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Clinical paper

Association between prehospital physician involvement and survival after out-of-hospital cardiac arrest: A Danish nationwide observational study☆

Annika Hamilton[a,*], Jacob Steinmetz[b,c], Mads Wissenberg[b], Christian Torp-Pedersen[d], Freddy K. Lippert[b], Lars Hove[a,b], Nicolai Lohse[a,c]

[a] Department of Anaesthesiology and Intensive Care, Hvidovre Hospital, University of Copenhagen, Copenhagen, Denmark
[b] Emergency Medical Services Copenhagen, Capital Region of Denmark, University of Copenhagen, Copenhagen, Denmark
[c] Department of Anaesthesia, Centre of Head and Orthopaedics, Rigshospitalet, University of Copenhagen, Copenhagen, Denmark
[d] The Institute of Health, Science and Technology, Aalborg University, Aalborg, Denmark

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ABSTRACT

Aim: Sudden out-of-hospital cardiac arrest (OHCA) is an important public health problem. While several interventions are known to improve survival, the impact of physician-delivered advanced cardiac life support for OHCA is unclear. We aimed to assess the association between prehospital physician involvement and 30-day survival.
Methods: Observational study including persons registered with first-time OHCA of any cause in the Danish Cardiac Arrest Registry during 2005–2012. We used logistic regression analysis to assess the association between 30-day survival and involvement of a physician at any time before arrival at the hospital. Secondary outcomes were 1-year survival and return of spontaneous circulation (ROSC) before arrival at the hospital. The associations were explored in three multivariable models: a model with simple adjustment, a model with multiple imputation of missing variables, and a propensity score model where exposed subjects were matched 1:1 with unexposed subjects on a propensity score reflecting the probability of being assigned to the exposure group.
Results: 21,165 persons with OHCA during 2005–2012 were included. Overall, 10.8% of OHCA patients with physician involvement and 8.1% of OHCA patients without physician involvement before arrival at hospital were alive after 30 days, crude odds ratio (OR) = 1.37 (95% CI = 1.24–1.51), adjusted OR = 1.18 (95% CI = 1.04–1.34). Physician involvement was also positively associated with ROSC, OR = 1.09 (95% CI = 1.00–1.19); and with 1-year survival, OR = 1.13 (95% CI = 0.99–1.29).
Conclusion: In this large population-based observational study, we found prehospital physician involvement after OHCA associated with better 30-day survival. This association was also found for ROSC, but with less certainty for 1-year survival.

Introduction

Cardiac arrest is an important public health problem which often occurs in the out-of-hospital setting in persons without a prior history of heart disease.[1] In Denmark, approximately 3500 out-of-hospital cardiac arrests (OHCAs) are registered per year.[2] The 30-day survival after OHCA is generally low, but has more than doubled in Denmark over the last ten years, and was 11.7% in 2012.[3] On an international scale, a systematic review and meta-analysis showed that overall survival from OHCA has been unchanged for almost 30 years, varying from 6.7 to 8.4%.[4]

Time to treatment is essential for survival, and several factors have been shown to improve survival following OHCA, including witnessed cardiac arrest, bystander cardiopulmonary resuscitation (CPR),[4,5,6] early defibrillation, and initial ventricular fibrillation (VF) or pulseless ventricular tachycardia (pVT) rhythm.[4] A high chest compression fraction is independently predictive of better survival in patients who suffer a prehospital VF/pVT cardiac arrest.[7] The strongest indicator associated with long-term survival from OHCA is return of spontaneous circulation (ROSC) in the field.[4]

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* Corresponding author at: Department of Anaesthesiology and Intensive Care 532, Hvidovre Hospital, Kettegaard Allé 30, DK-2650 Hvidovre, Denmark.
E-mail address: annykaw@hotmail.com (A. Hamilton).

