scenarios in nursing homes and private homes



[a]Best-case scenario means the combination of witnessed arrest, bystander cardiopulmonary resuscitation and pre-hospital defibrillation by bystander and/or Emergency Medical Services personnel.

[b]Worst-case scenario means the combination of unwitnessed arrest, no bystander cardiopulmonary resuscitation and no pre-hospital defibrillation by bystander and/or Emergency Medical Services personnel.

[c]Complete data.

[d]Imputed data.

Figure 3. Thirty-day survival and predicted probability of 30-day survival using logistic regression in best-case and worst-case scenarios in nursing homes and private homes

Supplementary

eFigure 1. Multiple logistic regression based on multiple imputation (400 imputations). Shown are analyses of factors associated with 30-day survival in nursing homes and private homes

Table 1. Patient characteristics according to OHCA location

Variables, number (%)	Arrest in nursing homes (n=2,516)	Arrest in private homes (n=24,483)	Total OHCA (n=26,999)
Age in years, median [Q1-Q3]	83 [75-89]	71 [61-80]	73 [62-81]
Male sex	1,051 (41.8)	15,432 (63.0)	16,483 (61.1)
Comorbidity			
Ischemic heart disease	625 (24.8)	5,822 (23.8)	6,447 (23.9)
Heart failure	503 (20.0)	4,430 (18.1)	4,933 (18.3)
COPD	550 (21.9)	4,384 (17.9)	4,934 (18.3)
Diabetes	466 (18.5)	3,989 (16.3)	4,455 (16.5)
Renal disease	182 (7.2)	1,337 (5.5)	1,519 (5.6)
Cancer	394 (15.7)	4,091 (16.7)	4,485 (16.6)
Stroke	753 (29.9)	2,948 (12.0)	3,701 (13.7)
Dementia	657 (26.1)	731 (3.0)	1,388 (5.1)
Presumed cause of arrest			
Cardiac cause of arrest	1,600 (63.6)	17,928 (73.2)	19,528 (72.3)
Missing	1 (0.04)	31 (0.1)	32 (0.1)
Bystander parameters			
Witnessed arrest	1,395 (55.4)	10,626 (43.4)	12,021 (44.5)
Missing	219 (8.7)	1,057 (4.3)	1,276 (4.7)
Bystander cardiopulmonary resuscitation	1,251 (49.7)	8,642 (35.3)	9,893 (36.6)
Missing	221 (8.8)	1,054 (4.3)	1,275 (4.7)
Bystander defibrillation	28 (1.1)	211 (0.9)	239 (0.9)
Missing	436 (17.3)	1,998 (8.2)	2,434 (9.0)
Time interval from recognition of arrest to EMS arrival			
Time in minutes, median [Q1-Q3]	9 [6-15]	11 [7-18]	11 [6-18]
Missing	205 (8.1)	1,931 (7.9)	2,136 (7.9)
EMS parameters			
Shockable rhythm upon EMS arrival	190 (7.6)	4,171 (17.0)	4,361 (16.2)
Missing	281 (11.2)	1,436 (5.9)	1,717 (6.4)
EMS defibrillation	363 (14.4)	7,190 (29.4)	7,553 (28.0)
Missing	451 (17.9)	2,226 (9.1)	2,677 (9.9)
Status upon hospital arrival			
Pronounced dead before arrival	1,374 (54.6)	12,288 (50.2)	13,662 (50.6)
Continuous resuscitation	407 (16.2)	7,029 (28.7)	7,436 (27.5)
Return of spontaneous circulation	249 (9.9)	3,031 (12.4)	3,280 (12.1)
Missing	486 (19.3)	2,135 (8.7)	2,621 (9.7)
Resuscitation attempt performed			
No bystander CPR but EMS defibrillation	177 (7.0)	4,238 (17.3)	4,415 (16.4)
Both bystander CPR and EMS defibrillation	175 (7.0)	2,821 (11.5)	2,996 (11.1)
Missing	452 (18.0)	2,249 (9.2)	2,701 (10.0)

Abbreviations: COPD, chronic obstructive pulmonary disease; CPR, cardiopulmonary resuscitation; EMS, Emergency Medical Service; OHCA, out-of-hospital cardiac arrest; Q1-Q3, 1st-3rd quartile [25%-75%].

