The bystander in out-of-hospital cardiac arrest: Preconditions for and consequences of providing cardiopulmonary resuscitation

by

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Forord

Wenche utpekte seg tidlig som en faglig flink og dedikert intensivsykepleier. Nysgjerrig og uredd var hun også. Stilte spørsmål og ville vite mer. Hun var ikke vanskelig å be som medarbeider i forskningsprosjekt knyttet til intensivteamet sitt samarbeid rundt respiratorbehandling. Kunne hun forske selv? Det var hun mer usikker på. Starten på dette ble jobben som registeransvarlig for alle hjertestansregistrene i Helse Stavanger. Så ble det master i samfunnssikkerhet og Wenche var ikke i tvil lenger. Da pengestøtten til hennes ph.d. var klar hoppet hun om bord i forskningstoget og forlot andre oppgaver med stor glede. Hva skulle hun forske på? Jo, der hadde hun selv en god idé.

Som registrar for hjertestansregisteret på SUS analyserte hun hva som ble gjort og ikke ble gjort ved hjertestanser i Rogaland. Men det var en ting hun alltid var opptatt av – det var den innsatsen førstehjelperne gjorde. Dette ville hun undersøke nærmere, derfor startet hun på en ph.d.-grad i 2012. Der skulle hun se på forutsetninger for og konsekvenser av at folk utfører hjerte-lunge-redning (HLR) ved hjertestans.

Wenche leverte inn sin ph.d.-avhandling sommeren 2018, og skulle etter planen disputere i november samme år. Dessverre ble hun alvorlig syk bare uker før planlagt disputas og den ble utsatt på ubestemt tid. Men hun fikk aldri den bedringen vi håpet på, og døde i mai 2019 uten at hun fikk oppleve avslutningen på sin egen doktorgrad som hun hadde jobbet så mye med i seks år.

Likevel oppnådde hun mer enn de fleste på veien mot en ph.d. – hun fikk frem kunnskap om at førstehjelpere er traumatiserte av opplevelsen med å utføre HLR, og at vi som samfunn må ta vare på disse menneskene. Det er tross alt vi som har bedt dem om å utføre HLR i mer enn 60 år. Budskapet var så viktig at det ble omtalt på Søndagsrevyen 20. november 2016. Der fortalte hun at førstehjelpere ikke hadde noe tilbud om oppfølging. Dette ønsket Wenche å gjøre noe med. Nå har drømmen hennes kommet i oppfyllelse – Helse Stavanger har opprettet et prosjekt for å lage et system for oppfølging av førstehjelpere. På den måten vil hennes forskning få betydning for veldig mange i lang tid fremover. Nå er det vår oppgave å sørge for at dette tilbudet blir tilgjengelig for alle.

Stavanger Universitetssykehus, 10. juni 2020.

Conrad Bjørshol
hovedveileder

Eldar Søreide
veileder

Hi,

I have a cardiac arrest patient here in the intensive care unit. The other day, he collapsed in the centre of the town. He received bystander cardiopulmonary resuscitation. The bystander called the ICU the day after. She was in despair for the need to know how the patient was doing. She was told she was not entitled to any information due to legislation. Luckily someone had noted her telephone number in case the patient later would be able to call her. Instead, I gave her number to his family and urged them to call. They did so, and I was told that the woman, who had saved the patient's life, did not sleep at all that night. When she heard how the patient was doing, she cried and said she was happy. The family will stay in contact with her.

This is yet an example of the importance of your work. I just wanted to share this with you.

Klaus Skrudland

Intensive care nurse

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Summary

Background: Out-of-hospital cardiac arrest (OHCA) is a major cause for death in the Western world. To optimise survival after OHCA incidents, health care systems depend on bystanders, who are not a part of an organised response system, to alarm the emergency medical dispatch centre and initiate cardio-pulmonary resuscitation (CPR). However, there is sparse knowledge on the preconditions that make bystanders actually perform CPR, the consequences of performing CPR for the bystanders themselves and how bystander CPR influences survival in rural and urban areas.

Aims: The aims of the current thesis were as follows: 1) to acquire more knowledge from the bystander's perspective regarding their preparedness and the consequences of CPR provision in OHCA incidents and 2) to measure the effect of bystander CPR on patient outcomes in rural and urban areas.

Methods: The project comprises qualitative and quantitative methodologies applied in four studies. In both qualitative studies, we used semi-structured in-depth interviews to interview bystanders who had provided CPR to OHCA victims. We used a qualitative content analysis for analysing the data. The quantitative methods entailed a cross-sectional survey and an observational registry study. The data were analysed with several statistical techniques.

Results: We found that most participants were prepared to receive CPR instructions from the dispatcher, but not aware of the assistance given in deciding whether to initiate CPR or not. Acting as responsible community citizens, trusting assistance from dispatchers, possessing the willingness and ability to provide CPR and being able to comprehend the severity of the OHCA incident were factors important for overcoming barriers to providing CPR. However, providing CPR was emotionally challenging for the bystanders, with consequences for both family and work life. Bystanders who had provided CPR described also

persistent mental recurrences concerning the outcome of the cardiac arrest victim and unknown or fatal outcomes caused feelings of guilt and were particularly difficult to handle.