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Emergency Medical Services (EMS) are organized in various ways in different countries. In Europe, physicians are widely used in the prehospital setting.[8] Benchmarking within individual EMS systems have demonstrated inconsistent results with benefits,[9] no differences,[10] or poorer outcomes[11] of physician-delivered advanced cardiac life support for OHCA. Some studies have been inconclusive,[12,13] and a systematic review[14] of the effect of EMS practitioners' experience and exposure to OHCA on patient survival concluded that further studies are required before any conclusions can be drawn.

With access to large clinical and administrative databases, we aimed to compare the effect of physician involvement as a supplement to EMS treatment in persons with sudden OHCA in Denmark. We hypothesized that physician involvement would be associated with better survival.

Methods

Design and approval

This observational study based on prospectively collected data from existing registries was approved by The Danish Data Protection Agency (J.nr. 2014-41-3020).

Study population and setting

The study was conducted in Denmark, a country with approximately 5.6 million inhabitants[15] covering an area of 43,000 km^2.[16] The study population included persons registered with OHCA of any cause in the Danish Cardiac Arrest Registry during 2005–2012. Only first-time cardiac arrests were included in the study.

Organization and staffing of the EMS in Denmark

In Denmark the pre-hospital EMS is based on a 'rendez-vous' system where emergency ambulances equipped with defibrillators and staffed with either emergency medical technicians (EMTs) who can perform basic life support or paramedics who can give advanced life support, team up with a mobile critical care unit (MCCU) when needed.[17] Some MCCUs are physician-staffed, and some are staffed with nurse anaesthetists or paramedics who have authorization to administer a limited number of drugs. Danish paramedics are not trained to perform endotracheal intubation, whereas nurse anaesthetists are experienced in endotracheal intubation. Paramedics and other EMS personnel operate under standing orders and protocols. Physicians in the MCCUs are typically specialists in anaesthesiology and intensive care and can as such provide advanced cardiac life support and intubation. Other advanced technical skills such as on-scene ECMO is not a standard option during OHCAs. In the event of an OHCA, the ambulance and the MCCU are normally dispatched simultaneously and meet at the scene. During the majority of the study period, a police-staffed call centre would receive all emergency calls and forward health-related calls to a medical dispatch centre responsible for dispatching the EMS vehicles. During 2009–2011, emergency calls concerning health issues were gradually overtaken by health personnel on a national level, thus allowing for more frequent telephone-guided bystander CPR.

Data sources

Danish Cardiac Arrest Registry

The Danish Cardiac Arrest Registry was established in June 2001. It contains data on all OHCAs in Denmark. Data collected are consistent to the Utstein model.[18] The capture of OHCA cases is close to complete since any emergency call activates the EMS in Denmark, and all EMS personnel are required to complete a case report to the Danish Cardiac Arrest Registry for every OHCA.[2,19] Only patients where an initial resuscitation attempt is performed, either by bystanders or by EMS personnel, are included. A new data collection form was gradually implemented from 2005. This form required a yes/no response to the question "was a physician involved before arrival at the hospital?" A positive answer meant that a physician had been present at the scene. Only OHCAs registered through this new form were included in this study. From 2007 and onwards, 96% of cases were registered with the newer version.

Danish Civil Registration System

The Danish Civil Registration System records demographic information, vital status, address, and immigration and emigration dates for all Danish citizens and is updated within a week of a person's birth, address change, death, or emigration.[20,21]

Danish National Patient Registry

The Danish National Patient Registry was established in 1977 by the Danish National Board of Health.[22] The registry has recorded all hospital admissions to Danish emergency care hospitals since 1977 and all hospital outpatient and emergency room visits since 1995. It is estimated to be more than 99% complete.[23]

Data linkage

The data collected from these registers were linked through the Civil Registration Number, a unique personal identifier assigned to all Danish citizens.

