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Outcome following physician supervised pre-hospital resuscitation: a retrospective study

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Abstract

Background: Pre-hospital care provided by specially trained physicians (P-EMS) is an integrated part of the emergency medical systems in many developed countries. To what extent P-EMS increases survival and favorable outcomes is still unclear. The aim of the study was thus to investigate ambulance runs initially assigned “life-saving missions” with special emphasis on long term outcome in patients treated by the Mobile Emergency Care Unit (MECU) in Odense, Denmark

Methods: All MECU runs are registered in a database by the attending physician, stating, amongst other parameters, the treatment given, outcome of the treatment and the patient´s diagnosis. Over a period of 80 months from May 1st 2006 to December 31st 2012, all missions in which the outcome of the treatment was registered as “life saving” were scrutinized. Initial outcome, level of competence of the caretaker, and diagnosis of each patient were manually established in each case in a combined audit of the pre-hospital database, the discharge summary of the MECU and the medical records from the hospital. Outcome parameters were final outcome, the etiology of the condition leading to a life-threatening situation, and the level of competences necessary to save the life of the patient.

Results: 225 patients were subjected to life saving physician directed medical treatment exceeding the competences of the attending paramedic or Emergency Medical Technician enabling these patients to be discharged to their own homes following a life-threatening event.

Conclusions: This paper demonstrates the beneficial effect of physician administrated pre-hospital treatment in case of life threatening events.

Article summary

Strenghts and limitations of this study:

- This study demonstrates that the competences required to perform life saving interventions in a large urban material to a large extent are competences well outside the competences of an ordinary emergency medical technician or paramedic but inside the curriculum of an attending anaesthesiologist.
- A considerable strength of the present study is the sample size and the small number of patients lost to follow-up.
- This paper demonstrates that the survivors are distributed within two distinct groups: One group containing patients, who, following a life saving intervention are discharged to their own homes in good condition and one group containing patients who, following an initial life saving effort die at the hospital. Only a small amount of patients recover in poor or moderately disabled condition.
- A considerable weakness of the study is that there is no formal validation whether the "life-saving intervention" was truly needed. It is possible that some of the patients would have survived transport to the hospital without intubation and controlled ventilation, without repetitive injections of vasopressors or without removal of foreign bodies in the airways.

Introduction

Physician-based pre-hospital emergency services (P-EMS) are established in many developed countries.[1,2]. The value of such services is debated and is difficult to assess scientifically.[3,4] Although no-one questions the value of physicians inside the hospital, ideally, the value of P-EMS should be addressed based on the context in which the service operates, both demographically, geographically and economically, as it has proven difficult to ascertain a positive relationship between the emergency care providers´ level of competence and the outcome of the patient.[5] The Mobile Emergency Care Unit (MECU) in Odense, Denmark, consists of a rapid-response car operating all year round. It is manned with a specialist in Anaesthesiology and an Emergency Medical Technician (EMT). It operates as a part of a two-tiered system, in which the MECU supplements an ordinary ambulance manned with two EMTs.

Upon inauguration of the MECU in Odense, Denmark in 2006, two questions were posed:

Does the attendance of a specialized physician at the scene make a difference to the patients´ survival compared with an EMT or paramedic (PM)?

and

Does the presence of a physician manned emergency care unit lead to a large number of resuscitated patients suffering from cerebral sequelae following medically directed resuscitation?

The aim of the present study was to investigate these two questions in relation to patients attended to by the MECU in Odense, Denmark, in whom the mission outcome was registered as life saving.

In order to study this subject, in each life saving mission we investigated whether the competences required to resuscitate the patient or prevent the patient from dying fell within the competences of the attending emergency medical technician or PM or whether the competences applied lay within the competences of the attending physician. In each mission, the final outcome of the patient was also sought in order to establish whether the patient's outcome was good, moderate or poor.

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Methods

Description of study context

The MECU covers an area of approximately 2.500 square km and serves a population of 250.000 to 400.000 depending on time of day.

In a typical year, the MECU is handling 4900 calls (13.5 calls per day). Due to apparent overtriage at the dispatch centre, in 13% to 20 % of the calls, the ambulance waives the MECU en route following initial contact with the patient. As a result of coincident requests for assistance, 3.2 % to 6.1 % of the requests are left unanswered.

The MECU is dispatched either by the dispatch centre on the basis of the information given by the caller or by request from the EMTs on the primary ambulance. From its inauguration in May 1st 2006 to April 30th 2011, the dispatch of the MECU was based on the criteria for dispatching the MECU along with an ambulance as seen in table 1. From May 1st 2011 and during the rest of the study period, a criteria-based nationwide Emergency Medical Dispatch (EMD) system was used.[6]

(Table 1 here)

Following each MECU run, patient characteristics (including the patient's Civil Registration System number (or Social Security Number), forming a unique identification of the patient),[7] the tentative patient diagnosis, and the treatment administered, are entered into the MECU database. The physician responsible for the treatment also assesses the immediate outcome of the patient. This assessment is graded into seven categories:

- Patient´s condition improved during treatment
- Patient´s condition significantly improved during treatment
- Patient undergoing life saving procedures

- Patient unchanged
- Patient deteriorating
- Patient dead during treatment
- Others

Design

The study is a retrospective, descriptive study approved by the Danish Data Protection Agency (journal numbers 2010-41-5097 and 2013-41-2439). Within an 80 months period (May 1st 2006 to December 31st 2012), all records at the MECU concerning patients with the outcome “Patient undergoing life-saving procedures” were sought. The medical records and the discharge letters from Odense University Hospital pertaining to these patients were then sought in the hospital’s patient registry database according to the patients´ Civil Registration System number.

All records were thoroughly read by the investigators and an audit was performed in each case to validate the immediate outcome determined by the treating physician. Patients were followed until either discharge to home, discharge to nursing home or death at hospital. On the basis of the information available in the MECU record and the in-hospital medical records and discharge letter, all authors independently should agree on the validity of the claim “Patient undergoing life-saving procedures”.

In case of disagreement, agreement was obtained following closer examination of each case.

In case of missing discharge letter from the hospital, the patient was considered lost-to-follow-up.

In all cases registered as “Patient undergoing life-saving procedures “, the competences required to save the patient´s life was assessed. Upon this assessment it was decided whether the competences required to save the patient lay within the competences of the attending PM or EMT or whether the competences required exceeded the competences of the PM or EMT.

Criteria for denoting a case “Patient undergoing life-saving procedures” within the competences of the physician were:

Explicit criteria:

- Intubation or other airway procedure exceeding the competences of PM or EMTs
- Advanced medical treatment exceeding the competences of PM or EMTs in cardiac arrest and/or defibrillation when indicated by the attending physician.

Implicit criteria:

- Advanced medical treatment exceeding the competences of the attending PM in severe shock states
- Fluid resuscitation exceeding the competences of the EMT or PM in cases of severe hypovolemia

In assessing the criteria and denoting a case “life saving within the competences of an EMT or paramedic” no account was taken whether the interaction saving the patient´s life or preventing death had in fact been carried out by the EMT or PM or an attending physician. If the interaction deemed necessary to save the patient´s life lay within the curriculum of the EMT or PM, the life saving effort was considered within the competences of the EMT or PM. Even if a physician had performed bag-mask ventilation and administrated naloxone to a patient with an opioid overdose, the effort was registered as “life saving within the competences of the EMT or PM” as both of these competences lie within the curriculum of the EMT and PM. Likewise, the administration of oxygen, furosemide, and nitroglycerine in a patient with severe pulmonary edema was considered within the competences of an EMT or PM. Only if intubation or non-invasive ventilation with continuous positive airway pressure had

been applied, the effort was considered “life saving requiring competences exceeding the competences of the EMT or PM.

All data were categorized using Microsoft Office Excel 2007 (Microsoft Corporation, Redmond, Washington, USA).

Statistical methods:

Demographic data are presented as mean and range. All other data were analyzed using non-parametric statistics (Chi-square and Kruskal-Wallis) (IBM SPSS Statistics 22, Armonk, New York, United States). Differences were considered significant when $p<0.05$. Bonferroni´s correction for repeated measurements was performed when pertinent.

Results

A total of 32,452 runs were recorded for the MECU during the study period. 25,647 (79 %) of these runs resulted in contact with a patient. 701 of these patients were subjected to “life saving treatment”. In 102 patients the treatment necessary to save the patient’s life was administered within the competences of the attending EMT or PM (typical treatment modalities: mask ventilation followed by injection of naloxone, injection of glucagon or intravenous glucose, administration of defibrillation with return of spontaneous circulation and breathing). Three patients were resuscitated within the competences of lay persons (in all three cases administration of defibrillation using an automatic external defibrillator resulting in return of spontaneous circulation, breathing and return of consciousness). 596 patients were subjected to life saving interventions performed by the attending physician. Compared to the number of patients resuscitated within the competences of the EMT or PM, this difference is highly significant ($P<0.001$).

Of the 596 patients subjected to life saving interventions performed by the attending physician, 286 patients (48.0 %) died at the hospital during the admission. Thirty patients were discharged to rehabilitation clinics or other hospitals with major or moderate sequelae. Twenty-five patients were discharged with minor sequelae requiring occupational therapy. Compared with patients surviving with sequelae, a significant majority - 225 patients in all (37.8 %) - were discharged to their own homes following in-hospital treatment ($P<0.001$). The mean age of patients resuscitated within the competences of an anesthesiologist was 54.3 years (range 0-91). No difference was observed between the number of patients suffering minor or moderate to severe sequelae ($p=0.39$). No differences in the number of survivors were found comparing each year (data not shown).

(Figures 1-4 near here)

The diagnoses of the patients that were discharged to their own homes following an incident requiring life saving competences exceeding the competences of an attending EMT or PM are shown in table 2.

(Table 2 near here)

Discussion

When a traumatized or critically ill patient is brought to the emergency room within the hospital, a specialist is usually called upon to treat the patient. However, the benefit gained by utilizing specialized physicians in the pre-hospital service is still somewhat disputed,[4,5,8-10] and some countries do not offer advanced pre-hospital treatment as performed by physicians but rely on EMTs or PMs with varying competences.[11] However, while PMs possess a considerable number of competences allowing them to treat a variety of conditions, pre-hospital physicians possess some additional critical care competences which are potentially life-saving but are required infrequently and can carry significant risks.[12]

The availability of advanced pre-hospital life support (ALS) and basic life support (BLS) differ between countries - as such rendering comparison difficult. Although endotracheal intubation of patients in cardiac arrest recently has been disputed [13] ALS however, seems to improve survival in patients with myocardial infarction while BLS may be the proper level of care for patients with penetrating injuries.[8] Papers describing both gains in quality-adjusted life-years as well as increased survival with physician treatment in trauma and, based on more limited evidence, cardiac arrest, have been published.[9,10]

Some studies indicate a beneficial effect of ALS administered by physicians in patients with blunt head trauma.[14-16] All these studies are retrospective in character and further high-quality research in this area would be welcome.[17]

However, pending results from an ongoing randomized study on the effect on mortality and morbidity in traumatized patients that an attending physician imposes versus a PM,[18] the best evidence regarding the possible impact of physician assisted pre-hospital treatment comes as yet from retrospective studies.

The concept of advanced pre-hospital treatment should be not attributed to intubation alone, as studies have suggested that advanced life support interventions (e.g. intubation) performed by PMs may have harmful effects compared to in-hospital treatment.[19,20] Apart from intubation, control of end-tidal CO2, and administration of carefully titrated doses of inotropic agents also forms a part of advanced pre-hospital treatment. In sepsis, early administration of antibiotics have proven valuable [21] and there is no reason to believe that timing of therapy does not also apply to the pre-hospital scene.

In the present study, we have found that the presence an anaesthesiologist -staffed MECU significantly improves patients´ survival based on an evaluation of the competences required to resuscitate or prevent a critically ill or injured patients from dying. Few patients recovered with moderate or severe sequelae. Our results are probably generalisable to all of Scandinavia as all Scandinavian countries provide anaesthesiologist-staffed pre-hospital services.[22] All of these services apply advanced emergency medical procedures in critically ill or injured patients, the lowest incidence of these procedures being exercised in Denmark.[1]

Our primary finding in this retrospective study is that the vast majority of the life saving procedures carried out in the MECU in Odense, Denmark is performed within the competences of the attending anaesthesiologist. Another important finding in this study is the outcome pattern of the patients resuscitated within the competences of the physician: Approximately half of the patients that survive the incident are discharged to their own homes without major or even moderate sequelae. Another half of the patients die at the hospital. Only a minute fraction of patients that survive a critical incident requiring resuscitation by the anaesthesiologist manning the MECU experience sequelae.

The subject of the present study was the life saving interventions. However, the MECU is not only a life saving service. Both supervision of EMTs and PMs and clinical decision-making might add value to the combined emergency system. Moreover, utilizing a physician in the pre-hospital environment actually enable withholding of futile advanced interventions, such as withholding intubation for ethical reasons in patients where such a treatment could be contra-indicated is probably beneficial for ethical reasons.[23] As such, advanced medical care including ICU admittance might be avoided in futile cases.

Strengths and limitations

The strength of the present study is the sample size and the small number of patients lost to follow-up. All data have been entered by the anaesthesiologist on call immediately following the mission. All missions assigned the outcome “life saving” have been audited by the authors of whom three are independent of the MECU. The validity of data thus is acceptable. Weaknesses of the present study however, are that the study is a retrospective study. In Scandinavia at the present time, it is not feasible to perform a prospective randomized study on the presence of an anesthesiologist at the scene. In this study, no comparison has been made with a period without a MECU. The present private ambulance operator in the area does not carry databases extensive enough to support such a study. Follow-up of patients have been reduced to establishing whether the patient was discharged to his/her own home. The study would have benefitted from assessing the patients using post hoc interviews to evaluate their status. However, given our large material and the time span of the investigation making post hoc interviews difficult, in this study, we assumed that a patient being discharged to his/her own home was a patient with favorable outcome.

An important limitation of the present study is the application of a subjective measure of life saving intervention. This may have given rise to reporting bias as the physician

responsible for the mission performed was the one who made the initial assessment of the mission. However, in our study we have subjected each self-reported case of "life saving mission" to an audit applying both explicit criteria and implicit criteria in order to assess, to what extent any given mission indeed correctly had been determined a life saving mission. Furthermore, the large numbers of missions not classified as life saving missions indicate a reliable reporting culture.

Finally, one might argue that However, all therapeutic interventions have been carried out by a specialist in anaesthesiologist at the scene following best standard of care. By definition, the specialist would be deemed negligent if he failed to use his level of skill, knowledge, and care in diagnosis and treatment of patients. Furthermore, it is impossible to validate the claim "life saving intervention" in a formal way: Should one withhold the intervention, the patient would die if the claim that the life saving intervention was indeed correct.

Conclusion

This retrospective study demonstrates that anesthesiologist administrated therapy increases the level of treatment modalities leading to an increased survival without an unacceptably high number of patients suffering severe sequelae. The present study thus lends firm support to the concept of applying specialists in anaesthesiology in the pre-hospital setting.