Table 2. Trends in patient characteristics and survival

Variables, number (%)	2001[a] (n=859)	2002 (n=1,580)	2003 (n=1,664)	2004 (n=1,617)	2005 (n=1,757)	2006 (n=1,434)	2007 (n=1,618)	2008 (n=1,765)	2009 (n=2,054)	2010 (n=2,241)	2011 (n=2,231)	2012 (n=2,657)	2013 (n=2,733)	2014 (n=2,789)	Total (n=26,999)	P-value[b]
Arrest in nursing homes	47 (5.5)	89 (5.6)	112 (6.7)	104 (6.4)	109 (6.2)	84 (5.9)	84 (5.2)	169 (9.6)	169 (8.2)	221 (9.9)	237 (10.6)	331 (12.5)	346 (12.7)	414 (14.8)	2,516 (9.3)	<0.001
Arrest in private homes	812 (94.5)	1,491 (94.4)	1,552 (93.3)	1,513 (93.6)	1,648 (93.8)	1,350 (94.1)	1,534 (94.8)	1,596 (90.4)	1,885 (91.8)	2,020 (90.1)	1,994 (89.4)	2,326 (87.5)	2,387 (87.3)	2,375 (85.2)	24,483 (90.7)	<0.001
New AED registrations per year																
Nursing homes, frequency (cumulative frequency)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	5 (6)	10 (16)	32 (48)	20 (68)	56 (124)	38 (162)	49 (211)	211 (211)	
Private homes, frequency (cumulative frequency)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	1 (1)	6 (7)	13 (20)	30 (50)	45 (95)	86 (181)	132 (313)	175 (488)	488 (488)	
Nursing home residents																
30-day survival	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	≤3 (≤2.8)[c]	≤3 (≤3.6)[c]	3 (3.6)	≤3 (≤1.8)[c]	6 (3.6)	8 (3.6)	5 (2.1)	≤3 (≤0.9)[c]	6 (1.7)	7 (1.7)	42 (1.7)	0.141
Witnessed arrest	20 (42.6)	35 (39.3)	48 (42.9)	57 (54.8)	61 (56.0)	42 (50.0)	43 (51.2)	98 (58.0)	106 (62.7)	126 (57.0)	154 (65.0)	188 (56.8)	177 (51.2)	240 (58.0)	1,395 (55.4)	<0.001
Missing	12 (25.5)	37 (41.6)	35 (31.3)	30 (28.8)	26 (23.9)	24 (28.6)	24 (28.6)	7 (4.1)	2 (1.2)	8 (3.6)	2 (0.8)	5 (1.5)	4 (1.2)	3 (0.7)	219 (8.7)	
Bystander cardiopulmonary resuscitation	5 (10.6)	8 (9.0)	14 (12.5)	14 (13.5)	17 (15.6)	15 (17.9)	17 (20.2)	42 (24.9)	48 (28.4)	92 (41.6)	151 (63.7)	237 (71.6)	264 (76.3)	327 (79.0)	1,251 (49.7)	<0.001
Missing	12 (25.5)	35 (39.3)	34 (30.4)	29 (27.9)	27 (24.8)	24 (28.6)	22 (26.2)	10 (5.9)	5 (3.0)	5 (2.3)	2 (0.8)	4 (1.2)	3 (0.9)	9 (2.2)	221 (8.8)	
Pre-hospital defibrillation by bystander and/or EMS	25 (53.2)	33 (37.1)	17 (15.2)	8 (7.7)	9 (8.3)	16 (19.0)	15 (17.9)	28 (16.6)	30 (17.8)	35 (15.8)	29 (12.2)	47 (14.2)	37 (10.7)	52 (12.6)	381 (15.1)	<0.001
Missing	12 (25.5)	35 (39.3)	33 (29.5)	29 (27.9)	26 (23.9)	24 (28.6)	27 (32.1)	34 (20.1)	38 (22.5)	28 (12.7)	29 (12.2)	35 (10.6)	36 (10.4)	47 (11.4)	433 (17.2)	
Time interval ≤10 minutes[d]	29 (61.7)	67 (75.3)	76 (67.9)	71 (68.3)	77 (70.6)	64 (76.2)	44 (52.4)	100 (59.2)	102 (60.4)	101 (45.7)	110 (46.4)	152 (45.9)	131 (37.9)	191 (46.1)	1,315 (52.3)	<0.001
Missing	3 (6.4)	4 (4.5)	9 (8.0)	2 (1.9)	2 (1.8)	2 (2.4)	10 (11.9)	6 (3.6)	13 (7.7)	17 (7.7)	28 (11.8)	35 (10.6)	43 (12.4)	31 (7.5)	205 (8.1)	
Private home residents																
30-day survival	17 (2.1)	21 (1.4)	37 (2.4)	34 (2.2)	46 (2.8)	55 (4.1)	66 (4.3)	80 (5.0)	104 (5.5)	113 (5.6)	134 (6.7)	154 (6.6)	147 (6.2)	193 (8.1)	1,201 (4.9)	<0.001
Witnessed arrest	317 (39.0)	541 (36.3)	660 (42.5)	605 (40.0)	684 (41.5)	547 (40.5)	616 (40.2)	705 (44.2)	884 (46.9)	923 (45.7)	924 (46.3)	1,073 (46.1)	1,053 (44.1)	1,094 (46.1)	10,626 (43.4)	0.023
Missing	70 (8.6)	196 (13.1)	161 (10.4)	120 (7.9)	99 (6.0)	155 (11.5)	155 (10.1)	18 (1.1)	17 (0.9)	11 (0.5)	17 (0.9)	18 (0.8)	8 (0.3)	12 (0.5)	1,057 (4.3)	
Bystander cardiopulmonary resuscitation	110 (13.5)	174 (11.7)	250 (16.1)	248 (16.4)	301 (18.3)	254 (18.8)	343 (22.4)	473 (29.6)	604 (32.0)	757 (37.5)	1,009 (50.6)	1,336 (57.4)	1,401 (58.7)	1,382 (58.2)	8,642 (35.3)	<0.001
Missing	67 (8.3)	190 (12.7)	148 (9.5)	117 (7.7)	99 (6.0)	156 (11.6)	159 (10.4)	26 (1.6)	17 (0.9)	8 (0.4)	14 (0.7)	25 (1.1)	11 (0.5)	17 (0.7)	1,054 (4.3)	
Pre-hospital defibrillation by bystander and/or EMS	637 (78.4)	923 (61.9)	423 (27.3)	340 (22.5)	381 (23.1)	391 (29.0)	390 (25.4)	450 (28.2)	519 (27.5)	552 (27.3)	547 (27.4)	614 (26.4)	555 (23.3)	580 (24.4)	7,302 (29.8)	<0.001
Missing	66 (8.1)	182 (12.2)	145 (9.3)	112 (7.4)	95 (5.8)	151 (11.2)	200 (13.0)	128 (8.0)	178 (9.4)	161 (8.0)	128 (6.4)	128 (5.5)	100 (4.2)	125 (5.3)	1,899 (7.8)	
Time interval ≤10 minutes[d]	376 (46.3)	692 (46.4)	767 (49.4)	742 (49.0)	809 (49.1)	692 (51.3)	746 (48.6)	713 (44.7)	906 (48.1)	865 (42.8)	822 (41.2)	898 (38.6)	850 (35.6)	874 (36.8)	10,752 (43.9)	<0.001
Missing	62 (7.6)	103 (6.9)	119 (7.7)	107 (7.1)	54 (3.3)	57 (4.2)	68 (4.4)	87 (5.5)	101 (5.4)	125 (6.2)	155 (7.8)	221 (9.5)	356 (14.9)	316 (13.3)	1,931 (7.9)	