Variables

An overview of the variables and data collected from different registries can be seen in Box 1. We created the binary variable "geographical location" based on the person's home address: Central and Greater Copenhagen (Copenhagen and Frederiksberg municipalities and the former Copenhagen county) or Outside of Copenhagen (the rest of the country). The variable was validated on a sub-sample and was shown to identify the actual geographical area of the OHCA in 98% (Greater Copenhagen) and 84–95% (Outside of Copenhagen) of cases. The Charlson Comorbidity Index score was calculated based on discharge diagnosis codes up to 10 years before the indexed OHCA.[24,25]

Exposure and outcome measures

Exposure was physician involvement before arrival at hospital. Primary outcome was 30-day survival, and secondary outcomes were 1-year survival and ROSC upon arrival at hospital.

Statistical analyses

Data were analysed using Stata, version 11 (StataCorp. 2009. Stata Statistical Software: Release 11. College Station, TX: StataCorp LP).

Descriptive characteristics

Characteristics among exposure groups are presented as frequencies with percentage for categorical data, and as median values with inter-quartile range (IQR) for continuous data. To compare differences between groups, two-sided tests were used. Categorical variables were tested with chi square test and continuous variables

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Box 1: Showing the origin of collected variables and data. CPR, cardiopulmonary resuscitation; VF, ventricular fibrillation; VT, ventricular tachycardia; OHCA, out of hospital cardiac arrest; MCCU, mobile critical care unit; ICD-8(10), International Classification of Diseases Revision 8(10); ROSC, return of spontaneous circulation; EMS, Emergency Medical Services; CCI, Charlson Comorbidity Index.

Danish Cardiac Arrest Registry Variables	Data
Civil Registration Number	Unique person identifier
Date of cardiac arrest	Day, month, year
Site of cardiac arrest	Private home/not private home
CPR before arrival of ambulance	Yes/no
First rhythm shockable (VF or pulseless VT)	Yes/no
Witnessed cardiac arrest	Yes/no
Estimated time from recognition of OHCA to first rhythm check by EMS personnel	Minutes
Physician involvement before arrival at hospital	MCCU physician or other physician/no physician
ROSC upon arrival at hospital	Yes/no
Danish Civil Registration System	
Civil Registration Number	Unique person identifier
Age (date of birth)	Years
Sex	Male/female
Municipality of residence	
Vital status	Alive/deceased/date of emigration
Danish National Patient Registry	
Civil Registration Number	Unique person identifier
Discharge diagnosis codes	ICD-8 or ICD-10 codes

with the Wilcoxon's rank-sum test. *P*-values < 0.05 were considered statistically significant. Poisson regression was used to test for trends in physician involvement and survival over time.

Regression analysis and model building

Crude and adjusted logistic regression was used to examine the association between exposure and outcome. Associations are presented as odds ratios (ORs) with 95% confidence intervals (CI). After checking for effect modification between potentially confounding variables and our primary outcome, we built three multivariable regression models with covariates selected prior to analysis, including all variables in Table 1. The first model was a complete-case analysis with standard adjustment, including 59% of all entries. In the second model, all missing variables were imputed 20 times using multivariable normal regression, hence the model included 100% of all cases. For the third model, chosen a priori as the main adjusted model, we used propensity score matching. Variables included in the propensity score, which is assumed to reflect the probability of being assigned to the exposure group, were year of OHCA, sex, age, site of cardiac arrest, CPR before arrival of ambulance, first rhythm shockable, witnessed cardiac arrest, geographical location, and estimated time from recognition of OHCA to first rhythm check by Emergency Medical Services personnel (more/less than 10 min). The propensity score was calculated by logistic regression and subsequently used to match each exposed person to one unexposed person by the "nearest neighbour" approach. The matching was validated by estimation of the bias for each variable, none of which exceeded 5.2%, $p = 0.118$. Difference in baseline characteristics was tested with chi square test for categorical variables and Wilcoxon's rank-sum test for continuous variables. Adjusted multivariable logistic regression analyses performed on the propensity score-matched cohort included all variables mentioned above.