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Legends to figures:

Table 1: MECU Dispatch criteria in parts of the observation period

Table 2: Diagnoses in patients discharged to their homes following anesthesiologist supervised resuscitation

Figure 1: Flowchart describing the patients

Figure 2: Distribution of patients resuscitated within the competences of emergency medical technician / paramedic, lay person and anaesthesiologist

*P<0.001 (Patients resuscitated within the competences of anaesthesiologists vs. patients resuscitated within the competences of the emergency medical technician/paramedic)

Figure 3: Age distribution of survivors discharged to home following resuscitation by anaesthesiologist

Figure 4: Outcome of patients resuscitated at the scene by anesthesiologists

*P<0.001 (Discharged to home vs. Surviving with minor or moderate to severe sequelae)

Table 1:

MECU Dispatch criteria in parts of the observation period

Ambulance + MECU

Life threatening conditions:

- Sudden loss of consciousness
- Absense of breathing
- Noisy or otherwise impaired breathing
- Possible life threatening conditions:
- Dyspnea
- Severe chest pain
- Sudden onset of serious headache
- Impaired breathing in infants and children
- Suspected serious illness in children or infants
- Sudden onset of severe oral or rectal bleeding
- Sudden onset of bleeding in pregnant women beyond 20th gestational week

Accidents implying a risk of life threatening conditions:

- Motorway accidents
- On highways
- High velocity car crash
- Entrapment
- Roll-over
- Lorry or bus involved
- Motorcycle involved
- Pedestrian against car / motorcycle

Other accidents

- Fall from heights
- Entrapped persons
- Accidents with bleeding victims
- Accidents involving horses
- Gunshot or stab wounds towards torso, neck, head
- Hanging
- Drowning
- Burns involving face or exceeding 20% (adults) or 10% (infants and children) of body surface area
- Accidents involving trains or airplanes

Fire implying a risk of damage to people

Chemical exposure

Table 2

Diagnoses in patients discharged to their homes following anesthesiologist supervised resuscitation	
Cardiac arrest	96
Respiratory insufficiency	42
Trauma	22
CNS pathology	15
Circulatory failure	12
Obstructed airway	12
Poisoning, other	8
Septicemia	6
Hypovolemia	3
Pulmonary edema	3
Drowning	2
Anaphylactic shock	2
Poisoning, opioids	1
Hypoglycemia	1
Unknown diagnosis (transferred to other hospital before a diagnosis was established)	3

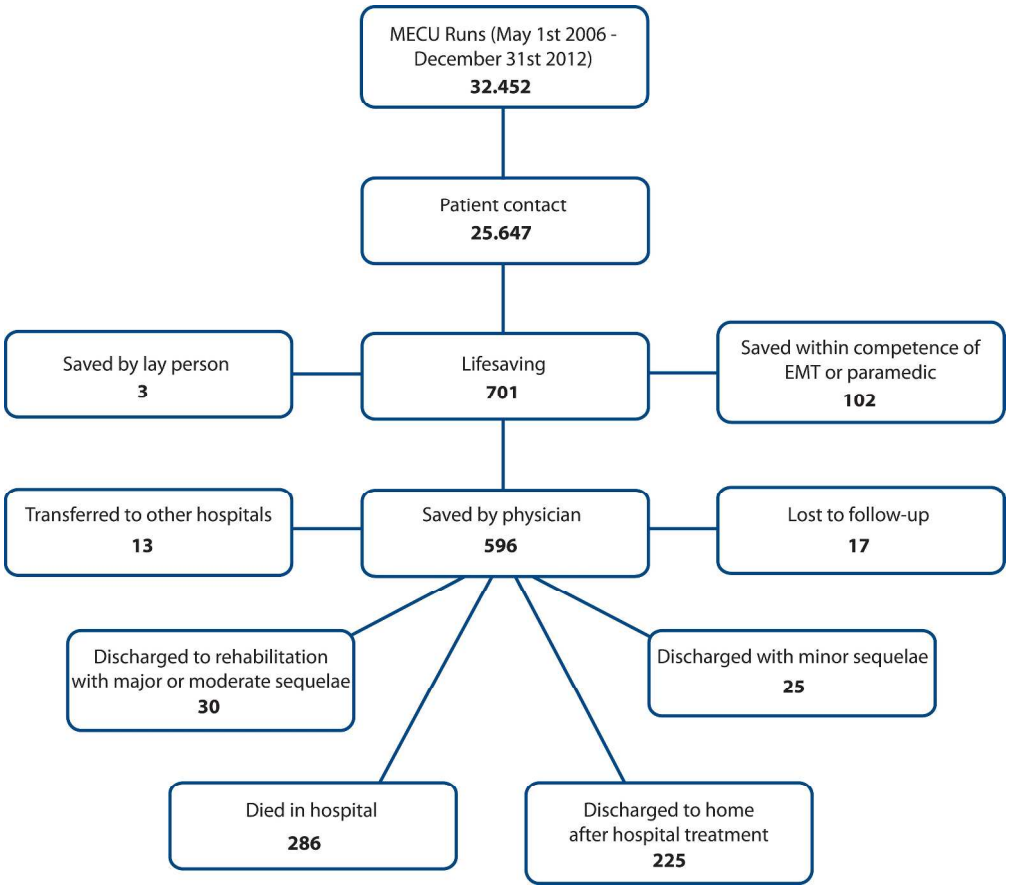
Competing interests

None of the authors have any competing interests to declare. No external funding was utilized.

Authors' contributions

SM contributed to this manuscript with idea and design as well as acquisition of data, analysis of data and drafting and revising of the manuscript. AJK contributed to this manuscript with idea, design, analysis of data, drafting and revision of the manuscript. STZ contributed to this manuscript with acquisition and analysis of the data, drafting and revising of the manuscript. ACB contributed to this manuscript with idea and design as well as acquisition of data, analysis of data and drafting and revising of the manuscript. All authors read and approved the final manuscript.

Data sharing statement
No additional data available.



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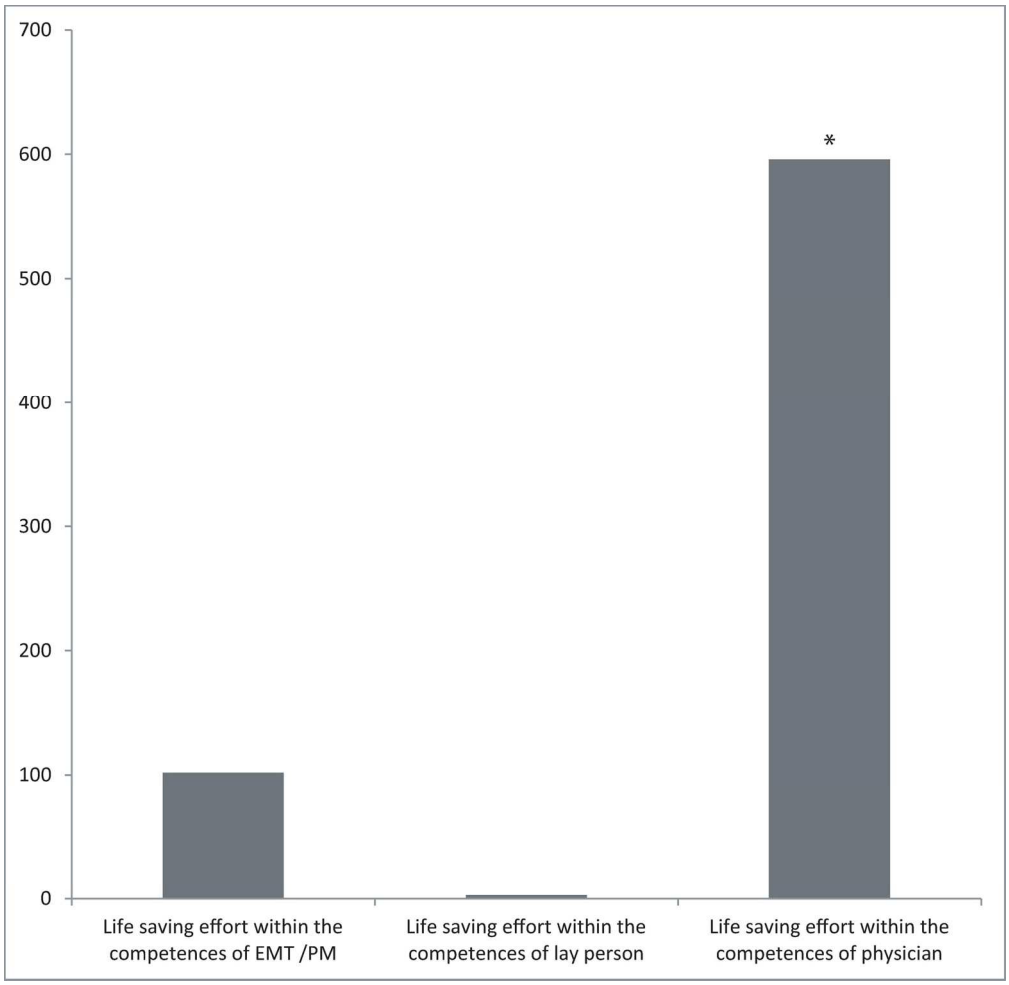

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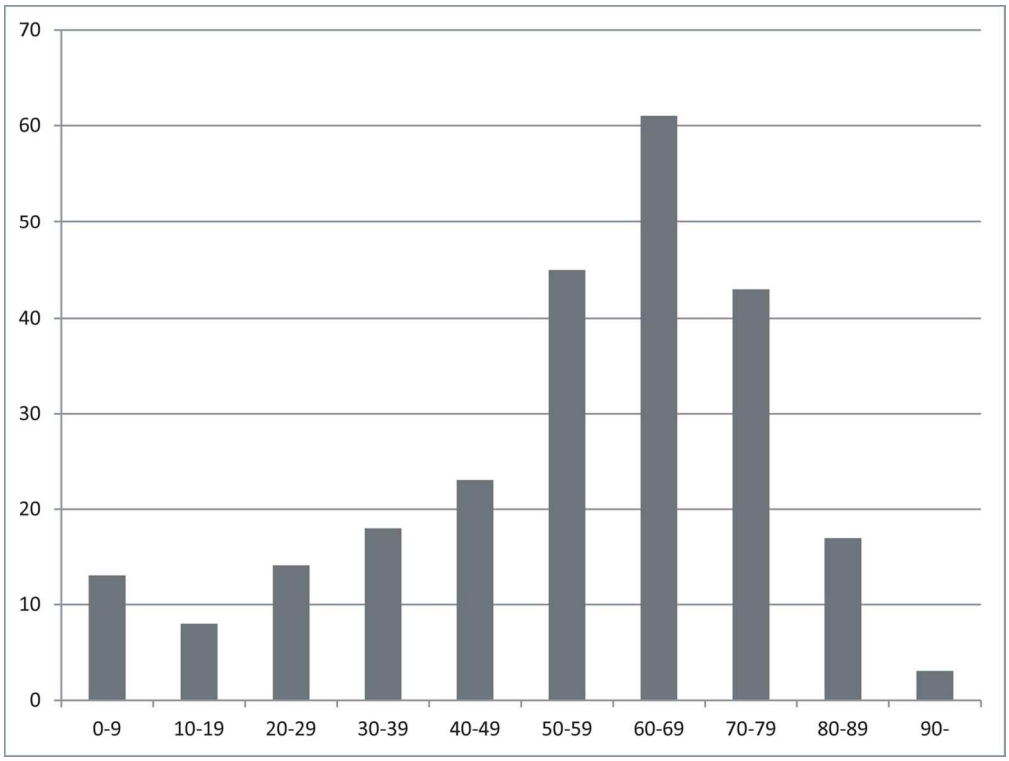

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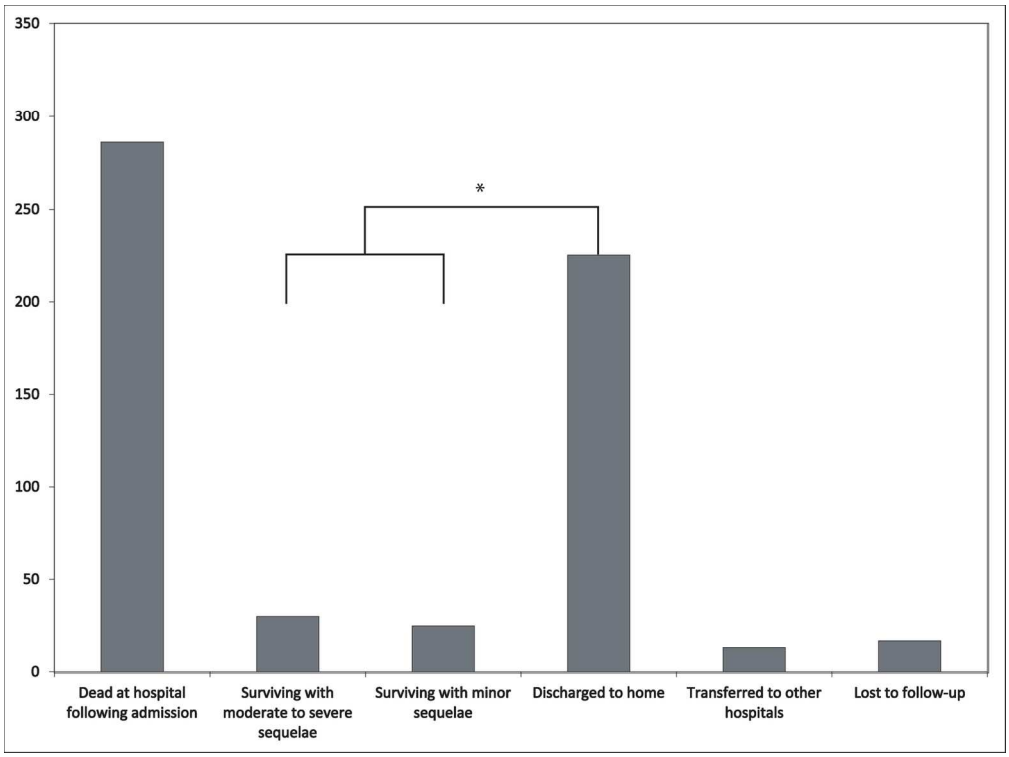

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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16a, b, c	Not relevant
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Outcome following physician supervised pre-hospital resuscitation: a retrospective study

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Abstract

Background: Pre-hospital care provided by specially trained physicians (P-EMS) is an integrated part of the emergency medical systems in many developed countries. To what extent P-EMS increases survival and favorable outcomes is still unclear. The aim of the study was thus to investigate ambulance runs initially assigned “life-saving missions” with special emphasis on long term outcome in patients treated by the Mobile Emergency Care Unit (MECU) in Odense, Denmark

Methods: All MECU runs are registered in a database by the attending physician, stating, amongst other parameters, the treatment given, outcome of the treatment and the patient´s diagnosis. Over a period of 80 months from May 1st 2006 to December 31st 2012, all missions in which the outcome of the treatment was registered as “life saving” were scrutinized. Initial outcome, level of competence of the caretaker, and diagnosis of each patient were manually established in each case in a combined audit of the pre-hospital database, the discharge summary of the MECU and the medical records from the hospital. Outcome parameters were final outcome, the etiology of the condition leading to a life-threatening situation, and the level of competences necessary to save the life of the patient.

Results: Of 25,647 patients treated by the MECU, 701 were subjected to prehospital “life saving treatment”. In 596 patients the treatment required to save the patient’s life exceeded the competences of the attending emergency medical technician or paramedic. Of these patients, 225 survived and following in-hospital treatment were discharged to their own home.

Conclusions: The present study supports the concept of applying specialists in anaesthesiology in the pre-hospital setting

Article summary

Strenghts and limitations of this study:

- This study demonstrates that the competences required to perform life saving interventions in a large urban population to a large extent are competences well outside the competences of an ordinary emergency medical technician or paramedic but inside the curriculum of an attending anaesthesiologist.
- A considerable strength of the present study is the sample size and the small number of patients lost to follow-up.
- This paper demonstrates that the survivors are distributed within two distinct groups: One group containing patients, who, following a life saving intervention are discharged to their own homes in good condition and one group containing patients who, following an initial life saving effort die at the hospital. Only a small amount of patients recover in poor or moderately disabled condition.
- A considerable weakness of the study is that there is no formal validation whether the "life-saving intervention" was truly needed. It is possible that some of the patients would have survived transport to the hospital without intubation and controlled ventilation, without repetitive injections of vasopressors or without removal of foreign bodies in the airways.

Introduction

Physician-based pre-hospital emergency services (P-EMS) are established in many developed countries.[1,2]. The value of such services is debated and is difficult to assess scientifically.[3,4] Although no-one questions the value of physicians inside the hospital, ideally, the value of P-EMS should be addressed based on the context in which the service operates, both demographically, geographically and economically, as it has proven difficult to ascertain a positive relationship between the emergency care providers´ level of competence and the outcome of the patient.[5] In the region of Southern Denmark, the competences of the emergency medical technicians (EMTs) are restricted to inhalational therapy with broncholytics, rectal administration of benzodiazepines, administration of intravenous glucose, intramuscular administration of naloxone, initial treatment of patients with myocardial infarction (thrombolytic agents, opioids, nitroglycerine), intramuscular adrenaline in the treatment of anaphylaxis as well as fluid administration and defibrillation. The competences of the paramedics mainly exceeds those of the EMT in the possibility of intravenous administration of adrenaline and amiodarone in ventricular fibrillation as well as intravenous administration of furosemide. The basic response to a request for prehospital assistance is an ambulance manned with two EMTs. According to the perceived severity of the task presented to the dispatch center, in lesser populated areas of the region, a paramedic is dispatched along with the ambulance in order to supplement the treatment. The 1st of may 2006, a Mobile Emergency care Unit (MECU) was initiated in Odense, Denmark. This consists of a rapid-response car operating all year round. It is manned with a specialist in Anaesthesiology and an Emergency Medical Technician (EMT). It operates as a part of a two-tiered system, in which the MECU supplements an ordinary ambulance manned with two EMTs.

Upon inauguration of the MECU in Odense, Denmark in 2006, two questions were posed:

Does the attendance of a specialized physician at the scene make a difference to the patients´ survival compared with the survival procured by the attending EMT or PM?

and

Does a presumed increase in patients resuscitated prehospitally as a result of the presence of a physician manned emergency care unit lead to a large number of resuscitated patients suffering from cerebral sequelae?

The aims of the present study were to investigate these two questions in relation to patients attended to by the MECU in Odense, Denmark, in whom the mission outcome was registered as life saving.

In order to study this subject, in each life saving mission we investigated whether the competences required to resuscitate the patient or prevent the patient from dying fell within the competences of the attending emergency medical technician or PM or whether the competences applied lay within the competences of the attending physician. In each mission, the final outcome of the patient was also sought in order to establish whether the patient's outcome was good, moderate or poor.

Methods

Description of study context

The MECU covers an area of approximately 2.500 square km and serves a population of 250.000 to 400.000 depending on time of day.

In a typical year, the MECU handles 4900 calls (13.5 calls per day). Due to apparent overtriage at the dispatch centre, in 13% to 20 % of the calls, the patient can be adequately treated within the competences of the EMT.and the ambulance thus waives the MECU en route following initial contact with the patient. As a result of coincident requests for MECU assistance, 3.2 % to 6.1 % of the requests are left unanswered.