Abbreviations: AED, Automated External Defibrillator; EMS, Emergency Medical Service

[a] The year 2001 includes data from June 1 to December 31. [b] Univariate logistic regression. [c] If a frequency is less than 3 data is not allowed to be presented for ethical reasons, except for missing data.

[d] Estimated time interval from recognition of cardiac arrest to first rhythm analysis by EMS, ≤10 minutes versus >10 minutes

Table 3. Survival outcomes in different ages

Variables, number (%)	Arrest in nursing homes (n=2,516)	Arrest in private homes (n=24,483)	Total OHCA (n=26,999)	*P*-value
Survival among all patients				
30-day survival	42 (1.7)	1,201 (4.9)	1,243 (4.6)	<0.001
1-year survival	29 (1.2)	1,053 (4.3)	1,082 (4.0)	<0.001
Survival among patients aged ≥65 years	**Arrest in nursing home (n=2,285)**	**Arrest in private home (n=16,671)**	**Total OHCA (n=18,956)**	***P*-value**
30-day survival	33 (1.4)	527 (3.2)	560 (3.0)	<0.001
1-year survival	20 (0.9)	432 (2.6)	452 (2.4)	<0.001
Survival among patients aged ≥80 years	**Arrest in nursing home (n=1,562)**	**Arrest in private home (n=6,666)**	**Total OHCA (n=8,228)**	***P*-value**
30-day survival	17 (1.1)	88 (1.3)	105 (1.3)	0.542
1-year survival	9 (0.6)	60 (0.9)	69 (0.8)	0.267

Abbreviations: OHCA, out-of-hospital cardiac arrest.