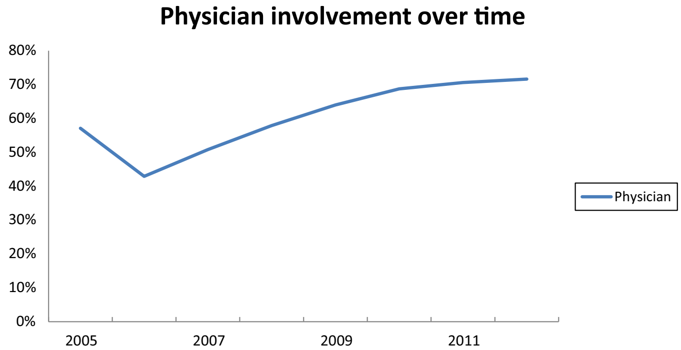

Fig. 1. The proportion of OHCA cases with physician involvement before arrival at the hospital, for each year from 2005 to 2012.

Exploratory analyses

To further assess the potentially confounding or effect modifying effect of each variable, adjusted analyses estimating the association between exposure and outcome were performed on binary strata of all variables. Due to the large number of interactions tested, interaction between variables were marked if *p*-values were <0.01. A pre-specified analysis restricted to cases with less than 10 min to rhythm check was performed to assess potential selection bias due to withheld resuscitation attempts if physicians were first on-scene.

Results

Baseline characteristics

A total of 25,452 patients experienced first-time OHCA during 2005–2012. Of these, 25,416 had available linkage to home address data in the Danish Civil Registration System. 323 cases had no information on the main exposure (physician involvement), and further 3928 were registered with the older version of the data collection form. The final study group included 21,165 persons. 13,234 (62.5%) had involvement of physician before arrival at hospital (physician involvement group), whereas 7931 (37.5%) patients were treated by other EMS personnel including other MCCU personnel (no physician involvement group) (Table 1). In the physician involvement group patients were a little younger; fewer patients had OHCA at a private home; more patients received bystander CPR; more patients had a shockable rhythm at first rhythm check; more patients had a witnessed cardiac arrest; more patients had OHCA in the Central and Greater Copenhagen area; and the comorbidity measured by the Charlson Comorbidity Index was higher (Table 1). The propensity score-matched cohort included 7854 exposed persons and 7854 unexposed persons (table in Supplementary material).

Changes in 30-day survival and physician involvement over time

The proportion of OHCAs with physician involvement increased from 57.1% in 2005 to 71.6% in 2012 (test for trend, $p < 0.001$) (Fig. 1). During the same time period, 30-day survival increased from 5.8% in 2005 to 11.5% in 2012 ($p < 0.001$) in the total study population, increasing from 8.6% in 2005 to 11.9% in 2012 in the physician involvement group ($p = 0.028$) and from 4.7% in 2005 to 9.6% in 2012 ($p < 0.001$) in the no physician involvement group (Fig. 2).

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Table 1
Basic characteristics.