The MECU is dispatched either by the dispatch centre on the basis of the information given by the caller or by request from the EMTs on the primary ambulance. From its inauguration in May 1st 2006 to April 30th 2011, the dispatch of the MECU was based on the criteria for dispatching the MECU along with an ambulance as seen in table 1. From May 1st 2011 and during the rest of the study period, a criteria-based nationwide Emergency Medical Dispatch (EMD) system was used.[6]

(Table 1 here)

Following each MECU run, patient characteristics (including the patient's Civil Registration System number (or Social Security Number), forming a unique identification of the patient),[7] the tentative patient diagnosis, and the treatment administered, are entered into the MECU database. The physician responsible for the treatment also assesses the immediate outcome of the patient. This assessment is graded into seven categories:

- Patient´s condition improved during treatment

- Patient´s condition significantly improved during treatment
- Patient undergoing life saving procedures
- Patient unchanged
- Patient deteriorating
- Patient dead during treatment
- Others

Design

The study is a retrospective, descriptive study approved by the Danish Data Protection Agency (journal numbers 2010-41-5097 and 2013-41-2439). Within an 80 month period (May 1st 2006 to December 31st 2012), all records at the MECU concerning patients with the outcome “Patient undergoing life-saving procedures” were sought. The medical records and the discharge letters from Odense University Hospital pertaining to these patients were then sought in the hospital’s patient registry database according to the patients´ Civil Registration System number.

All records were thoroughly read by the investigators and an audit was performed in each case to validate the immediate outcome determined by the treating physician. Patients were followed until either discharge to home, discharge to nursing home or death at hospital. On the basis of the information available in the MECU record and the in-hospital medical records and discharge letter, all authors independently agreed on the validity of the claim “Patient undergoing life-saving procedures”.

In case of disagreement, agreement was obtained following closer examination of each case.

In case of missing discharge letter from the hospital, the patient was considered lost-to-follow-up.

In all cases registered as “Patient undergoing life-saving procedures “, the competences required to save the patient´s life was assessed. Upon this assessment it was decided whether the competences required to save the patient lay within the competences of the attending PM or EMT or whether the competences required exceeded the competences of the PM or EMT.

Criteria for denoting a case “Patient undergoing life-saving procedures” within the competences of the physician were:

Explicit criteria:

- Intubation or other airway procedure exceeding the competences of PM or EMTs
- Advanced medical treatment exceeding the competences of PM or EMTs in cardiac arrest and/or defibrillation when indicated by the attending physician.

Implicit criteria:

- Advanced medical treatment exceeding the competences of the attending PM in severe shock states
- Fluid resuscitation exceeding the competences of the EMT or PM in cases of severe hypovolemia

In assessing the criteria and denoting a case “life saving within the competences of an EMT or paramedic” no account was taken whether the interaction saving the patient´s life or preventing death had in fact been carried out by the EMT or PM or an attending physician. If the interaction deemed necessary to save the patient´s life lay within the curriculum of the EMT or PM, the life saving effort was considered within the competences of the EMT or PM. Even if a physician had performed bag-mask ventilation and administrated naloxone to a patient with an opioid overdose, the effort was registered as “life saving within the competences of the EMT or PM” as both of these competences lie within the curriculum of the EMT and PM. Likewise, the administration of oxygen, furosemide, and nitroglycerine in a patient with severe pulmonary edema was considered within the competences of an EMT or PM. Only if intubation or non-invasive ventilation with continuous positive airway pressure had

been applied, the effort was considered “life saving requiring competences exceeding the competences of the EMT or PM.

All data were categorized using Microsoft Office Excel 2007 (Microsoft Corporation, Redmond, Washington, USA).

Statistical methods:

Demographic data are presented as mean and range. All other data were analyzed using non-parametric statistics (Chi-square and Kruskal-Wallis) (IBM SPSS Statistics 22, Armonk, New York, United States). Differences were considered significant when $p<0.05$. Bonferroni´s correction for repeated measurements was performed comparing physician supervised resuscitation with EMT-directed resuscitation and PM-directed resuscitation..

Results

A total of 32,452 runs were recorded for the MECU during the study period. 25,647 (79 %) of these runs resulted in contact with a patient. 701 of these patients were subjected to prehospital “life saving treatment”. In 102 patients the treatment necessary to save the patient’s life was administered within the competences of the attending EMT or PM (typical treatment modalities: mask ventilation followed by injection of naloxone, injection of glucagon or intravenous glucose, administration of defibrillation with return of spontaneous circulation and breathing). Three patients were resuscitated within the competences of lay persons (in all three cases administration of defibrillation using an automatic external defibrillator resulting in return of spontaneous circulation, breathing and return of consciousness). 596 patients were subjected to life saving interventions performed by the attending physician. This difference from the number of patients resuscitated within the competences of the EMT or PM is highly significant ($P<0.001$).

Of the 596 patients subjected to life saving interventions performed by the attending physician, 286 patients (48.0 %) died at the hospital during the admission. Thirty patients were discharged to rehabilitation clinics or other hospitals with major or moderate sequelae, these sequelae consisting primarily of cerebral impairment . Twenty-five patients were discharged with minor sequelae stemming primarily from the musculo-skeletal system requiring occupational therapy. Compared with patients surviving with sequelae, a significant majority - 225 patients in all (37.8 %) - were discharged to their own homes following in-hospital treatment ($P<0.001$). The mean age of patients resuscitated within the competences of an anesthesiologist was 54.3 years (range 0-91). The number of patients suffering minor or moderate sequelae or severe sequelae did not differ ($p=0.39$). No differences in the number of survivors were found comparing each year (data not shown).

(Figures 1-4 near here)

The diagnoses of the patients that were discharged to their own homes following an incident requiring life saving competences exceeding the competences of an attending EMT or PM are shown in table 2.

(Figure 5 near here)

No valid account of the age distribution of patients receiving prehospital life saving treatment within the competences of the EMT or PM can be given. Within this group of patients a large number of drug addicts are found. These patients generally left the scene following successful treatment with naloxone by the EMT or PM and were not always identified.

In all, 17 patients were lost to follow-up. These patients were primarily foreign citizens transferred to hospitals outside of Denmark. Thirteen patients were transferred to other Danish hospitals before the patients´ final outcome could be established.

Discussion

This study demonstrates that the presence of an anaesthesiologist manned mobile emergency care unit results in a large number of patients receiving prehospital life saving treatment exceeding the competences of the EMTs or PMs..

When a traumatized or critically ill patient is brought to the emergency room within the hospital, a specialist is usually called upon to treat the patient. However, the benefit gained by utilizing specialized physicians in the pre-hospital service is still somewhat disputed,[4,5,8-10] and some countries do not offer advanced pre-hospital treatment as performed by physicians but rely on EMTs or PMs with varying competences.[11] However, while PMs possess a considerable number of competences allowing them to treat a variety of conditions, pre-hospital physicians possess some additional critical care competences which are potentially life-saving but are required infrequently and can carry significant risks.[12]

The availability of advanced pre-hospital life support (ALS) and basic life support (BLS) differ between countries - as such rendering comparison difficult. Although endotracheal intubation of patients in cardiac arrest recently has been disputed, [13] ALS however, seems to improve survival in patients with myocardial infarction while BLS may be the proper level of care for patients with penetrating injuries.[8] Papers describing both gains in quality-adjusted life-years as well as increased survival with physician treatment in trauma and, based on more limited evidence, cardiac arrest, have been published.[9,10]

Some studies indicate a beneficial effect of ALS administered by physicians in patients with blunt head trauma.[14-16] All these studies are retrospective in character and further high-quality research in this area would be welcome.[17]

However, pending results from an ongoing randomized study on the effect on an attending physician versus a PM in treating traumatized patients,[18] the best evidence regarding the possible impact of physician assisted pre-hospital treatment comes as yet from retrospective studies.

The concept of advanced pre-hospital treatment should be not attributed to intubation alone, as studies have suggested that advanced life support interventions (e.g. intubation) performed by PMs may have harmful effects compared to in-hospital treatment.[19,20] Apart from intubation, control of end-tidal CO2, and administration of carefully titrated doses of inotropic agents also forms a part of advanced pre-hospital treatment. In sepsis, early administration of antibiotics have proven valuable [21] and there is no reason to believe that timing of therapy does not also apply to the pre-hospital scene.

In the present study, we have found that the presence an anaesthesiologist -staffed MECU significantly improves patients´ survival based on an evaluation of the competences required to resuscitate or prevent a critically ill or injured patients from dying. Few patients recovered with moderate or severe sequelae. Our results are probably generalisable to all of Scandinavia as the level of competence of the EMTs or PMs does not differ markedly in the Scandinavian countries and as all Scandinavian countries provide anaesthesiologist-staffed pre-hospital services.[22] All of these services apply advanced emergency medical procedures in critically ill or injured patients, the lowest incidence of these procedures being exercised in Denmark.[1] Direct comparison between the United States and Europe, however, is difficult, as the prehospital concept differs. In the United States, the primary prehospital resource is an EMT supported by a PM while the general European prehospital resource consist of a P-EMS supporting a general ambulance.

Our primary finding in this retrospective study is that the vast majority of the life saving procedures carried out in the MECU in Odense, Denmark is performed within the competences of the attending anaesthesiologist. Another important finding in this study is the outcome pattern of the patients resuscitated within the competences of the physician: Approximately half of the patients that survive the incident are discharged to their own homes without major or even moderate sequelae. Another half of the patients die at the hospital. Only a minute fraction of patients that survive a critical incident requiring resuscitation by the anaesthesiologist manning the MECU experience sequelae.

The subject of the present study was the life saving interventions. However, the MECU is not only a life saving service. Both supervision of EMTs and PMs and clinical decision-making might add value to the combined emergency system. Moreover, utilizing a physician in the pre-hospital environment may actually enable withholding of futile advanced interventions, such as withholding intubation for ethical reasons in patients where such a treatment could be contra-indicated is probably beneficial for ethical reasons.[23] As such, advanced medical care including ICU admittance might be avoided in futile cases.

Strengths and limitations

Two different criteria systems for dispatch used within the study period. However, the main characteristics of the patient population presumably remained unchanged throughout the study period. Firstly, as the general activity of the MECU was constant throughout the period, and secondly, because the principles applied in the region are that any ambulance meeting demands that cannot be covered by the EMTs manning the ambulance are requested to summon the MECU for help. Any patient requiring advanced medical assistance thus would presumably be seen by the MECU.

The strength of the present study is the sample size and the small number of patients lost to follow-up. All data have been entered by the anaesthesiologist on call immediately following the mission. All missions assigned the outcome “life saving” have been audited by the authors of whom three are independent of the MECU. The validity of data thus is acceptable. Weaknesses of the present study however, are that the study is a retrospective study. In Scandinavia at the present time, it is not feasible to perform a prospective randomized study on the presence of an anesthesiologist at the scene. In this study, no comparison has been made with a period without a MECU. The present private ambulance operator in the area does not carry databases extensive enough to support such a study. Follow-up of patients have been reduced to establishing whether the patient was discharged to his/her own home. The study would have benefitted from assessing the patients using post hoc interviews to evaluate their status. However, given our large material and the time span of the investigation making post hoc interviews difficult, in this study, we assumed that a patient being discharged to his/her own home was a patient with favorable outcome.

An important limitation of the present study is the application of a subjective measure of life saving intervention. This may have given rise to reporting bias as the physician responsible for the mission performed was the one who made the initial assessment of the mission. In our study we have subjected each self-reported case of “life saving mission” to an audit applying both explicit criteria and implicit criteria in order to assess, to what extent any given mission indeed correctly had been determined a life saving mission. Furthermore, the large numbers of missions not classified as life saving missions indicate a reliable reporting culture.

Finally, one might argue that, all therapeutic interventions have been carried out by a specialist in anaesthesiologist at the scene following best standard of care. By definition, the specialist would be deemed negligent if he failed to use his level of

skill, knowledge, and care in diagnosis and treatment of patients. Furthermore, it is impossible to validate the claim “life saving intervention” in a formal way: Should one withhold the intervention, the patient would die if the claim that the life saving intervention was indeed correct.

Conclusion

This retrospective study demonstrates that anesthesiologist administrated therapy increases the level of treatment modalities leading to an increased survival in relation to a prehospital system consisting of emergency medical technicians and paramedics alone without an unacceptably high number of patients suffering severe sequelae. The present study thus lends firm support to the concept of applying specialists in anaesthesiology in the pre-hospital setting.

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Legends to figures:

Figure 1: Flowchart describing the patients

Figure 2: Distribution of patients resuscitated within the competences of emergency medical technician / paramedic, lay person and anaesthesiologist

*P<0.001 (Patients resuscitated within the competences of anaesthesiologists vs. patients resuscitated within the competences of the emergency medical technician/paramedic)

Figure 3: Age distribution of survivors discharged to home following resuscitation by anaesthesiologist

Figure 4: Outcome of patients resuscitated at the scene by anesthesiologists

*P<0.001 (Discharged to home vs. Surviving with minor or moderate to severe sequelae)

Figure 5: Diagnoses in patients discharged to their homes following anesthesiologist supervised resuscitation

Table 1:

MECU Dispatch criteria in parts of the observation period

Ambulance + MECU

Life threatening conditions:

- Sudden loss of consciousness
- Absense of breathing
- Noisy or otherwise impaired breathing
- Possible life threatening conditions:
- Dyspnea
- Severe chest pain
- Sudden onset of serious headache
- Impaired breathing in infants and children
- Suspected serious illness in children or infants
- Sudden onset of severe oral or rectal bleeding
- Sudden onset of bleeding in pregnant women beyond 20th gestational week

Accidents implying a risk of life threatening conditions:

- Motorway accidents
- On highways
- High velocity car crash
- Entrapment
- Roll-over
- Lorry or bus involved
- Motorcycle involved
- Pedestrian against car / motorcycle

Other accidents

- Fall from heights
- Entrapped persons
- Accidents with bleeding victims
- Accidents involving horses
- Gunshot or stab wounds towards torso, neck, head
- Hanging
- Drowning
- Burns involving face or exceeding 20% (adults) or 10% (infants and children) of body surface area
- Accidents involving trains or airplanes

Fire implying a risk of damage to people

Chemical exposure

Competing interests

None of the authors have any competing interests to declare. No external funding was utilized.

Authors' contributions

SM contributed to this manuscript with idea and design as well as acquisition of data, analysis of data and drafting and revising of the manuscript. AJK contributed to this manuscript with idea, design, analysis of data, drafting and revision of the manuscript. STZ contributed to this manuscript with acquisition and analysis of the data, drafting and revising of the manuscript. ACB contributed to this manuscript with idea and design as well as acquisition of data, analysis of data and drafting and revising of the manuscript. All authors read and approved the final manuscript.

Data sharing statement
No additional data available.

Outcome following physician supervised pre-hospital resuscitation: a retrospective study

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Abstract

Background: Pre-hospital care provided by specially trained physicians (P-EMS) is an integrated part of the emergency medical systems in many developed countries. To what extent P-EMS increases survival and favorable outcomes is still unclear. The aim of the study was thus to investigate ambulance runs initially assigned “life-saving missions” with special emphasis on long term outcome in patients treated by the Mobile Emergency Care Unit (MECU) in Odense, Denmark

Methods: All MECU runs are registered in a database by the attending physician, stating, amongst other parameters, the treatment given, outcome of the treatment and the patient´s diagnosis. Over a period of 80 months from May 1st 2006 to December 31st 2012, all missions in which the outcome of the treatment was registered as “life saving” were scrutinized. Initial outcome, level of competence of the caretaker, and diagnosis of each patient were manually established in each case in a combined audit of the pre-hospital database, the discharge summary of the MECU and the medical records from the hospital. Outcome parameters were final outcome, the etiology of the condition leading to a life-threatening situation, and the level of competences necessary to save the life of the patient.

Results: Of 25,647 patients treated by the MECU, 701 were subjected to prehospital “life saving treatment”. In 596 patients the treatment required to save the patient’s life exceeded the competences of the attending emergency medical technician or paramedic. Of these patients, 225 ~~patients were subjected to life saving physician directed medical treatment exceeding the competences of the attending paramedic or Emergency Medical Technician~~ survived and following in-hospital treatment were ~~enabling these patients to be~~ discharged to their own home~~s following a life-threatening event~~.

Conclusions: The present study supports the concept of applying specialists in anaesthesiology in the pre-hospital setting~~This paper demonstrates the beneficial effect of physician administrated pre-hospital treatment in case of life threatening events.~~

Article summary

Strenghts and limitations of this study:

- This study demonstrates that the competences required to perform life saving interventions in a large urban ~~material~~ population to a large extent are competences well outside the competences of an ordinary emergency medical technician or paramedic but inside the curriculum of an attending anaesthesiologist.
- A considerable strength of the present study is the sample size and the small number of patients lost to follow-up.
- This paper demonstrates that the survivors are distributed within two distinct groups: One group containing patients, who, following a life saving intervention are discharged to their own homes in good condition and one group containing patients who, following an initial life saving effort die at the hospital. Only a small amount of patients recover in poor or moderately disabled condition.
- A considerable weakness of the study is that there is no formal validation whether the "life-saving intervention" was truly needed. It is possible that some of the patients would have survived transport to the hospital without intubation and controlled ventilation, without repetitive injections of vasopressors or without removal of foreign bodies in the airways.