In patients who received bystander CPR before EMS arrival, the odds of survival to hospital discharge increased more than threefold. However, bystander CPR was associated with survival only for patients in urban areas. OHCA survival was higher in urban compared to rural areas, and the effect of modifiable factors, like bystander CPR, differed between urban and rural areas.

Conclusion: In OHCA incidents, a mutual trust between community citizens and social institutions seems to be a precondition for bystander CPR provision. To overcome the natural reluctance to provide CPR, support and instructions from emergency medical dispatchers is of vital importance. This support is expected by the public, particularly in the form of CPR instructions. When bystanders establish a causal relationship between the provided CPR and patient outcome, this may cause serious and persistent distress.

We also found that bystander CPR drastically increases the chance of survival in OHCA incidents. However, the effect of bystander CPR seems to differ between rural and urban areas.

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This thesis is based on the following papers that are referred to in the text using Roman numerals:

I. Mathiesen WT, Birkenes T, Lund H, Ushakova A, Søreide E, Bjørshol CA, **Public knowledge and expectations to dispatcher assistance in out-of-hospital cardiac arrest**. Submitted to Journal of Advanced Nursing, 19-Apr-2018, JAN-2018-0403

II. Mathiesen WT, Bjørshol CA, Høyland S, Braut GS, Søreide E (2017) **Exploring How Lay Rescuers Overcome Barriers to Provide Cardiopulmonary Resuscitation**: **A Qualitative Study**. doi.org/10.1017/S1049023X16001278, Prehospital and Disaster Medicine 1-6

III. Mathiesen WT, Bjørshol CA, Braut GS, Søreide E (2016) **Reactions and coping strategies in lay rescuers who have provided CPR to out-of-hospital cardiac arrest victims: a qualitative study**. doi.org/10.1136/bmjopen-2015-010671, BMJ open 6.5

IV. Mathiesen WT, Bjorshol CA, Kvaloy JT, Soreide E. **Effects of modifiable prehospital factors on survival after out-of-hospital cardiac arrest in rural versus urban areas**. Critical care. 2018;22(1):99. Epub 2018/04/20.

Abbreviations

AED	Automatic external defibrillator
AHA	American Heart Association
ALS	Advanced life support
AOR	Adjusted odds ratio
COCPR	Compression only cardiopulmonary resuscitation
CPC	Cerebral Performance Category
CPR	Cardiopulmonary resuscitation
ED	Emergency department
EMD	Emergency Medical Dispatcher
EMDC	Emergency Medical Dispatcher Centre
EMS	Emergency Medical Services
ERC	European Resuscitation Council
ICU	Intensive care unit
ILCOR	International Liaison Committee on Resuscitation
NAKOS	Norwegian National Advisory Unit on Prehospital Emergency Medicine
NRC	Norwegian Resuscitation Council
OHCA	Out-of-hospital cardiac arrest
OR	Odds ratio
PAD	Public automated defibrillators

PEA	Pulseless electrical activity
ROSC	Return of spontaneous circulation
SUH	Stavanger University Hospital
T-CPR	Telephone cardiopulmonary resuscitation
VF	Ventricular fibrillation

1 Introduction

Before the introduction of cardiopulmonary resuscitation (CPR), death was the inevitable outcome of most sudden events of cardiac arrest. Although efforts to bring individuals back to life have existed since ancient times,[1] it was first described in 1976 that CPR, provided by lay people before ambulance arrival, increased survival of cardiac arrest victims.[2] By acknowledging that CPR could save lives, the outcome of cardiac arrest no longer was entirely determined by fate or 'the will of God'.[3] People who were standing close to the cardiac arrest victim could, with their bare hands and breaths, influence the outcome of cardiac arrest. From this, the 'bystander' concept emerged.

Out-of-hospital cardiac arrest (OHCA) is one of the leading causes of death in the Western world. Annually, 275,000 individuals in Europe and 420,000 in the United States suffer from OHCA.[4, 5] The pivotal importance of CPR given by bystanders for survival after OHCA is well documented.[6-10] Overall, bystander CPR provided to OHCA victims increases survival by over threefold when compared with not receiving bystander CPR.[6, 7] However, both bystander CPR rates and patient survival differ substantially between countries and regions.[8, 11-14] Considering the importance of CPR and the large variations in the percentage of people who provide CPR, it is surprising that the experiences from the bystander perspective rarely have been studied. Also, most of the CPR training offered to the public regarding decision making in an OHCA setting is presented as a straightforward issue. However, cardiac arrest may not be a clear case; it can be ambiguous, complex and with an unpredictable outcome. The knowledge concerning bystanders' preparedness for and decision making in OHCA, along with how bystanders process the incident, is extremely sparse.

Important determinants for survival after OHCA are the response time of the emergency medical services (EMS),[15] and the attention of the pre-hospital physician.[16, 17] CPR, EMS response times and the attendance of

the pre-hospital physician are all modifiable factors that represent opportunities for improvements in saving lives.[18] How these factors influence OHCA survival according to rural and urban areas may be important knowledge that can be used to improve current EMS-systems.