Variable	Physician not involved before arrival at hospital	Physician involved before arrival at hospital	*p*-value	Missing values, *N* (%)
Study population, *N*	7931	13,234		
Year, *N* (%)			<0.001	0 (0.0)
2005	298 (3.8)	396 (3.0)		
2006	1170 (14.8)	881 (6.7)		
2007	1200 (15.1)	1240 (9.4)		
2008	1114 (14.0)	1529 (11.6)		
2009	1100 (13.9)	1951 (14.7)		
2010	1001 (12.6)	2192 (16.6)		
2011	982 (12.4)	2353 (17.8)		
2012	1066 (13.4)	2692 (20.3)		
Sex, *N* (%)			0.292	0 (0.0)
Male	5052 (63.7)	8252 (62.4)		
Female	2879 (36.3)	4709 (35.6)		
Age, median (IQR)	72 (61–81)	70 (59–80)	<0.001	0 (0.0)
Cardiac arrest in private home, *N* (%)			<0.001	716 (3.4)
Yes	5941 (74.9)	9060 (68.5)		
No	1835 (23.1)	3613 (27.3)		
CPR before arrival of ambulance, *N* (%)			<0.001	932 (4.4)
Yes	2636 (33.2)	5263 (39.8)		
No	5278 (66.5)	7056 (53.3)		
First rhythm shockable, *N* (%)			0.002	1363 (6.4)
Yes	1587 (20.0)	2736 (20.7)		
No	6092 (76.8)	9387 (70.9)		
Witnessed arrest, *N* (%)			<0.001	1034 (4.9)
Yes	3231 (40.7)	5738 (43.4)		
No	4666 (58.8)	6496 (49.1)		
Geographical location, *N* (%)			<0.001	0 (0.0)
Central and Greater Copenhagen	1173 (14.8)	5207 (39.3)		
Outside of Copenhagen	6758 (85.2)	8027 (60.7)		
Time from cardiac arrest to first rhythm check, minutes (median [IQR])	12 (7–20)	12 (8–19)	0.084	6679 (31.6)
Time from cardiac arrest to first rhythm check, *N* (%)			0.012	6679 (31.6)
0–2 min	454 (5.7)	515 (3.9)		
3–4 min	324 (4.1)	443 (3.3)		
5–6 min	516 (6.5)	666 (5.0)		
7–8 min	598 (7.5)	853 (6.4)		
9–10 min	640 (8.1)	961 (7.3)		
>10 min	3651 (46.0)	4765 (36.0)		
Charlson Comorbidity Index, *N* (%)			0.009	0 (0.0)
0	3771 (47.5)	6595 (49.8)		
1	1360 (17.1)	2119 (16.0)		
2	1261 (15.9)	2074 (15.7)		
≥3	1539 (19.4)	2446 (18.5)		

Basic characteristics for the whole study population. IQR, interquartile range; *N*, number.

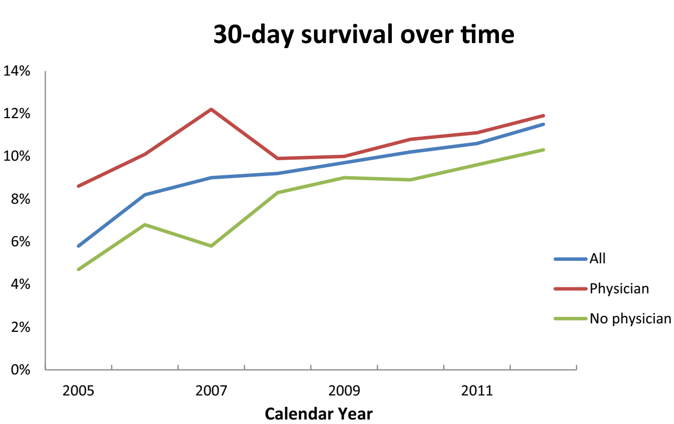

Fig. 2. The proportion of OHCA patients who survived for at least 30 days for each year from 2005 to 2012, shown for all patients, patients with physician involvement, and patients without physician involvement.

Association between physician involvement and 30-day survival

Overall, 10.8% of OHCA patients with physician involvement and 8.1% of OHCA patients without physician involvement before arrival at hospital were alive after 30 days, crude odds ratio (OR) = 1.37 (95% CI = 1.24–1.51), adjusted OR (aOR) = 1.18 (95% CI = 1.04–1.34) (Fig. 3). The positive association between physician involvement and 30-day survival was consistent across covariate strata, except for in persons with high Charlson Comorbidity Index and persons with initial non-shockable heart rhythm (Table 2).