Introduction

Physician-based pre-hospital emergency services (P-EMS) are established in many developed countries.[1,2]. The value of such services is debated and is difficult to assess scientifically.[3,4] Although no-one questions the value of physicians inside the hospital, ideally, the value of P-EMS should be addressed based on the context in which the service operates, both demographically, geographically and economically, as it has proven difficult to ascertain a positive relationship between the emergency care providers´ level of competence and the outcome of the patient.[5] In the region of Southern Denmark, the competences of the emergency medical technicians (EMTs) are restricted to inhalational therapy with broncholytics, rectal administration of benzodiazepines, administration of intravenous glucose, intramuscular administration of naloxone, initial treatment of patients with myocardial infarction (thrombolytic agents, opioids, nitroglycerine), intramuscular adrenaline in the treatment of anaphylaxis as well as fluid administration and defibrillation. The competences of the paramedics mainly exceeds those of the EMT in the possibility of intravenous administration of adrenaline and amiodarone in ventricular fibrillation as well as intravenous administration of furosemide. The basic response to a request for prehospital assistance is an ambulance manned with two EMTs. According to the perceived severity of the task presented to the dispatch center, in lesser populated areas of the region, a paramedic is dispatched along with the ambulance in order to supplement the treatment. The 1st of may 2006, a Mobile Emergency care Unit (MECU) was initiated in Odense, Denmark. This~~The Mobile Emergency Care Unit (MECU) in Odense, Denmark,~~ consists of a rapid-response car operating all year round. It is manned with a specialist in Anaesthesiology and an Emergency Medical Technician (EMT). It operates as a part of a two-tiered system, in which the MECU supplements an ordinary ambulance manned with two EMTs.

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Upon inauguration of the MECU in Odense, Denmark in 2006, two questions were posed:

Does the attendance of a specialized physician at the scene make a difference to the patients´ survival compared with the survival procured by the attendingan EMT or paramedic (PM)?

and

Does the a presumed increase in patients resuscitated prehospitally as a result of the presence of a physician manned emergency care unit lead to a large number of resuscitated patients suffering from cerebral sequelae following medically directed resuscitation?

The aims of the present study wereas to investigate these two questions in relation to patients attended to by the MECU in Odense, Denmark, in whom the mission outcome was registered as life saving.

In order to study this subject, in each life saving mission we investigated whether the competences required to resuscitate the patient or prevent the patient from dying fell within the competences of the attending emergency medical technician or PM or whether the competences applied lay within the competences of the attending physician. In each mission, the final outcome of the patient was also sought in order to establish whether the patient's outcome was good, moderate or poor.

Methods

Description of study context

The MECU covers an area of approximately 2.500 square km and serves a population of 250.000 to 400.000 depending on time of day.

In a typical year, the MECU ~~is handling~~handles 4900 calls (13.5 calls per day). Due to apparent overtriage at the dispatch centre, in 13% to 20 % of the calls, the patient can be adequately treated within the competences of the EMT.and the ambulance thus waives the MECU en route following initial contact with the patient. ~~–~~As a result of coincident requests for MECU assistance, 3.2 % to 6.1 % of the requests are left unanswered.

The MECU is dispatched either by the dispatch centre on the basis of the information given by the caller or by request from the EMTs on the primary ambulance. From its inauguration in May 1st 2006 to April 30th 2011, the dispatch of the MECU was based on the criteria for dispatching the MECU along with an ambulance as seen in table 1. From May 1st 2011 and during the rest of the study period, a criteria-based nationwide Emergency Medical Dispatch (EMD) system was used.[6]

(Table 1 here)

Following each MECU run, patient characteristics (including the patient's Civil Registration System number (or Social Security Number), forming a unique identification of the patient),[7] the tentative patient diagnosis, and the treatment administered, are entered into the MECU database. The physician responsible for the treatment also assesses the immediate outcome of the patient. This assessment is graded into seven categories:

- Patient´s condition improved during treatment

- Patient´s condition significantly improved during treatment
- Patient undergoing life saving procedures
- Patient unchanged
- Patient deteriorating
- Patient dead during treatment
- Others

Design

The study is a retrospective, descriptive study approved by the Danish Data Protection Agency (journal numbers 2010-41-5097 and 2013-41-2439). Within an 80 month~~s~~ period (May 1st 2006 to December 31st 2012), all records at the MECU concerning patients with the outcome “Patient undergoing life-saving procedures” were sought. The medical records and the discharge letters from Odense University Hospital pertaining to these patients were then sought in the hospital’s patient registry database according to the patients´ Civil Registration System number.

All records were thoroughly read by the investigators and an audit was performed in each case to validate the immediate outcome determined by the treating physician. Patients were followed until either discharge to home, discharge to nursing home or death at hospital. On the basis of the information available in the MECU record and the in-hospital medical records and discharge letter, all authors independently ~~should~~ agreed on the validity of the claim “Patient undergoing life-saving procedures”.

In case of disagreement, agreement was obtained following closer examination of each case.

In case of missing discharge letter from the hospital, the patient was considered lost-to-follow-up.

In all cases registered as “Patient undergoing life-saving procedures “, the competences required to save the patient´s life was assessed. Upon this assessment it was decided whether the competences required to save the patient lay within the competences of the attending PM or EMT or whether the competences required exceeded the competences of the PM or EMT.

Criteria for denoting a case “Patient undergoing life-saving procedures” within the competences of the physician were:

Explicit criteria:

- Intubation or other airway procedure exceeding the competences of PM or EMTs
- Advanced medical treatment exceeding the competences of PM or EMTs in cardiac arrest and/or defibrillation when indicated by the attending physician.

Implicit criteria:

- Advanced medical treatment exceeding the competences of the attending PM in severe shock states
- Fluid resuscitation exceeding the competences of the EMT or PM in cases of severe hypovolemia

In assessing the criteria and denoting a case “life saving within the competences of an EMT or paramedic” no account was taken whether the interaction saving the patient´s life or preventing death had in fact been carried out by the EMT or PM or an attending physician. If the interaction deemed necessary to save the patient´s life lay within the curriculum of the EMT or PM, the life saving effort was considered within the competences of the EMT or PM. Even if a physician had performed bag-mask ventilation and administrated naloxone to a patient with an opioid overdose, the effort was registered as “life saving within the competences of the EMT or PM” as both of these competences lie within the curriculum of the EMT and PM. Likewise, the administration of oxygen, furosemide, and nitroglycerine in a patient with severe pulmonary edema was considered within the competences of an EMT or PM. Only if intubation or non-invasive ventilation with continuous positive airway pressure had

been applied, the effort was considered “life saving requiring competences exceeding the competences of the EMT or PM.

All data were categorized using Microsoft Office Excel 2007 (Microsoft Corporation, Redmond, Washington, USA).

Statistical methods:

Demographic data are presented as mean and range. All other data were analyzed using non-parametric statistics (Chi-square and Kruskal-Wallis) (IBM SPSS Statistics 22, Armonk, New York, United States). Differences were considered significant when $p<0.05$. Bonferroni´s correction for repeated measurements was performed ~~when pertinent~~comparing physician supervised resuscitation with EMT-directed resuscitation and PM-directed resuscitation..

Results

A total of 32,452 runs were recorded for the MECU during the study period. 25,647 (79 %) of these runs resulted in contact with a patient. 701 of these patients were subjected to prehospital "life saving treatment". In 102 patients the treatment necessary to save the patient's life was administered within the competences of the attending EMT or PM (typical treatment modalities: mask ventilation followed by injection of naloxone, injection of glucagon or intravenous glucose, administration of defibrillation with return of spontaneous circulation and breathing). Three patients were resuscitated within the competences of lay persons (in all three cases administration of defibrillation using an automatic external defibrillator resulting in return of spontaneous circulation, breathing and return of consciousness). 596 patients were subjected to life saving interventions performed by the attending physician. ~~Compared to the number of patients resuscitated within the competences of the EMT or PM, t~~This difference from the number of patients resuscitated within the competences of the EMT or PM is highly significant (P<0.001).

Of the 596 patients subjected to life saving interventions performed by the attending physician, 286 patients (48.0 %) died at the hospital during the admission. Thirty patients were discharged to rehabilitation clinics or other hospitals with major or moderate sequelae, these sequelae consisting primarily of cerebral impairment. Twenty-five patients were discharged with minor sequelae stemming primarily from the musculo-skeletal system requiring occupational therapy. Compared with patients surviving with sequelae, a significant majority - 225 patients in all (37.8 %) - were discharged to their own homes following in-hospital treatment (P<0.001). The mean age of patients resuscitated within the competences of an anesthesiologist was 54.3 years (range 0-91). ~~No difference was observed between~~ The number of patients suffering minor or moderatesequelae or ~~to~~ severe ~~sequelae~~ sequelae did not differ

(p=0.39). No differences in the number of survivors were found comparing each year (data not shown).

(Figures 1-4 near here)

The diagnoses of the patients that were discharged to their own homes following an incident requiring life saving competences exceeding the competences of an attending EMT or PM are shown in table 2.

(~~Table 2~~Figure 5 near here)

No valid account of the age distribution of patients receiving prehospital life saving treatment within the competences of the EMT or PM can be given. Within this group of patients a large number of drug addicts are found. These patients generally left the scene following successful treatment with naloxone by the EMT or PM and were not always identified.

In all, 17 patients were lost to follow-up. These patients were primarily foreign citizens transferred to hospitals outside of Denmark. Thirteen patients were transferred to other Danish hospitals before the patients´ final outcome could be established.

Discussion

This study demonstrates that the presence of an anaesthesiologist manned mobile emergency care unit results in a large number of patients receiving prehospital life saving treatment exceeding the competences of the EMTs or PMs..

When a traumatized or critically ill patient is brought to the emergency room within the hospital, a specialist is usually called upon to treat the patient. However, the benefit gained by utilizing specialized physicians in the pre-hospital service is still somewhat disputed,[4,5,8-10] and some countries do not offer advanced pre-hospital treatment as performed by physicians but rely on EMTs or PMs with varying competences.[11] However, while PMs possess a considerable number of competences allowing them to treat a variety of conditions, pre-hospital physicians possess some additional critical care competences which are potentially life-saving but are required infrequently and can carry significant risks.[12]

The availability of advanced pre-hospital life support (ALS) and basic life support (BLS) differ between countries - as such rendering comparison difficult. Although endotracheal intubation of patients in cardiac arrest recently has been disputed, [13] ALS however, seems to improve survival in patients with myocardial infarction while BLS may be the proper level of care for patients with penetrating injuries.[8] Papers describing both gains in quality-adjusted life-years as well as increased survival with physician treatment in trauma and, based on more limited evidence, cardiac arrest, have been published.[9,10]

Some studies indicate a beneficial effect of ALS administered by physicians in patients with blunt head trauma.[14-16] All these studies are retrospective in character and further high-quality research in this area would be welcome.[17]

However, pending results from an ongoing randomized study on the effect on ~~mortality and morbidity in traumatized patients that~~ an attending physician ~~imposes~~ versus a PM in treating traumatized patients,[18] the best evidence regarding the possible impact of physician assisted pre-hospital treatment comes as yet from retrospective studies.

The concept of advanced pre-hospital treatment should be not attributed to intubation alone, as studies have suggested that advanced life support interventions (e.g. intubation) performed by PMs may have harmful effects compared to in-hospital treatment.[19,20] Apart from intubation, control of end-tidal CO2, and administration of carefully titrated doses of inotropic agents also forms a part of advanced pre-hospital treatment. In sepsis, early administration of antibiotics have proven valuable [21] and there is no reason to believe that timing of therapy does not also apply to the pre-hospital scene.

In the present study, we have found that the presence an anaesthesiologist -staffed MECU significantly improves patients´ survival based on an evaluation of the competences required to resuscitate or prevent a critically ill or injured patients from dying. Few patients recovered with moderate or severe sequelae. Our results are probably generalisable to all of Scandinavia as the level of competence of the EMTs or PMs does not differ markedly in the Scandinavian countries and as all Scandinavian countries provide anaesthesiologist-staffed pre-hospital services.[22] All of these services apply advanced emergency medical procedures in critically ill or injured patients, the lowest incidence of these procedures being exercised in Denmark.[1] Direct comparison between the United States and Europe, however, is difficult, as the prehospital concept differs. In the United States, the primary prehospital resource is an EMT supported by a PM while the general European prehospital resource consist of a P-EMS supporting a general ambulance.

Our primary finding in this retrospective study is that the vast majority of the life saving procedures carried out in the MECU in Odense, Denmark is performed within the competences of the attending anaesthesiologist. Another important finding in this study is the outcome pattern of the patients resuscitated within the competences of the physician: Approximately half of the patients that survive the incident are discharged to their own homes without major or even moderate sequelae. Another half of the patients die at the hospital. Only a minute fraction of patients that survive a critical incident requiring resuscitation by the anaesthesiologist manning the MECU experience sequelae.

The subject of the present study was the life saving interventions. However, the MECU is not only a life saving service. Both supervision of EMTs and PMs and clinical decision-making might add value to the combined emergency system. Moreover, utilizing a physician in the pre-hospital environment may actually enable withholding of futile advanced interventions, such as withholding intubation for ethical reasons in patients where such a treatment could be contra-indicated is probably beneficial for ethical reasons.[23] As such, advanced medical care including ICU admittance might be avoided in futile cases.

Strengths and limitations

Two different criteria systems for dispatch used within the study period. However, the main characteristics of the patient population presumably remained unchanged throughout the study period. Firstly, as the general activity of the MECU was constant throughout the period, and secondly, because the principles applied in the region are that any ambulance meeting demands that cannot be covered by the EMTs manning the ambulance are requested to summon the MECU for help. Any patient requiring advanced medical assistance thus would presumably be seen by the MECU.

The strength of the present study is the sample size and the small number of patients lost to follow-up. All data have been entered by the anaesthesiologist on call immediately following the mission. All missions assigned the outcome “life saving” have been audited by the authors of whom three are independent of the MECU. The validity of data thus is acceptable. Weaknesses of the present study however, are that the study is a retrospective study. In Scandinavia at the present time, it is not feasible to perform a prospective randomized study on the presence of an anesthesiologist at the scene. In this study, no comparison has been made with a period without a MECU. The present private ambulance operator in the area does not carry databases extensive enough to support such a study. Follow-up of patients have been reduced to establishing whether the patient was discharged to his/her own home. The study would have benefitted from assessing the patients using post hoc interviews to evaluate their status. However, given our large material and the time span of the investigation making post hoc interviews difficult, in this study, we assumed that a patient being discharged to his/her own home was a patient with favorable outcome.

An important limitation of the present study is the application of a subjective measure of life saving intervention. This may have given rise to reporting bias as the physician responsible for the mission performed was the one who made the initial assessment of the mission. ~~However,~~ ~~in~~ In our study we have subjected each self-reported case of “life saving mission” to an audit applying both explicit criteria and implicit criteria in order to assess, to what extent any given mission indeed correctly had been determined a life saving mission. Furthermore, the large numbers of missions not classified as life saving missions indicate a reliable reporting culture.

Finally, one might argue that ~~However~~, all therapeutic interventions have been carried out by a specialist in anaesthesiologist at the scene following best standard of care. By definition, the specialist would be deemed negligent if he failed to use his

level of skill, knowledge, and care in diagnosis and treatment of patients. Furthermore, it is impossible to validate the claim “life saving intervention” in a formal way: Should one withhold the intervention, the patient would die if the claim that the life saving intervention was indeed correct.

Conclusion

This retrospective study demonstrates that anesthesiologist administrated therapy increases the level of treatment modalities leading to an increased survival in relation to a prehospital system consisting of emergency medical technicians and paramedics alone without an unacceptably high number of patients suffering severe sequelae. The present study thus lends firm support to the concept of applying specialists in anaesthesiology in the pre-hospital setting.