Association between physician involvement and secondary outcomes

Physician involvement was also positively associated with ROSC upon arrival at the hospital, OR = 1.32 (95% CI = 1.22–1.42), aOR = 1.09 (95% CI = 1.00–1.19); and with 1-year survival, OR = 1.35 (95% CI = 1.22–1.50), aOR = 1.13 (95% CI = 0.99–1.29). The positive

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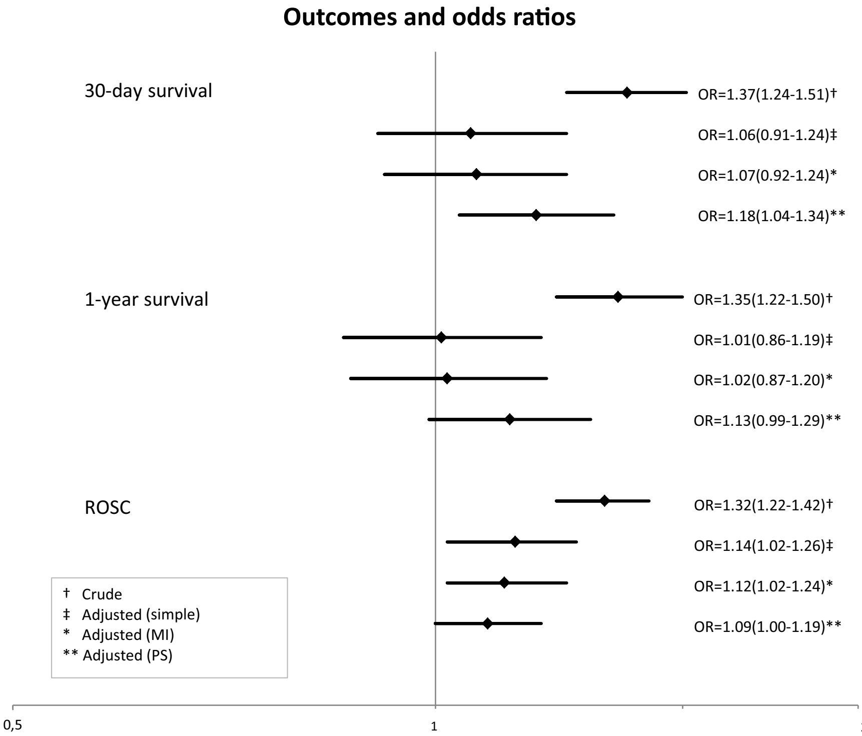

Fig. 3. Primary and secondary outcomes comparing the crude regression model and the three adjusted regression models. Simple stands for simple adjustment; MI, multiple imputation; PS, propensity score matched.

associations were consistent across covariate strata, and across different adjusted models (Fig. 3), with patterns similar to those observed for the primary outcome (Table 2).

Discussion

In this nationwide observational study of 21,165 patients with out-of-hospital cardiac arrest of any cause, we found 30-day and 1-year survival positively associated with physician involvement before arrival at hospital. Additionally, more patients had ROSC upon arrival at hospital if a physician had been involved. Survival improved with time in both exposure groups during the 8-year study period but most prominent in arrests without physician involvement, leading to a decrease in both the absolute and relative difference between groups over time.