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Legends to figures:

~~Table 1: MECU Dispatch criteria in parts of the observation period~~

~~Table 2: Diagnoses in patients discharged to their homes following anesthesiologist supervised resuscitation~~

Figure 1: Flowchart describing the patients

Figure 2: Distribution of patients resuscitated within the competences of emergency medical technician / paramedic, lay person and anaesthesiologist

*P<0.001 (Patients resuscitated within the competences of anaesthesiologists vs. patients resuscitated within the competences of the emergency medical technician/paramedic)

Figure 3: Age distribution of survivors discharged to home following resuscitation by anaesthesiologist

Figure 4: Outcome of patients resuscitated at the scene by anesthesiologists

*P<0.001 (Discharged to home vs. Surviving with minor or moderate to severe sequelae)

Figure 5: Diagnoses in patients discharged to their homes following anesthesiologist supervised resuscitation

Table 1:

MECU Dispatch criteria in parts of the observation period

Ambulance + MECU

Life threatening conditions:

- Sudden loss of consciousness
- Absense of breathing
- Noisy or otherwise impaired breathing
- Possible life threatening conditions:
- Dyspnea
- Severe chest pain
- Sudden onset of serious headache
- Impaired breathing in infants and children
- Suspected serious illness in children or infants
- Sudden onset of severe oral or rectal bleeding
- Sudden onset of bleeding in pregnant women beyond 20th gestational week

Accidents implying a risk of life threatening conditions:

- Motorway accidents
- On highways
- High velocity car crash
- Entrapment
- Roll-over
- Lorry or bus involved
- Motorcycle involved
- Pedestrian against car / motorcycle

Other accidents

- Fall from heights
- Entrapped persons
- Accidents with bleeding victims
- Accidents involving horses
- Gunshot or stab wounds towards torso, neck, head
- Hanging
- Drowning
- Burns involving face or exceeding 20% (adults) or 10% (infants and children) of body surface area
- Accidents involving trains or airplanes

Fire implying a risk of damage to people

Chemical exposure

~~Table 2~~

~~Diagnoses in patients discharged to their homes following anesthesiologist supervised resuscitation~~
~~Cardiac arrest~~
~~Respiratory insufficiency~~
~~Trauma~~
~~CNS pathology~~
~~Circulatory failure~~
~~Obstructed airway~~
~~Poisoning, other~~
~~Septicemia~~
~~Hypovolemia~~
~~Pulmonary edema~~
~~Drowning~~
~~Anaphylactic shock~~
~~Poisoning, opioids~~
~~Hypoglycemia~~
~~Unknown diagnosis (transferred to other hospital before a diagnosis was established)~~

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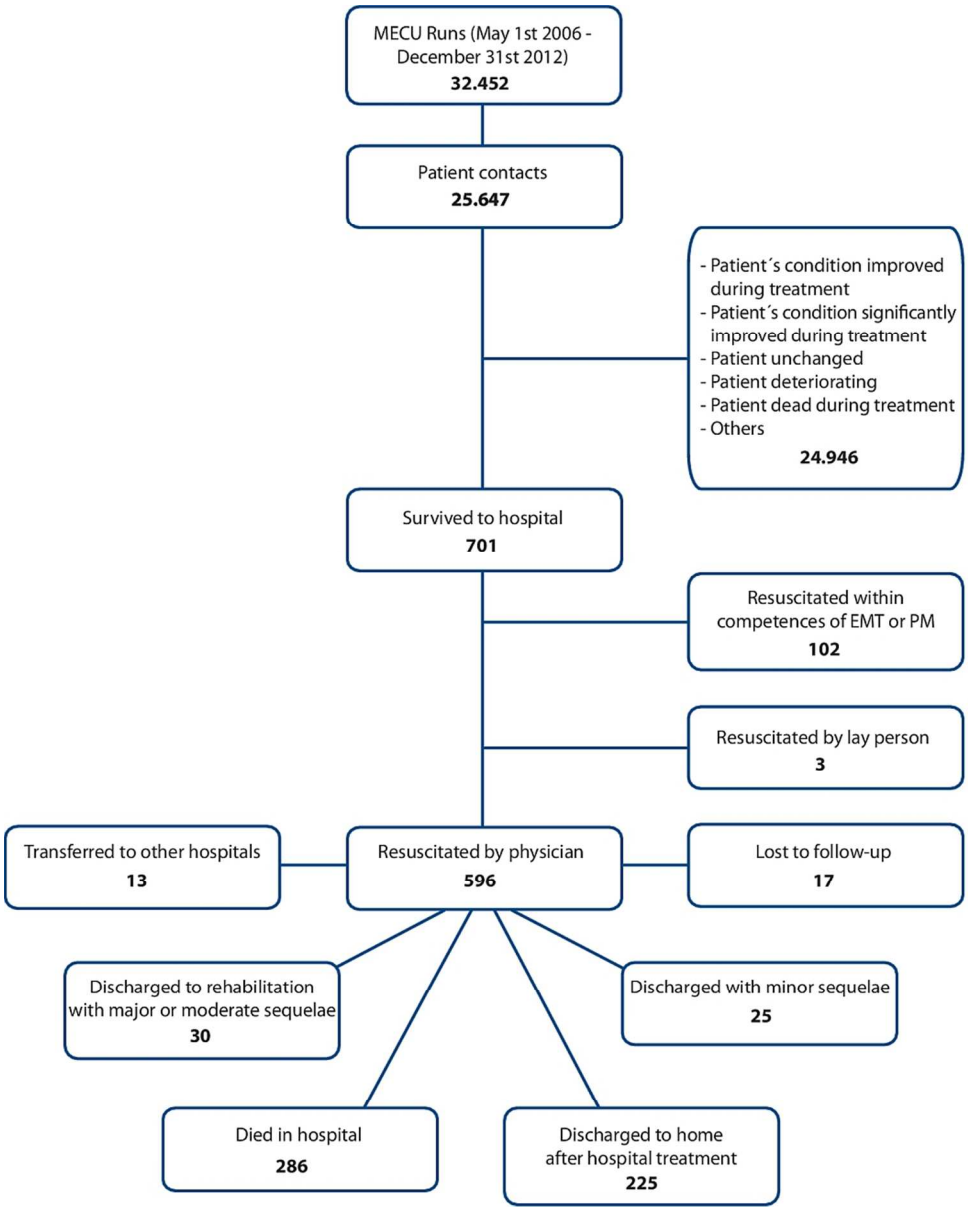
Competing interests

None of the authors have any competing interests to declare. No external funding was utilized.

Authors' contributions

SM contributed to this manuscript with idea and design as well as acquisition of data, analysis of data and drafting and revising of the manuscript. AJK contributed to this manuscript with idea, design, analysis of data, drafting and revision of the manuscript. STZ contributed to this manuscript with acquisition and analysis of the data, drafting and revising of the manuscript. ACB contributed to this manuscript with idea and design as well as acquisition of data, analysis of data and drafting and revising of the manuscript. All authors read and approved the final manuscript.

Data sharing statement
No additional data available.



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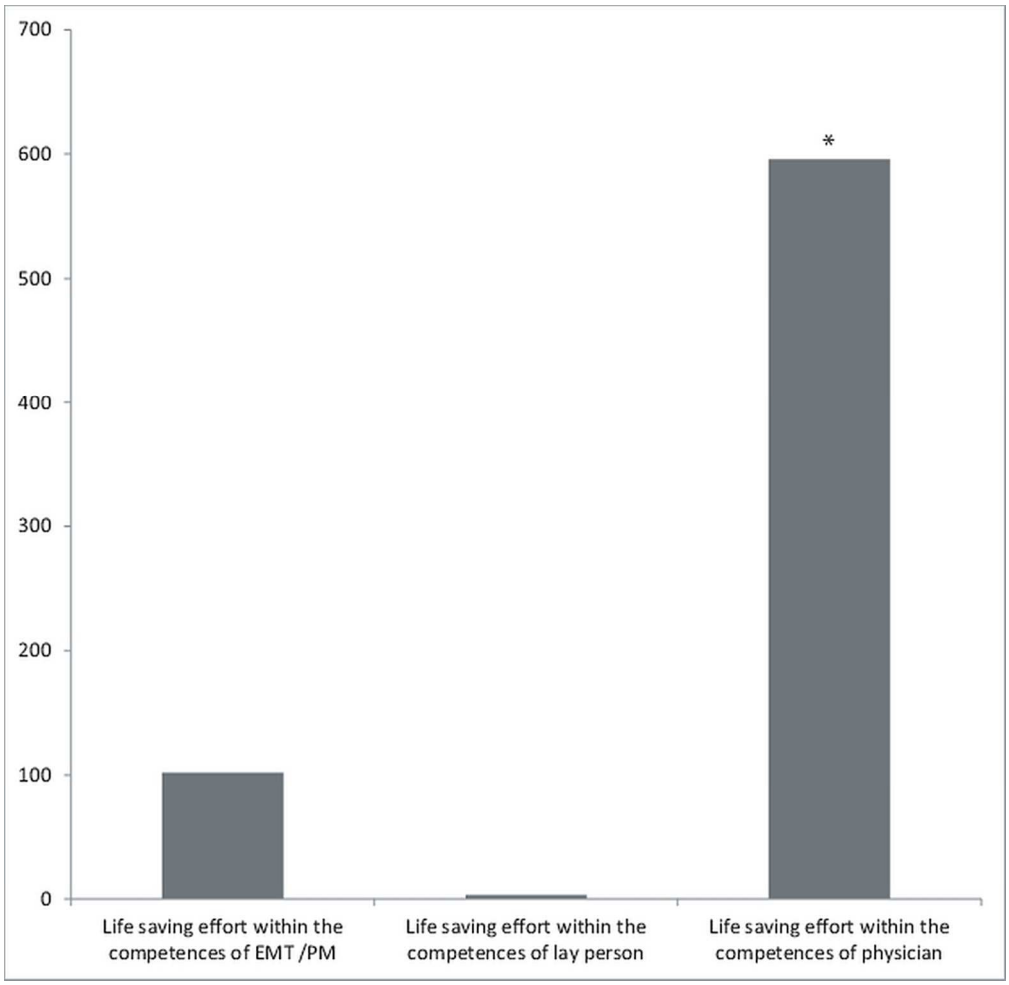

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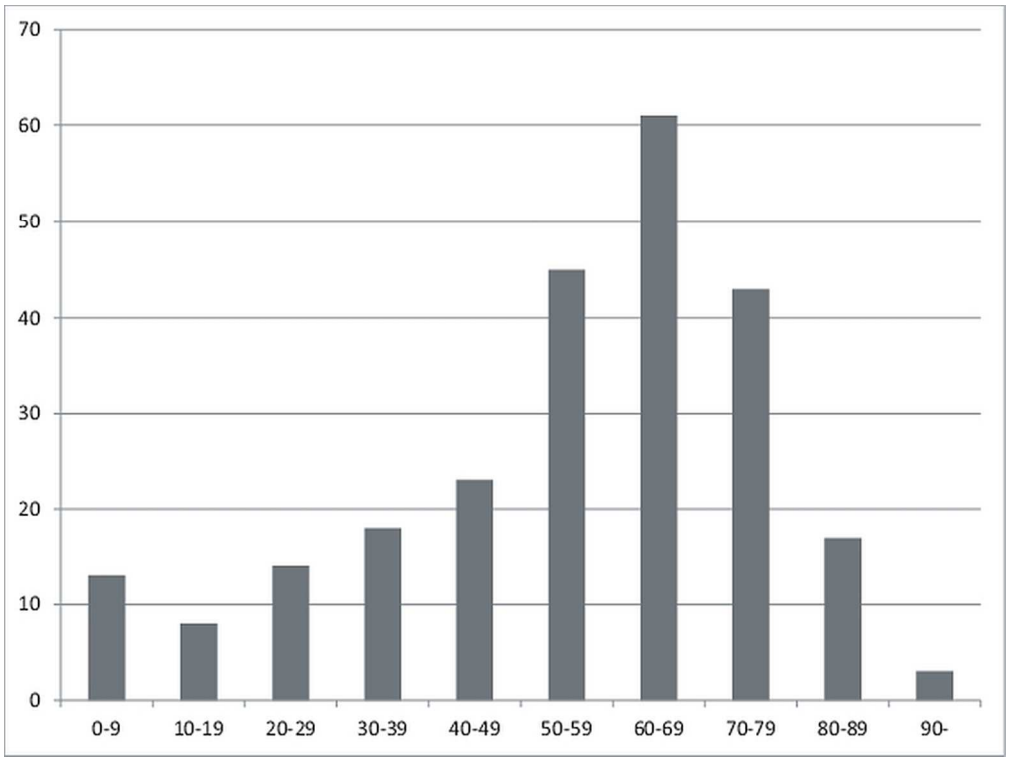

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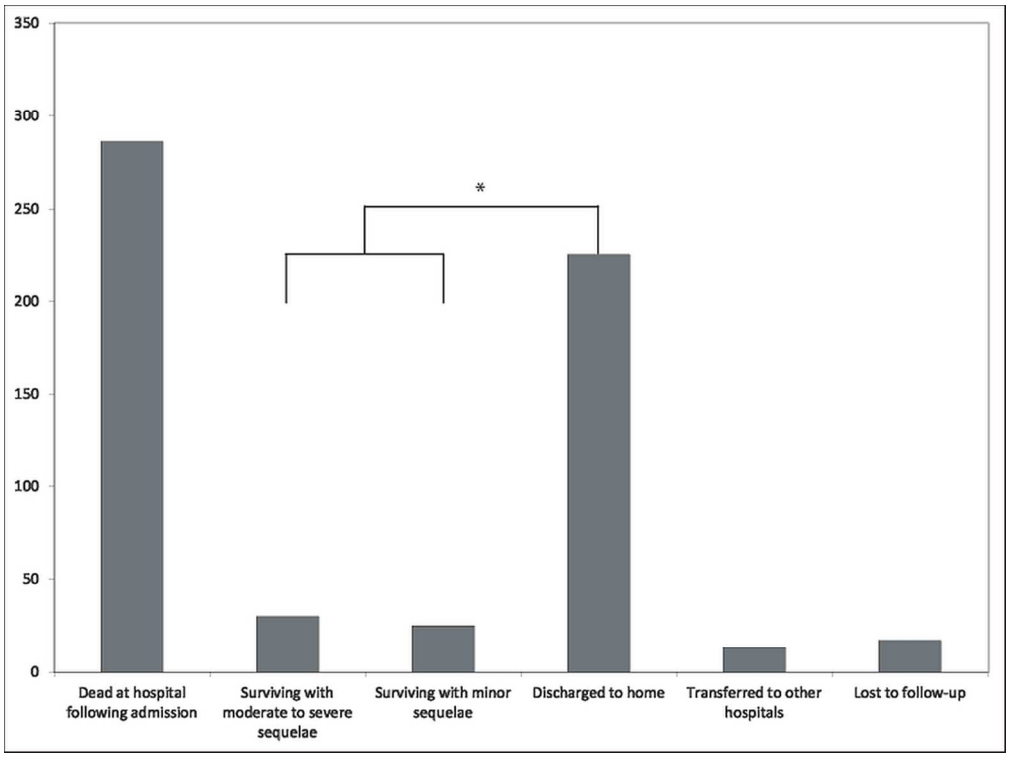

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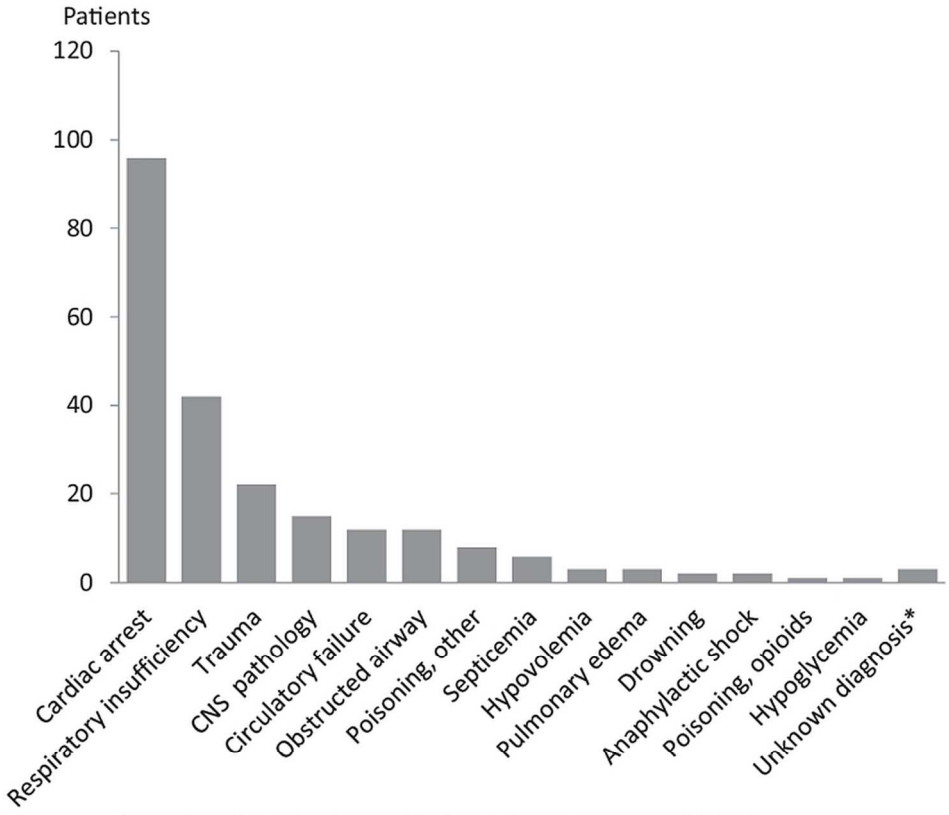

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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1b	2
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5	6,7,8
6a	6,7
6b	Not relevant
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10	8
11	8,9,10
12a	10
12b	Not relevant
12c	9
12d	Not relevant
12e	Not relevant
13a	11
13b	Not relevant
13c	Fig. 1
14a	Fig. 2
14b	Table 2
14c	8
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16a, b, c	Not relevant
17	Not relevant
18	17
19	15,16
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Outcome following physician supervised pre-hospital resuscitation: a retrospective study

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Outcome following physician supervised pre-hospital resuscitation: a retrospective study

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Abstract

Background: Pre-hospital care provided by specially trained physicians (P-EMS) is an integrated part of the emergency medical systems in many developed countries. To what extent P-EMS increases survival and favorable outcomes is still unclear. The aim of the study was thus to investigate ambulance runs initially assigned “life-saving missions” with emphasis on long term outcome in patients treated by the Mobile Emergency Care Unit (MECU) in Odense, Denmark

Methods: All MECU runs are registered in a database by the attending physician, stating, amongst other parameters, the treatment given, outcome of the treatment and the patient´s diagnosis. Over a period of 80 months from May 1st 2006 to December 31st 2012, all missions in which the outcome of the treatment was registered as “life saving” were scrutinized. Initial outcome, level of competence of the caretaker, and diagnosis of each patient were manually established in each case in a combined audit of the pre-hospital database, the discharge summary of the MECU and the medical records from the hospital. Outcome parameters were final outcome, the etiology of the life-threatening condition , and the level of competences necessary to treat the patient.