The main strength of our study was the availability of a large, nationwide dataset with high data completeness. The data were prospectively collected and therefore unbiased with regard to the study question. We had data on most variables known to be associated with survival and thus potential confounders, and the results remained consistent in stratified analyses and across different adjusted regression models. We found a stronger effect in persons with shockable initial rhythm, supporting the assumption that physicians provide benefit also in this important subgroup that are more likely to survive. The study also had a number of weaknesses. First, the exposure groups differed from each other with regard to distribution of crucial variables such as witnessed cardiac arrest, shockable rhythm, CPR before ambulance arrival, and time to first rhythm check. We dealt with these potential confounders or effect modifiers by checking our results in several multivariable models, and by testing for interaction in the propensity score-matched model. Despite our efforts, we cannot exclude residual confounding, which could be present if the decision to dispatch a physician was somehow related to the prognosis of the patient and therefore to the outcome. One could imagine that physician-staffed MCCUs were more likely to be allocated to cardiac arrests that were witnessed and located within short driving distance, so that the observed effect was driven by the fact that OHCAs with a priori poor prognosis was attended by ambulances with no physician staffing. However, patients in the physician group had more co-morbidity. Further, the level of response (physician/no physician) would also depend on whether physician-staffed MCCUs were operating or not in the specific area (i.e. a political decision and not a decision made by the dispatcher). The fact that only physicians are allowed to state that a patient is dead and therefore refrain from resuscitation attempts could introduce bias away from null, as these patients would not be registered in the Danish Cardiac Arrest Registry. This would be most common in cases with long time from arrest to arrival of EMS personnel since it would be less likely that a physician would withhold from resuscitation attempt when time from cardiac arrest to first rhythm check is less than 10 min. However, the positive effect on survival persisted in a sensitivity analysis restricted to those with less than or equal to 10 min until rhythm check. In addition, due to a limited number of physician-manned units, the ambulance would often arrive first and commence resuscitation, which would lead to registration in DCAR even if the later-arriving physician should decide to end resuscitation activity. Finally, another potential confounder of the primary outcome could be if the in-hospital treatment is better in areas with better physician coverage for OHCA, and we did indeed find a stronger association with the primary outcome in OHCAs closer to the capital. Even so, the association between physician involvement and the secondary outcome "ROSC upon arrival at hospital" was considerably stronger in geographic areas closer to Copenhagen, indicating that the observed effect begins before the patient reaches the hospital. Our data did not allow us to assess the neurological outcome for the surviving patients. We did not differentiate between aetiology of cardiac arrests as suggested by the Utstein template[18] because the main purpose was to examine the effect of pre-hospital physician involvement in the total OHCA

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Table 2
Stratified analyses.

Association between physician involvement and outcomes in covariate strata		30-day survival	Interaction	1-year survival	Interaction	ROSC	Interaction
		OR (95% CI)	$p < 0.01$	OR (95% CI)	$p < 0.01$	OR (95% CI)	$p < 0.01$
All		1.18 (1.04–1.34)		1.13 (0.99–1.28)		1.09 (1.00–1.19)	
Year	2005–2008	1.39 (1.08–1.79)		1.29 (0.99–1.67)		1.84 (1.54–2.20)	*
	2009–2012	1.11 (0.96–1.29)		1.08 (0.92–1.26)		0.93 (0.84–1.03)	
Sex	Female	1.32 (1.01–1.72)		1.12 (0.85–1.47)		1.14 (0.98–1.33)	
	Male	1.13 (0.97–1.30)		1.11 (0.96–1.30)		1.07 (0.97–1.20)	
Age	<70 years	1.07 (0.92–1.24)		1.04 (0.89–1.21)		1.01 (0.90–1.14)	
	≥70 years	1.51 (1.18–1.94)		1.43 (1.09–1.89)		1.22 (1.07–1.39)	
Private home	No	1.17 (0.97–1.41)		1.10 (0.91–1.33)		1.09 (0.94–1.26)	
	Yes	1.19 (1.00–1.41)		1.15 (0.96–1.39)		1.10 (0.99–1.22)	
CPR before ambulance	No	1.29 (1.00–1.65)		1.29 (0.98–1.69)		1.46 (1.27–1.68)	*
	Yes	1.14 (0.98–1.32)		1.07 (0.92–1.25)		0.93 (0.83–1.03)	
First rhythm shockable	No	0.99 (0.77–1.26)		0.93 (0.71–1.22)		1.08 (0.96–1.21)	
	Yes	1.25 (1.07–1.45)		1.18 (1.01–1.37)		1.12 (0.98–1.29)	
Witnessed arrest	No	1.27 (0.93–1.73)		1.36 (0.97–1.90)		1.28 (1.08–1.51)	
	Yes	1.16 (1.00–1.33)		1.08 (0.94–1.25)		1.03 (0.93–1.14)	
Location	Close to Cph	1.40 (1.10–1.78)		1.22 (0.95–1.56)		1.26 (1.07–1.48)	
	Far from Cph	1.11 (0.95–1.29)		1.10 (0.94–1.28)		1.05 (0.95–1.16)	
Time to first rhythm check	≤10 min	1.15 (0.97–1.36)		1.11 (0.93–1.33)		1.07 (0.95–1.21)	
	>10 min	1.17 (0.96–1.42)		1.09 (0.89–1.34)		1.11 (0.98–1.26)	
Charlson index	0 or 1	1.34 (1.16–1.55)	*	1.24 (1.07–1.43)		1.14 (1.03–1.26)	
	≥2	0.71 (0.54–0.94)		0.74 (0.54–1.00)		1.00 (0.86–1.17)	