Results: Of 25,647 patients treated by the MECU, 701 (2.7 %) received prehospital “life saving treatment”. In 596 (2.3%) patients this treatment exceeded the competences of the attending emergency medical technician or paramedic. Of these patients, 225 (0.9%) were ultimately discharged to their own home.

Conclusions: The present study demonstrates that anesthesiologist administrated prehospital therapy increases the level of treatment modalities leading to an increased survival in relation to a prehospital system consisting of emergency medical technicians and paramedics alone and thus supports the concept of applying

specialists in anaesthesiology in the pre-hospital setting especially when treating patients with cardiac arrest, patients in need of respiratory support and trauma patients.

Article summary

Strenghts and limitations of this study:

- This study demonstrates that the competences required to perform life saving interventions in a large urban population to a large extent are competences outside the competences of an ordinary emergency medical technician or paramedic but inside the curriculum of an attending anaesthesiologist.
- A considerable strength of the present study is the sample size and the small number of patients lost to follow-up.
- This paper demonstrates that the survivors are distributed within two distinct groups: One group containing patients, who, following a life saving intervention are discharged to their own homes in good condition and one group containing patients who, following an initial life saving effort die at the hospital. Only a small amount of patients recover in poor or moderately disabled condition.
- A considerable weakness of the study is that there is no formal validation whether the "life-saving intervention" was truly needed. It is possible that some of the patients would have survived transport to the hospital without intubation and controlled ventilation, without repetitive injections of vasopressors or without removal of foreign bodies in the airways.

Introduction

Physician-based pre-hospital emergency services (P-EMS) are established in many developed countries.[1,2]. The value of such services is debated and is difficult to assess scientifically.[3,4] Although no-one questions the value of physicians inside the hospital, ideally, the value of P-EMS should be addressed based on the context in which the service operates, both demographically, geographically and economically, as it has proven difficult to ascertain a positive relationship between the emergency care providers´ level of competence and the outcome of the patient.[5] In the region of Southern Denmark, the competences of the emergency medical technicians (EMTs) are restricted to inhalational therapy with broncholytics, rectal administration of benzodiazepines, administration of intravenous glucose, intramuscular administration of naloxone, initial treatment of patients with myocardial infarction (thrombolytic agents, opioids, nitroglycerine), intramuscular adrenaline in the treatment of anaphylaxis as well as fluid administration and defibrillation. The competences of the paramedics (PM) mainly exceeds those of the EMT in the possibility of intravenous administration of adrenaline and amiodarone in ventricular fibrillation as well as intravenous administration of furosemide. The basic response to a request for prehospital assistance is an ambulance manned with two EMTs. According to the perceived severity of the task presented to the dispatch center, in lesser populated areas of the region, a paramedic is dispatched along with the ambulance in order to supplement the treatment. On the 1st of may 2006, a Mobile Emergency care Unit (MECU) was initiated in Odense, Denmark. This consists of a rapid-response car operating all year round. It is manned with a physician specialist in Anaesthesiology and an Emergency Medical Technician (EMT). It operates as a part of a two-tiered system, in which the MECU supplements an ordinary ambulance manned with two EMTs.

Upon inauguration of the MECU in Odense, Denmark in 2006, two questions were posed:

Does the attendance of a specialized physician at the scene make a difference to the patients´ survival compared with the survival procured by the attending EMT or PM?

and

Does a presumed increase in patients resuscitated prehospitally as a result of the presence of a physician manned emergency care unit lead to a large number of resuscitated patients suffering from cerebral sequelae?

The aims of the present study were to investigate these two questions in relation to patients attended to by the MECU in Odense, Denmark, in whom the mission outcome was registered as life saving.

In order to study this subject, in each life saving mission we investigated whether the competences required to resuscitate the patient or prevent the patient from dying fell within the competences of the attending EMT or PM or whether the competences applied lay within the competences of the attending physician. In each mission, the final outcome of the patient was also sought in order to establish whether the patient's outcome was good, moderate or poor.

Methods

Description of study context

The MECU covers an area of approximately 2.500 square km and serves a population of 250.000 to 400.000 depending on time of day.

In a typical year, the MECU handles 4900 calls (13.5 calls per day). Due to apparent overtriage at the dispatch centre, in 13% to 20 % of the calls, the patient can be adequately treated within the competences of the EMT.and the ambulance thus waives the MECU en route following initial contact with the patient. As a result of coincident requests for MECU assistance, 3.2 % to 6.1 % of the requests are left unanswered.

The MECU is dispatched either by the dispatch centre on the basis of the information given by the caller or by request from the EMTs on the primary ambulance. From its inauguration in May 1st 2006 to April 30th 2011, the dispatch of the MECU was based on the criteria for dispatching the MECU along with an ambulance as seen in table 1. From May 1st 2011 and during the rest of the study period, a criteria-based nationwide Emergency Medical Dispatch (EMD) system was used.[6]

(Table 1 here)

Following each MECU run, patient characteristics (including the patient's Civil Registration System number (or Social Security Number), forming a unique identification of the patient),[7] the tentative patient diagnosis, and the treatment administered, are entered into the MECU database. The physician responsible for the treatment also assesses the immediate prehospital outcome of the patient. This assessment is graded into seven categories:

- Patient´s condition improved during treatment

- Patient´s condition significantly improved during treatment
- Patient undergoing life saving procedures
- Patient unchanged
- Patient deteriorating
- Patient dead during treatment
- Others

Design

The study is a retrospective, descriptive study approved by the Danish Data Protection Agency (journal numbers 2010-41-5097 and 2013-41-2439). Within an 80 month period (May 1st 2006 to December 31st 2012), all records at the MECU concerning patients with the outcome “Patient undergoing life-saving procedures” were sought. The medical records and the discharge letters from Odense University Hospital pertaining to these patients were then sought in the hospital’s patient registry database according to the patients´ Civil Registration System number.

All records were thoroughly read by the investigators and an audit was performed in each case to validate the immediate prehospital outcome determined by the treating physician. Patients were followed until either discharge to home, discharge to nursing home or death at hospital. On the basis of the information available in the MECU record and the in-hospital medical records and discharge letter, all authors independently agreed on the validity of the claim “Patient undergoing life-saving procedures”.

In case of disagreement, agreement was obtained following closer examination of each case.

In case of missing discharge letter from the hospital, or transfer to another hospital the patient was considered lost-to-follow-up.

In all cases registered as “Patient undergoing life-saving procedures “, the competences required to save the patient´s life was assessed by the authors. Upon this assessment it was decided whether the competences required to save the patient lay within the competences of the attending PM or EMT or whether the competences required exceeded the competences of the PM or EMT.

Criteria for denoting a case “Patient undergoing life-saving procedures” within the competences of the physician were:

Explicit criteria:

- Intubation or other airway procedure exceeding the competences of PM or EMTs
- Advanced medical treatment exceeding the competences of PM or EMTs in cardiac arrest and/or defibrillation when indicated by the attending physician.

Implicit criteria:

- Advanced medical treatment exceeding the competences of the attending PM in severe shock states
- Fluid resuscitation exceeding the competences of the EMT or PM in cases of severe hypovolemia

In assessing the criteria and denoting a case “life saving within the competences of an EMT or paramedic” no account was taken whether the interaction saving the patient´s life or preventing death had in fact been carried out by the EMT or PM or an attending physician. If the interaction deemed necessary to save the patient´s life lay within the curriculum of the EMT or PM, the life saving effort was considered within the competences of the EMT or PM. Even if a physician had performed bag-mask ventilation and administrated naloxone to a patient with an opioid overdose, the effort was registered as “life saving within the competences of the EMT or PM” as both of these competences lie within the curriculum of the EMT and PM. Likewise, the administration of oxygen, furosemide, and nitroglycerine in a patient with severe pulmonary edema was considered within the competences of an EMT or PM. Only if intubation or non-invasive ventilation with continuous positive airway pressure had

been applied, the effort was considered “life saving requiring competences exceeding the competences of the EMT or PM.

All data were categorized using Microsoft Office Excel 2007 (Microsoft Corporation, Redmond, Washington, USA).

Statistical methods:

Demographic data are presented as mean and range. All other data were analyzed using non-parametric statistics (Chi-square and Kruskal-Wallis) (IBM SPSS Statistics 22, Armonk, New York, United States). Differences were considered significant when $p<0.05$. Bonferroni´s correction for repeated measurements was performed comparing physician supervised resuscitation with EMT-directed resuscitation and PM-directed resuscitation..

Results

A total of 32,452 runs were recorded for the MECU during the study period. 25,647 (79 %) of these runs resulted in contact with a patient. 701 of these patients received prehospital “life saving treatment”. In 102 patients the treatment necessary to save the patient’s life was administered within the competences of the attending EMT or PM (typical treatment modalities: mask ventilation followed by injection of naloxone, injection of glucagon or intravenous glucose, administration of defibrillation with return of spontaneous circulation and breathing). Three patients were resuscitated within the competences of lay persons (in all three cases administration of defibrillation using an automatic external defibrillator resulting in return of spontaneous circulation, breathing and return of consciousness). 596 patients were subjected to life saving interventions performed by the attending physician. This difference from the number of patients resuscitated within the competences of the EMT or PM is highly significant (P<0.001).

Of the 596 patients subjected to life saving interventions performed by the attending physician, 286 patients (48.0 %) died at the hospital during the admission. Thirty patients were discharged to rehabilitation clinics or other hospitals with major or moderate sequelae, these sequelae consisting primarily of cerebral impairment . Twenty-five patients were discharged with minor sequelae stemming primarily from the musculo-skeletal system requiring occupational therapy. Compared with patients surviving with sequelae, a significant majority - 225 patients in all (37.8 %) - were discharged to their own homes following in-hospital treatment (P<0.001). The mean age of patients resuscitated within the competences of an anesthesiologist was 54.3 years (range 0-91). The number of patients suffering minor or moderate sequelae or severe sequelae did not differ (p=0.39). No differences in the number of survivors were found comparing each year (data not shown).

(Figures 1-4 near here)

The diagnoses of the patients that were discharged to their own homes following an incident requiring life saving competences exceeding the competences of an attending EMT or PM are shown in figure 5.

(Figure 5 near here)

No valid account of the age distribution of patients receiving prehospital life saving treatment within the competences of the EMT or PM can be given. Within this group of patients a large number of drug addicts are found. These patients generally left the scene following successful treatment with naloxone by the EMT or PM and were not always identified.

In all, 17 patients were lost to follow-up. These patients were primarily foreign citizens transferred to hospitals outside of Denmark. Thirteen patients were transferred to other Danish hospitals before the patients´ final outcome could be established.

Discussion

This study demonstrates that the presence of an anaesthesiologist manned mobile emergency care unit results in a large number of patients receiving prehospital life saving treatment exceeding the competences of the EMTs or PMs..

When a traumatized or critically ill patient is brought to the emergency room within the hospital, a specialist is usually called upon to treat the patient. However, the benefit gained by utilizing specialized physicians in the pre-hospital service is still somewhat disputed,[4,5,8-10] and some countries do not offer advanced pre-hospital treatment as performed by physicians but rely on EMTs or PMs with varying competences.[11] However, while PMs possess a considerable number of competences allowing them to treat a variety of conditions, pre-hospital physicians possess some additional critical care competences which are potentially life-saving but are required infrequently and can carry significant risks.[12]

The availability of advanced pre-hospital life support (ALS) and basic life support (BLS) differ between countries - as such rendering comparison difficult. Although endotracheal intubation of patients in cardiac arrest recently has been disputed, [13] ALS however, seems to improve survival in patients with myocardial infarction while BLS may be the proper level of care for patients with penetrating injuries.[8] Papers describing both gains in quality-adjusted life-years as well as increased survival with physician treatment in trauma and, based on more limited evidence, cardiac arrest, have been published.[9,10]

Some studies indicate a beneficial effect of ALS administered by physicians in patients with blunt head trauma.[14-16] All these studies are retrospective in character and further high-quality research in this area would be welcome.[17]

However, pending results from an ongoing randomized study on the effect on an attending physician versus a PM in treating traumatized patients,[18] the best evidence regarding the possible impact of physician assisted pre-hospital treatment comes as yet from retrospective studies.

The concept of advanced pre-hospital treatment should be not attributed to intubation alone, as studies have suggested that advanced life support interventions (e.g. intubation) performed by PMs may have harmful effects compared to in-hospital treatment.[19,20] Apart from intubation, control of end-tidal CO2, and administration of carefully titrated doses of inotropic agents also forms a part of advanced pre-hospital treatment. In sepsis, early administration of antibiotics have proven valuable [21] and there is no reason to believe that timing of therapy does not also apply to the pre-hospital scene.

In the present study, we have found that the presence an anaesthesiologist -staffed MECU significantly improves patients´ survival based on an evaluation of the competences required to resuscitate or prevent a critically ill or injured patients from dying. Few patients recovered with moderate or severe sequelae. Our results are probably generalisable to all of Scandinavia as the level of competence of the EMTs or PMs does not differ markedly in the Scandinavian countries and as all Scandinavian countries provide anaesthesiologist-staffed pre-hospital services.[22] All of these services apply advanced emergency medical procedures in critically ill or injured patients, the lowest incidence of these procedures being exercised in Denmark.[1] Direct comparison between the United States and Europe, however, is difficult, as the prehospital concept differs. In the United States, the primary prehospital resource is an EMT supported by a PM while the general European prehospital resource consist of a P-EMS supporting a general ambulance.

Our primary finding in this retrospective study is that the vast majority of the life saving procedures carried out in the MECU in Odense, Denmark is performed within the competences of the attending anaesthesiologist. Another important finding in this study is the outcome pattern of the patients resuscitated within the competences of the physician: Approximately half of the patients that survive the incident are discharged to their own homes without major or even moderate sequelae. Another half of the patients die at the hospital. Only a minute fraction of patients that survive a critical incident requiring resuscitation by the anaesthesiologist manning the MECU experience sequelae.

The subject of the present study was the life saving interventions. However, the MECU is not only a life saving service. Both supervision of EMTs and PMs and clinical decision-making might add value to the combined emergency system. Moreover, utilizing a physician in the pre-hospital environment may actually enable withholding of futile advanced interventions, such as withholding intubation for ethical reasons in patients where such a treatment could be contra-indicated is probably beneficial for ethical reasons.[23] As such, advanced medical care including ICU admittance might be avoided in futile cases.

Strengths and limitations

Two different criteria systems for dispatch used within the study period. However, the main characteristics of the patient population presumably remained unchanged throughout the study period. Firstly, as the general activity of the MECU was constant throughout the period, and secondly, because the principles applied in the region are that any ambulance meeting demands that cannot be covered by the EMTs manning the ambulance are requested to summon the MECU for help. Any patient requiring advanced medical assistance thus would presumably be seen by the MECU.

The strength of the present study is the sample size and the small number of patients lost to follow-up. All data have been entered by the anaesthesiologist on call immediately following the mission. All missions assigned the outcome “life saving” have been audited by the authors of whom three are independent of the MECU. The validity of data thus is acceptable. Weaknesses of the present study however, are that the study is a retrospective study. In Scandinavia at the present time, it is not feasible to perform a prospective randomized study on the presence of an anesthesiologist at the scene. In this study, no comparison has been made with a period without a MECU. The present private ambulance operator in the area does not carry databases extensive enough to support such a study. Follow-up of patients have been reduced to establishing whether the patient was discharged to his/her own home. The study would have benefitted from assessing the patients using post hoc interviews to evaluate their status. However, given our large material and the time span of the investigation making post hoc interviews difficult, in this study, we assumed that a patient being discharged to his/her own home was a patient with favorable outcome.

An important limitation of the present study is the application of a subjective measure of life saving intervention. This may have given rise to reporting bias as the physician responsible for the mission performed was the one who made the initial assessment of the mission. In our study we have subjected each self-reported case of “life saving mission” to an audit applying both explicit criteria and implicit criteria in order to assess, to what extent any given mission indeed correctly had been determined a life saving mission. Furthermore, the large numbers of missions not classified as life saving missions indicate a reliable reporting culture.

Finally, one might argue that, all therapeutic interventions have been carried out by a specialist in anaesthesiologist at the scene following best standard of care. By definition, the specialist would be deemed negligent if he failed to use his level of

skill, knowledge, and care in diagnosis and treatment of patients. Furthermore, it is impossible to validate the claim “life saving intervention” in a formal way: Should one withhold the intervention, the patient would die if the claim that the life saving intervention was indeed correct.

Conclusion

This retrospective study demonstrates that anesthesiologist administrated therapy increases the level of treatment modalities leading to an increased survival in relation to a prehospital system consisting of emergency medical technicians and paramedics alone without an unacceptably high number of patients suffering severe sequelae. The present study thus lends firm support to the concept of applying physician specialists in anaesthesiology in the pre-hospital setting.

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Legends to figures:

Figure 1: Flowchart describing the patients

Figure 2: Distribution of patients resuscitated within the competences of emergency medical technician / paramedic, lay person and anaesthesiologist

*P<0.001 (Patients resuscitated within the competences of anaesthesiologists vs. patients resuscitated within the competences of the emergency medical technician/paramedic)

Figure 3: Age distribution of survivors discharged to home following resuscitation by anaesthesiologist

Figure 4: Outcome of patients resuscitated at the scene by anesthesiologists

*P<0.001 (Discharged to home vs. Surviving with minor or moderate to severe sequelae)

Figure 5: Diagnoses in patients discharged to their homes following anesthesiologist supervised resuscitation

Table 1:

MECU Dispatch criteria in parts of the observation period

Ambulance + MECU

Life threatening conditions:

- Sudden loss of consciousness
- Absense of breathing
- Noisy or otherwise impaired breathing
- Possible life threatening conditions:
- Dyspnea
- Severe chest pain
- Sudden onset of serious headache
- Impaired breathing in infants and children
- Suspected serious illness in children or infants
- Sudden onset of severe oral or rectal bleeding
- Sudden onset of bleeding in pregnant women beyond 20th gestational week

Accidents implying a risk of life threatening conditions:

- Motorway accidents
- On highways
- High velocity car crash
- Entrapment
- Roll-over
- Lorry or bus involved
- Motorcycle involved
- Pedestrian against car / motorcycle

Other accidents

- Fall from heights
- Entrapped persons
- Accidents with bleeding victims
- Accidents involving horses
- Gunshot or stab wounds towards torso, neck, head
- Hanging
- Drowning
- Burns involving face or exceeding 20% (adults) or 10% (infants and children) of body surface area
- Accidents involving trains or airplanes

Fire implying a risk of damage to people

Chemical exposure

Competing interests

None of the authors have any competing interests to declare. No external funding was utilized.

Authors' contributions

SM contributed to this manuscript with idea and design as well as acquisition of data, analysis of data and drafting and revising of the manuscript. AJK contributed to this manuscript with idea, design, analysis of data, drafting and revision of the manuscript. STZ contributed to this manuscript with acquisition and analysis of the data, drafting and revising of the manuscript. ACB contributed to this manuscript with idea and design as well as acquisition of data, analysis of data and drafting and revising of the manuscript. All authors read and approved the final manuscript.

Data sharing statement
No additional data available.

Outcome following physician supervised pre-hospital resuscitation: a retrospective study

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Abstract

Background: Pre-hospital care provided by specially trained physicians (P-EMS) is an integrated part of the emergency medical systems in many developed countries. To what extent P-EMS increases survival and favorable outcomes is still unclear. The aim of the study was thus to investigate ambulance runs initially assigned "life-saving missions" with ~~special~~ emphasis on long term outcome in patients treated by the Mobile Emergency Care Unit (MECU) in Odense, Denmark

Methods: All MECU runs are registered in a database by the attending physician, stating, amongst other parameters, the treatment given, outcome of the treatment and the patient´s diagnosis. Over a period of 80 months from May 1st 2006 to December 31st 2012, all missions in which the outcome of the treatment was registered as "life saving" were scrutinized. Initial outcome, level of competence of the caretaker, and diagnosis of each patient were manually established in each case in a combined audit of the pre-hospital database, the discharge summary of the MECU and the medical records from the hospital. Outcome parameters were final outcome, the etiology of the life-threatening condition ~~leading to a life-threatening situation~~, and the level of competences necessary to ~~save the life of~~treat the patient.

Results: Of 25,647 patients treated by the MECU, 701 (2.7 %) ~~were subjected to~~received prehospital "life saving treatment". In 596 (2.3%) patients ~~the treatment required to save the patient's life~~this~~e~~ treatment exceeded the competences of the attending emergency medical technician or paramedic. Of these patients, 225 (0.9%) ~~survived and following in-hospital treatment were discharged~~ were ultimately discharged to their own home.

Conclusions: The present study demonstrates that anesthesiologist administrated prehospital therapy increases the level of treatment modalities leading to an

increased survival in relation to a prehospital system consisting of emergency medical technicians and paramedics alone and thus supports the concept of applying specialists in anaesthesiology in the pre-hospital setting especially when treating patients with cardiac arrest, patients in need of respiratory support and trauma patients.

Article summary

Strenghts and limitations of this study:

- This study demonstrates that the competences required to perform life saving interventions in a large urban population to a large extent are competences ~~well~~ outside the competences of an ordinary emergency medical technician or paramedic but inside the curriculum of an attending anaesthesiologist.
- A considerable strength of the present study is the sample size and the small number of patients lost to follow-up.
- This paper demonstrates that the survivors are distributed within two distinct groups: One group containing patients, who, following a life saving intervention are discharged to their own homes in good condition and one group containing patients who, following an initial life saving effort die at the hospital. Only a small amount of patients recover in poor or moderately disabled condition.
- A considerable weakness of the study is that there is no formal validation whether the "life-saving intervention" was truly needed. It is possible that some of the patients would have survived transport to the hospital without intubation and controlled ventilation, without repetitive injections of vasopressors or without removal of foreign bodies in the airways.

Introduction

Physician-based pre-hospital emergency services (P-EMS) are established in many developed countries.[1,2]. The value of such services is debated and is difficult to assess scientifically.[3,4] Although no-one questions the value of physicians inside the hospital, ideally, the value of P-EMS should be addressed based on the context in which the service operates, both demographically, geographically and economically, as it has proven difficult to ascertain a positive relationship between the emergency care providers´ level of competence and the outcome of the patient.[5] In the region of Southern Denmark, the competences of the emergency medical technicians (EMTs) are restricted to inhalational therapy with broncholytics, rectal administration of benzodiazepines, administration of intravenous glucose, intramuscular administration of naloxone, initial treatment of patients with myocardial infarction (thrombolytic agents, opioids, nitroglycerine), intramuscular adrenaline in the treatment of anaphylaxis as well as fluid administration and defibrillation. The competences of the paramedics (PM) mainly exceeds those of the EMT in the possibility of intravenous administration of adrenaline and amiodarone in ventricular fibrillation as well as intravenous administration of furosemide. The basic response to a request for prehospital assistance is an ambulance manned with two EMTs. According to the perceived severity of the task presented to the dispatch center, in lesser populated areas of the region, a paramedic is dispatched along with the ambulance in order to supplement the treatment. On t~~T~~he 1st of may 2006, a Mobile Emergency care Unit (MECU) was initiated in Odense, Denmark. This consists of a rapid-response car operating all year round. It is manned with a physician specialist in Anaesthesiology and an Emergency Medical Technician (EMT). It operates as a part of a two-tiered system, in which the MECU supplements an ordinary ambulance manned with two EMTs.

Upon inauguration of the MECU in Odense, Denmark in 2006, two questions were posed:

Does the attendance of a specialized physician at the scene make a difference to the patients´ survival compared with the survival procured by the attending EMT or PM?

and

Does a presumed increase in patients resuscitated prehospitally as a result of the presence of a physician manned emergency care unit lead to a large number of resuscitated patients suffering from cerebral sequelae?

The aims of the present study were to investigate these two questions in relation to patients attended to by the MECU in Odense, Denmark, in whom the mission outcome was registered as life saving.

In order to study this subject, in each life saving mission we investigated whether the competences required to resuscitate the patient or prevent the patient from dying fell within the competences of the attending ~~emergency medical technician~~EMT or PM or whether the competences applied lay within the competences of the attending physician. In each mission, the final outcome of the patient was also sought in order to establish whether the patient's outcome was good, moderate or poor.

Methods

Description of study context

The MECU covers an area of approximately 2.500 square km and serves a population of 250.000 to 400.000 depending on time of day.

In a typical year, the MECU handles 4900 calls (13.5 calls per day). Due to apparent overtriage at the dispatch centre, in 13% to 20 % of the calls, the patient can be adequately treated within the competences of the EMT.and the ambulance thus waives the MECU en route following initial contact with the patient. As a result of coincident requests for MECU assistance, 3.2 % to 6.1 % of the requests are left unanswered.

The MECU is dispatched either by the dispatch centre on the basis of the information given by the caller or by request from the EMTs on the primary ambulance. From its inauguration in May 1st 2006 to April 30th 2011, the dispatch of the MECU was based on the criteria for dispatching the MECU along with an ambulance as seen in table 1. From May 1st 2011 and during the rest of the study period, a criteria-based nationwide Emergency Medical Dispatch (EMD) system was used.[6]

(Table 1 here)

Following each MECU run, patient characteristics (including the patient's Civil Registration System number (or Social Security Number), forming a unique identification of the patient),[7] the tentative patient diagnosis, and the treatment administered, are entered into the MECU database. The physician responsible for the treatment also assesses the ~~immediate~~ immediate prehospital outcome of the patient. This assessment is graded into seven categories:

- Patient´s condition improved during treatment

- Patient´s condition significantly improved during treatment
- Patient undergoing life saving procedures
- Patient unchanged
- Patient deteriorating
- Patient dead during treatment
- Others

Design

The study is a retrospective, descriptive study approved by the Danish Data Protection Agency (journal numbers 2010-41-5097 and 2013-41-2439). Within an 80 month period (May 1st 2006 to December 31st 2012), all records at the MECU concerning patients with the outcome “Patient undergoing life-saving procedures” were sought. The medical records and the discharge letters from Odense University Hospital pertaining to these patients were then sought in the hospital’s patient registry database according to the patients´ Civil Registration System number.

All records were thoroughly read by the investigators and an audit was performed in each case to validate the immediate prehospital outcome determined by the treating physician. Patients were followed until either discharge to home, discharge to nursing home or death at hospital. On the basis of the information available in the MECU record and the in-hospital medical records and discharge letter, all authors independently agreed on the validity of the claim “Patient undergoing life-saving procedures”.

In case of disagreement, agreement was obtained following closer examination of each case.

In case of missing discharge letter from the hospital, or transfer to another hospital the patient was considered lost-to-follow-up.

In all cases registered as “Patient undergoing life-saving procedures “, the competences required to save the patient´s life was assessed by the authors. Upon this assessment it was decided whether the competences required to save the patient lay within the competences of the attending PM or EMT or whether the competences required exceeded the competences of the PM or EMT.

Criteria for denoting a case “Patient undergoing life-saving procedures” within the competences of the physician were:

Explicit criteria:

- Intubation or other airway procedure exceeding the competences of PM or EMTs
- Advanced medical treatment exceeding the competences of PM or EMTs in cardiac arrest and/or defibrillation when indicated by the attending physician.

Implicit criteria:

- Advanced medical treatment exceeding the competences of the attending PM in severe shock states
- Fluid resuscitation exceeding the competences of the EMT or PM in cases of severe hypovolemia

In assessing the criteria and denoting a case “life saving within the competences of an EMT or paramedic” no account was taken whether the interaction saving the patient´s life or preventing death had in fact been carried out by the EMT or PM or an attending physician. If the interaction deemed necessary to save the patient´s life lay within the curriculum of the EMT or PM, the life saving effort was considered within the competences of the EMT or PM. Even if a physician had performed bag-mask ventilation and administrated naloxone to a patient with an opioid overdose, the effort was registered as “life saving within the competences of the EMT or PM” as both of these competences lie within the curriculum of the EMT and PM. Likewise, the administration of oxygen, furosemide, and nitroglycerine in a patient with severe pulmonary edema was considered within the competences of an EMT or PM. Only if intubation or non-invasive ventilation with continuous positive airway pressure had

been applied, the effort was considered “life saving requiring competences exceeding the competences of the EMT or PM.

All data were categorized using Microsoft Office Excel 2007 (Microsoft Corporation, Redmond, Washington, USA).

Statistical methods:

Demographic data are presented as mean and range. All other data were analyzed using non-parametric statistics (Chi-square and Kruskal-Wallis) (IBM SPSS Statistics 22, Armonk, New York, United States). Differences were considered significant when $p<0.05$. Bonferroni´s correction for repeated measurements was performed comparing physician supervised resuscitation with EMT-directed resuscitation and PM-directed resuscitation..

Results

A total of 32,452 runs were recorded for the MECU during the study period. 25,647 (79 %) of these runs resulted in contact with a patient. 701 of these patients ~~were subjected to~~received prehospital "life saving treatment". In 102 patients the treatment necessary to save the patient's life was administered within the competences of the attending EMT or PM (typical treatment modalities: mask ventilation followed by injection of naloxone, injection of glucagon or intravenous glucose, administration of defibrillation with return of spontaneous circulation and breathing). Three patients were resuscitated within the competences of lay persons (in all three cases administration of defibrillation using an automatic external defibrillator resulting in return of spontaneous circulation, breathing and return of consciousness). 596 patients were subjected to life saving interventions performed by the attending physician. This difference from the number of patients resuscitated within the competences of the EMT or PM is highly significant ($P<0.001$).

Of the 596 patients subjected to life saving interventions performed by the attending physician, 286 patients (48.0 %) died at the hospital during the admission. Thirty patients were discharged to rehabilitation clinics or other hospitals with major or moderate sequelae, these sequelae consisting primarily of cerebral impairment . Twenty-five patients were discharged with minor sequelae stemming primarily from the musculo-skeletal system requiring occupational therapy. Compared with patients surviving with sequelae, a significant majority - 225 patients in all (37.8 %) - were discharged to their own homes following in-hospital treatment ($P<0.001$). The mean age of patients resuscitated within the competences of an anesthesiologist was 54.3 years (range 0-91). The number of patients suffering minor or moderate sequelae or severe sequelae did not differ ($p=0.39$). No differences in the number of survivors were found comparing each year (data not shown).

(Figures 1-4 near here)

The diagnoses of the patients that were discharged to their own homes following an incident requiring life saving competences exceeding the competences of an attending EMT or PM are shown in ~~table 2~~figure 5.

(Figure 5 near here)

No valid account of the age distribution of patients receiving prehospital life saving treatment within the competences of the EMT or PM can be given. Within this group of patients a large number of drug addicts are found. These patients generally left the scene following successful treatment with naloxone by the EMT or PM and were not always identified.

In all, 17 patients were lost to follow-up. These patients were primarily foreign citizens transferred to hospitals outside of Denmark. Thirteen patients were transferred to other Danish hospitals before the patients´ final outcome could be established.

Discussion

This study demonstrates that the presence of an anaesthesiologist manned mobile emergency care unit results in a large number of patients receiving prehospital life saving treatment exceeding the competences of the EMTs or PMs..

When a traumatized or critically ill patient is brought to the emergency room within the hospital, a specialist is usually called upon to treat the patient. However, the benefit gained by utilizing specialized physicians in the pre-hospital service is still somewhat disputed,[4,5,8-10] and some countries do not offer advanced pre-hospital treatment as performed by physicians but rely on EMTs or PMs with varying competences.[11] However, while PMs possess a considerable number of competences allowing them to treat a variety of conditions, pre-hospital physicians possess some additional critical care competences which are potentially life-saving but are required infrequently and can carry significant risks.[12]

The availability of advanced pre-hospital life support (ALS) and basic life support (BLS) differ between countries - as such rendering comparison difficult. Although endotracheal intubation of patients in cardiac arrest recently has been disputed, [13] ALS however, seems to improve survival in patients with myocardial infarction while BLS may be the proper level of care for patients with penetrating injuries.[8] Papers describing both gains in quality-adjusted life-years as well as increased survival with physician treatment in trauma and, based on more limited evidence, cardiac arrest, have been published.[9,10]

Some studies indicate a beneficial effect of ALS administered by physicians in patients with blunt head trauma.[14-16] All these studies are retrospective in character and further high-quality research in this area would be welcome.[17]

However, pending results from an ongoing randomized study on the effect on an attending physician versus a PM in treating traumatized patients,[18] the best evidence regarding the possible impact of physician assisted pre-hospital treatment comes as yet from retrospective studies.

The concept of advanced pre-hospital treatment should be not attributed to intubation alone, as studies have suggested that advanced life support interventions (e.g. intubation) performed by PMs may have harmful effects compared to in-hospital treatment.[19,20] Apart from intubation, control of end-tidal CO2, and administration of carefully titrated doses of inotropic agents also forms a part of advanced pre-hospital treatment. In sepsis, early administration of antibiotics have proven valuable [21] and there is no reason to believe that timing of therapy does not also apply to the pre-hospital scene.

In the present study, we have found that the presence an anaesthesiologist -staffed MECU significantly improves patients´ survival based on an evaluation of the competences required to resuscitate or prevent a critically ill or injured patients from dying. Few patients recovered with moderate or severe sequelae. Our results are probably generalisable to all of Scandinavia as the level of competence of the EMTs or PMs does not differ markedly in the Scandinavian countries and as all Scandinavian countries provide anaesthesiologist-staffed pre-hospital services.[22] All of these services apply advanced emergency medical procedures in critically ill or injured patients, the lowest incidence of these procedures being exercised in Denmark.[1] Direct comparison between the United States and Europe, however, is difficult, as the prehospital concept differs. In the United States, the primary prehospital resource is an EMT supported by a PM while the general European prehospital resource consist of a P-EMS supporting a general ambulance.

Our primary finding in this retrospective study is that the vast majority of the life saving procedures carried out in the MECU in Odense, Denmark is performed within the competences of the attending anaesthesiologist. Another important finding in this study is the outcome pattern of the patients resuscitated within the competences of the physician: Approximately half of the patients that survive the incident are discharged to their own homes without major or even moderate sequelae. Another half of the patients die at the hospital. Only a minute fraction of patients that survive a critical incident requiring resuscitation by the anaesthesiologist manning the MECU experience sequelae.