Stratified analyses for all outcomes. OR, odds ratio; CI, confidence interval; ROSC, return of spontaneous circulation; CPR, cardio-pulmonary resuscitation; Cph, Copenhagen.
* Indicates interaction between variables with $p < 0.01$.

population, to provide information that can be used for EMS planning purposes.

An observational study conducted in the county of Nottinghamshire (England) in the early 90s concluded that survival after OHCA was higher when EMTs were assisted by a paramedic, and even higher when supported by another health professional trained in basic life support.[9] The overall survival at discharge was low (6.1%) but they found a crude OR of 4.03 (95% CI 1.87–8.66) on survival to discharge when paramedics were assisted by a physician compared to treatment by EMTs only, which is consistent with our findings. A small Norwegian study did not find improved survival with a physician-staffed ambulance in Oslo even though they saw that CPR-quality measures such as hands-off time and pre-shock pauses were minimized,[10] nor did a German study find a physician on board of the advanced life support unit to be related to improved survival.[13] This latter study, however, only assessed those providing the initial CPR in a population where a physician was always present in the event of an OHCA.

The European Resuscitation Council and American Heart Association guidelines for cardiac arrest are based on the 'chain of survival'.[6] It consists of four links; early access to emergency medical care, early cardiopulmonary resuscitation, early defibrillation, and early advanced cardiac life support. In 2005, new cardiac arrest guidelines were implemented and the improvement in survival seen in both our exposure groups over time, may partly be explained by this.[26] National initiatives taken during the last decade in Denmark to improve cardiac arrest management, may also have contributed to the improved survival.[2] The effect observed in the physician-treated group might be associated with a combination of technical and non-technical skills related to; endotracheal intubation and other advanced airway management, differential diagnostics, choice of medication, team leader function, more hands available, experience, knowledge of critical care and guidelines, post-resuscitation care, etc. Whatever the mechanism, our results indicate that by using physicians in the pre-hospital setting in Denmark, we may be optimizing one or more of the links in the chain-of-survival after OHCA. However, our study does not allow any conclusions to be drawn on which specific factors have contributed most to the increase in survival. Hence, our findings may not be directly applicable in other countries with different EMS systems.

To further guide policy making, additional studies are needed on the cost-effectiveness and cost-utility of having physicians in the pre-hospital setting. We also need to learn more about the factors driving the positive impact on survival, ultimately allowing us to improve the outcome for all patients with OHCA, including those in areas where it is not possible to have physicians in the prehospital setting.

Conclusions

In conclusion, we found prehospital physician involvement after sudden OHCA associated with better 30-day survival, better 1-year survival, and higher chance of ROSC on arrival at hospital; but with less certainty for 1-year survival.

Conflict of interest statement

AH and NL received a grant from TrygFonden during the conduct of the study. JS and LH are working as physicians on a physician-staffed mobile critical care unit and receive personal fees for that. CTP received grants from Biotronic and grants and personal fees from Bayer and BMS, outside the submitted work. All other authors declare no competing interests.

Ethics approval

The study was approved by The Danish Data Protection Agency (J.nr. 2014-41-3020), and did not require informed patient consent according to Danish health law.

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cardiac arrest. The study was further supported by the Department of Anaesthesiology and Intensive Care Medicine, Copenhagen University Hospital Hvidovre.

The study sponsor had no role in the design and conduct of the study; the collection, management, analysis, or interpretation of the data; the preparation, review, or approval of manuscript; or the decision to submit the manuscript for publication.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.resuscitation.2016.08.007.

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