The subject of the present study was the life saving interventions. However, the MECU is not only a life saving service. Both supervision of EMTs and PMs and clinical decision-making might add value to the combined emergency system. Moreover, utilizing a physician in the pre-hospital environment may actually enable withholding of futile advanced interventions, such as withholding intubation for ethical reasons in patients where such a treatment could be contra-indicated is probably beneficial for ethical reasons.[23] As such, advanced medical care including ICU admittance might be avoided in futile cases.

Strengths and limitations

Two different criteria systems for dispatch used within the study period. However, the main characteristics of the patient population presumably remained unchanged throughout the study period. Firstly, as the general activity of the MECU was constant throughout the period, and secondly, because the principles applied in the region are that any ambulance meeting demands that cannot be covered by the EMTs manning the ambulance are requested to summon the MECU for help. Any patient requiring advanced medical assistance thus would presumably be seen by the MECU.

The strength of the present study is the sample size and the small number of patients lost to follow-up. All data have been entered by the anaesthesiologist on call immediately following the mission. All missions assigned the outcome “life saving” have been audited by the authors of whom three are independent of the MECU. The validity of data thus is acceptable. Weaknesses of the present study however, are that the study is a retrospective study. In Scandinavia at the present time, it is not feasible to perform a prospective randomized study on the presence of an anesthesiologist at the scene. In this study, no comparison has been made with a period without a MECU. The present private ambulance operator in the area does not carry databases extensive enough to support such a study. Follow-up of patients have been reduced to establishing whether the patient was discharged to his/her own home. The study would have benefitted from assessing the patients using post hoc interviews to evaluate their status. However, given our large material and the time span of the investigation making post hoc interviews difficult, in this study, we assumed that a patient being discharged to his/her own home was a patient with favorable outcome.

An important limitation of the present study is the application of a subjective measure of life saving intervention. This may have given rise to reporting bias as the physician responsible for the mission performed was the one who made the initial assessment of the mission. In our study we have subjected each self-reported case of “life saving mission” to an audit applying both explicit criteria and implicit criteria in order to assess, to what extent any given mission indeed correctly had been determined a life saving mission. Furthermore, the large numbers of missions not classified as life saving missions indicate a reliable reporting culture.

Finally, one might argue that, all therapeutic interventions have been carried out by a specialist in anaesthesiologist at the scene following best standard of care. By definition, the specialist would be deemed negligent if he failed to use his level of

skill, knowledge, and care in diagnosis and treatment of patients. Furthermore, it is impossible to validate the claim “life saving intervention” in a formal way: Should one withhold the intervention, the patient would die if the claim that the life saving intervention was indeed correct.

Conclusion

This retrospective study demonstrates that anesthesiologist administrated therapy increases the level of treatment modalities leading to an increased survival in relation to a prehospital system consisting of emergency medical technicians and paramedics alone without an unacceptably high number of patients suffering severe sequelae. The present study thus lends firm support to the concept of applying physician specialists in anaesthesiology in the pre-hospital setting.

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Table 1:

MECU Dispatch criteria in parts of the observation period

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Fire implying a risk of damage to people

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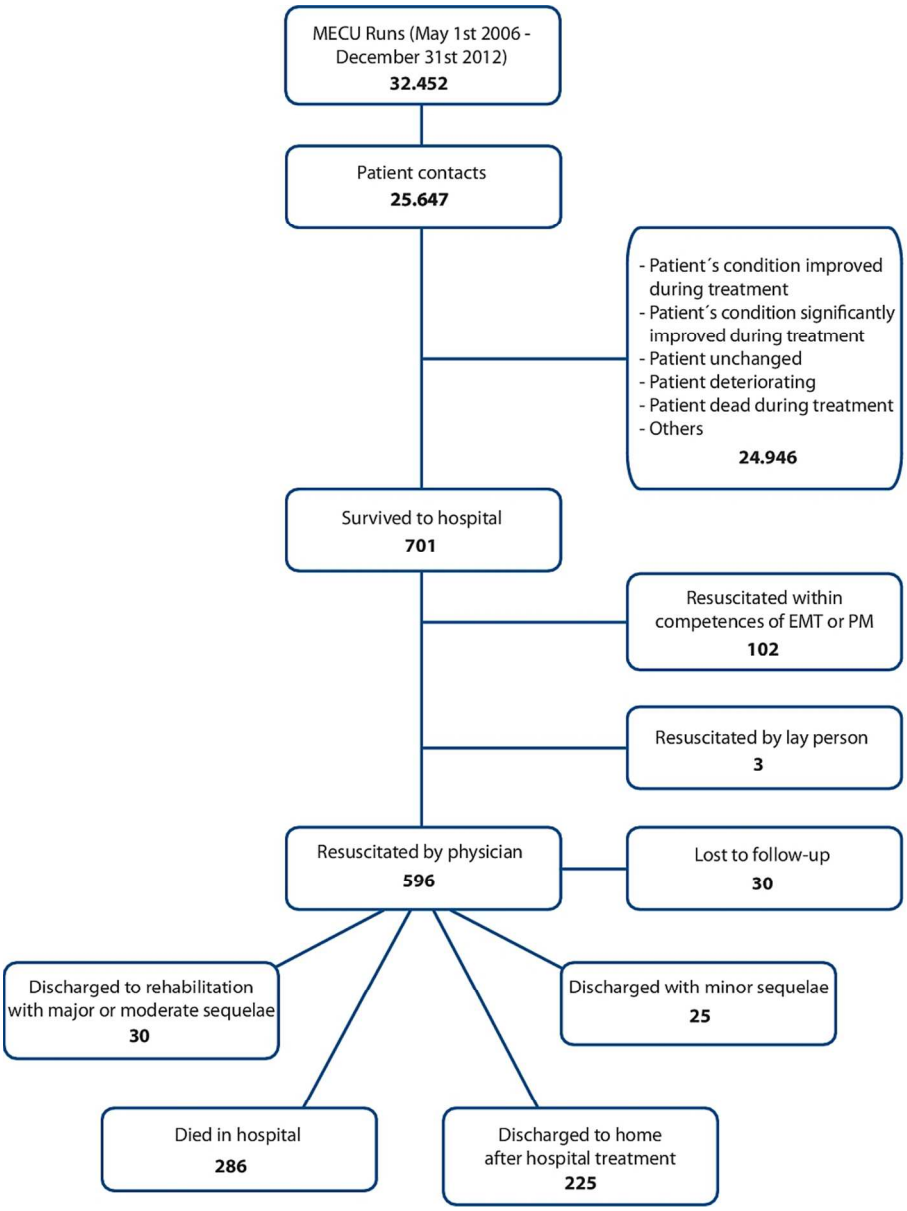
Competing interests

None of the authors have any competing interests to declare. No external funding was utilized.

Authors' contributions

SM contributed to this manuscript with idea and design as well as acquisition of data, analysis of data and drafting and revising of the manuscript. AJK contributed to this manuscript with idea, design, analysis of data, drafting and revision of the manuscript. STZ contributed to this manuscript with acquisition and analysis of the data, drafting and revising of the manuscript. ACB contributed to this manuscript with idea and design as well as acquisition of data, analysis of data and drafting and revising of the manuscript. All authors read and approved the final manuscript.

Data sharing statement
No additional data available.



90x117mm (300 x 300 DPI)

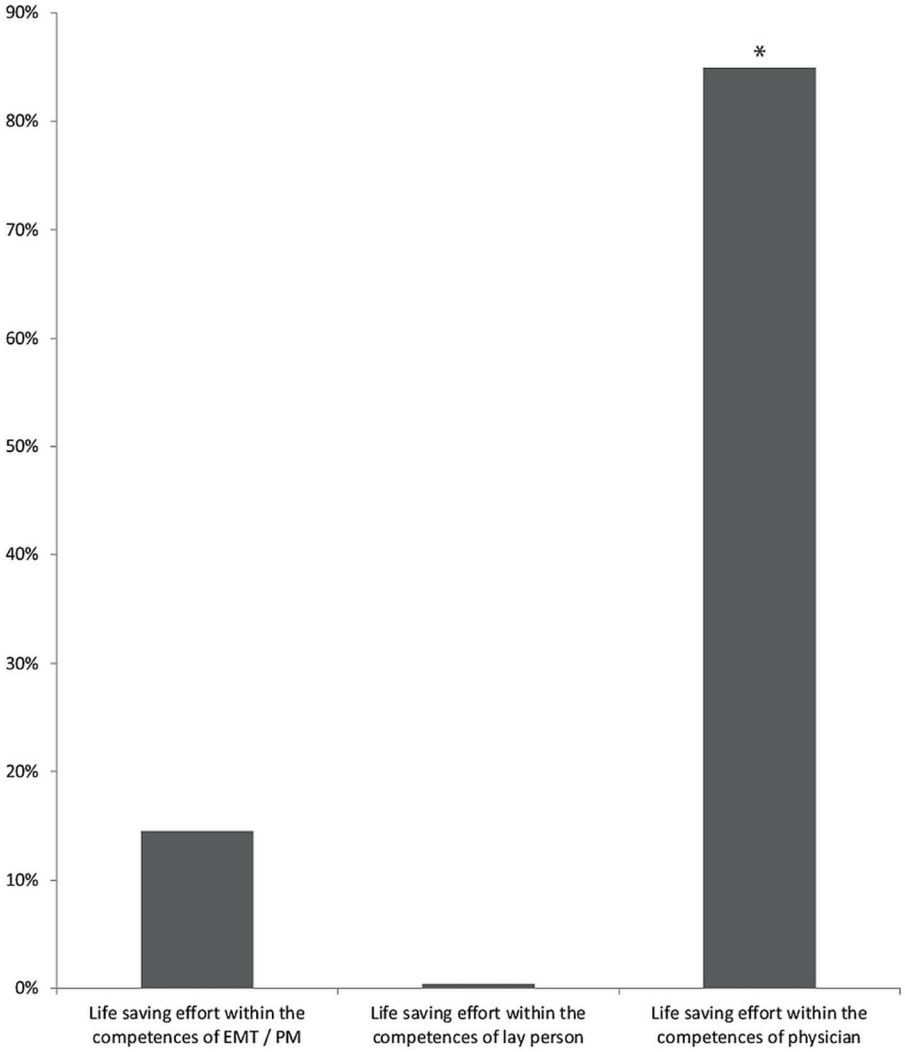


Figure 2
*p>0.001 (Patients resuscitated within the competences of anaesthesiologists vs. patients resuscitated within the competences of EMT / PM)

90x109mm (300 x 300 DPI)

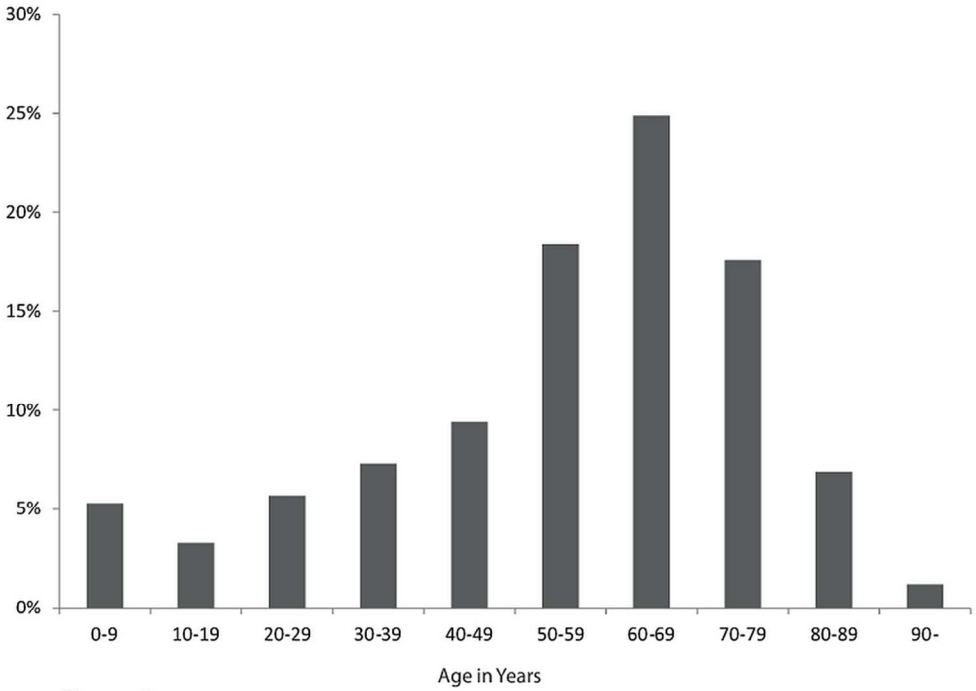


Figure 3
Age distribution of patients resuscitated by anaesthesiologists

90x73mm (300 x 300 DPI)

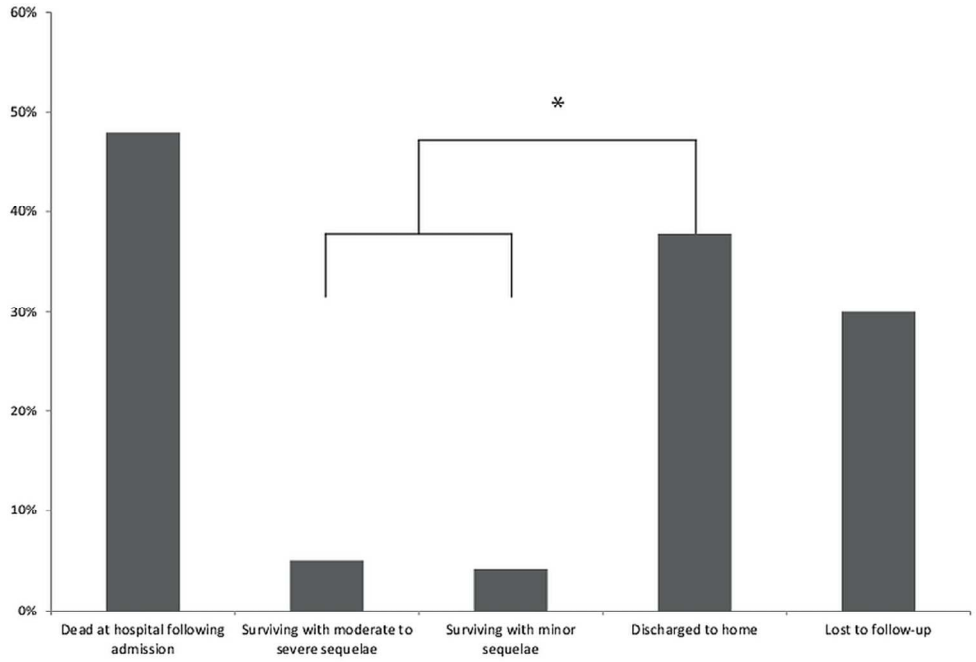


Figure 4
*p<0.001 (Discharged to home vs. surviving with minor or moderate to severe sequelae)

90x72mm (300 x 300 DPI)

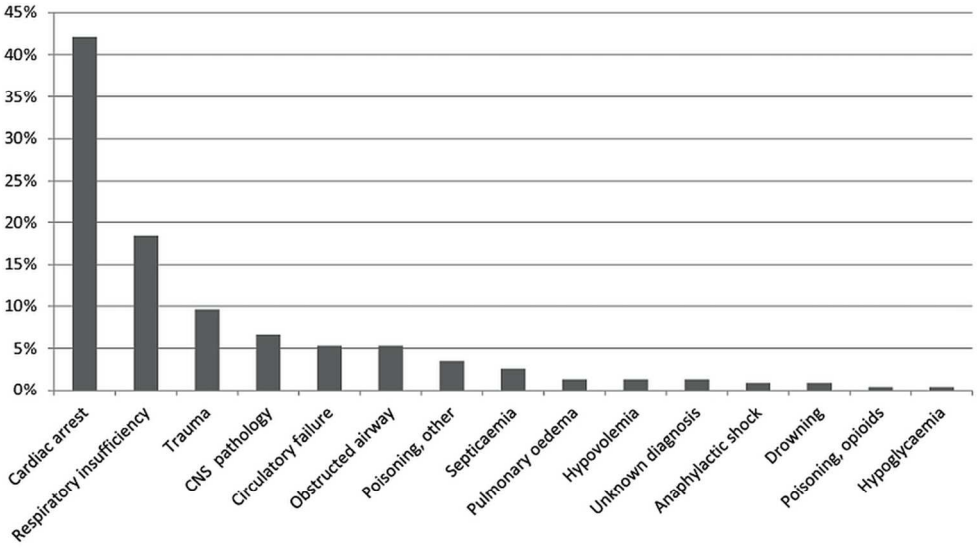


Figure 5
Diagnoses in patients discharged to their homes following anesthesiologist supervised resuscitation

90x62mm (300 x 300 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses

Continued on next page

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Item number	Reported on page
1a	1
1b	2
2	4
3	4
4	5,6,7
5	6,7,8
6a	6,7
6b	Not relevant
7	9
8	9
9	8
10	8
11	8,9,10
12a	10
12b	Not relevant
12c	9
12d	Not relevant
12e	Not relevant
13a	11
13b	Not relevant
13c	Fig. 1
14a	Fig. 2
14b	Table 2
14c	8
15	11
16a, b, c	Not relevant
17	Not relevant
18	17
19	15,16
20	17
21	14
22	24