1.1 Thesis

The CPR provided by bystanders has significant impacts for cardiac arrest victims' outcomes. These bystanders operate outside organised health care systems in contexts that influence their behaviour. Thus, it is interesting to explore the bystanders' experiences in terms of preconditions for and consequences of CPR related to a contextual perspective. Thus, the current project is positioned between health science and social science. The applied philosophical position is social constructivism, meaning that individuals' actions are contextually based. This dimension of interpreting bystander action in OHCA is new. Applying various research strategies in the present project implies that the quantitative approaches serve as contextual background for the findings in the qualitative approaches.

1.1.1 The aims of the thesis

The purpose of this PhD project is to discover areas where improved efforts could influence survival after OHCA. The aim is to study the preconditions for and consequences of bystander CPR by 1) acquiring more knowledge from the bystanders' perspective regarding their preparedness and reactions of CPR provision in OHCA incidents and 2) measuring the effect of bystander CPR on patient outcomes in rural and urban areas.

The preconditions for providing CPR are approached in both Paper I and Paper II. In Paper I, we aimed at studying the knowledge and expectations of the general public regarding the emergency medical services (EMS) dispatchers' assistance in OHCA, while in Paper II we also aimed at

exploring how barriers to providing CPR are overcome. In Paper III we aimed at approaching the consequences of CPR by exploring the reactions and coping strategies of bystanders who have provided CPR. In Paper IV we aimed at examining how bystander CPR, EMS response time and EMS physician attendance in rural versus urban areas influence patient survival.

1.1.2 The structure of the thesis

The current thesis comprises seven chapters. Chapter 1 describes the bystander term as it is related to the CPR concept and provides a description of the setting from where most of the data were collected, including a cardiac arrest registry. Chapter 2 introduces the applied research position for the thesis, which is followed by theoretical frameworks and theories explaining human perceptions and behaviour. Chapter 3 describes the methods applied to the main findings presented in Chapter 4. In Chapter 5, the findings are discussed in light of theoretical approaches to human behavior in time-critical incidents and previous research. Also, the methodological considerations related to the quantitative and qualitative methods used are given in Chapter 5. Chapter 6 provides the conclusion, and Chapter 7 suggests implications for practice and future research.

1.2 The bystander

The term ‘bystander’ in the CPR concept denotes an individual who is present in a cardiac arrest incident outside hospital (OHCA), without being a part of an organized emergency medical system (EMS).[19] Other commonly used words for bystander is ‘lay rescuer’. In the following of this thesis the term ‘bystander’ will be used.

Bystanders include a wide range of potential rescuers, including individuals with formal health care training.[20] CPR provided by bystanders is denoted as ‘bystander CPR’.[19] Bystanders are, in general,

members of the public. Because approximately 70% of all OHCA occurs in private homes, [21] most bystanders are family members or friends of the cardiac arrest victim. Some bystanders do not have training in CPR, while others have various years, quality and quantity of CPR training. For most bystanders, the experience of cardiac arrest is highly unexpected.[22, 23] Some bystanders choose not to intervene in OHCA incidents.[24, 25] Others provide ventilations and or chest compressions and the alarm the emergency medical dispatch centre.[26, 27] Some bystanders operate on their own, and some collaborate with others.

1.2.1 The CPR procedure

The technical side of bystander CPR provision needs to be clarified. An important distinction in the scientific literature of OHCA is the term 'bystander CPR'. Bystander CPR means chest compressions only (COCPR) or compressions with ventilations (CPR).[19] According to internationally recommended guidelines, the CPR procedure implies a chest compression rate of 100 to 120 compressions per minute with a 30:2 compression-to-ventilation interval; for adults, the chest compression depth is ≥ 50 mm.[20, 28] (22, 30) In infants, the compression depth should be 4 cm and in children 5 cm.[20]

1.2.2 Bystander CPR

Research on bystanders' experiences and reactions to providing CPR is sparse and divergent. Some have been conducted by Axelsson and colleagues. In 1996, they reported the findings from 742 participants' descriptions of bystander CPR, the circumstances and the experiences. They found that 93% of participants regarded their intervention as a mainly positive experience.[29] However, all participants in the study were CPR-trained and approximately half were health care workers; thus, the findings may not apply to the general population. In a later report, Axelsson et al. investigated factors influencing bystanders' psychological reactions to providing CPR.[30] They found a highly significant

association between the overall bystander experience and the outcome of the OHCA victim.[30] Zilstra et al. found also that lay rescuers did not experience significant adverse effects after providing CPR.[31] However, in that study nearly half of the participants were off-duty professional rescuers and all were connected to an OHCA text message alert system.[31] Similarly, Møller et al. found no psychological sequelae and good coping strategies in bystanders following participation in a resuscitation attempt, but all participants had been debriefed and only half had actually provided CPR.[26] In contrast, Genest et al. found persistent psychological aftereffects among volunteer ambulance attendants after resuscitation attempts.[32] Skora et al. found that bystanders reported both positive and negative feelings after providing CPR.[22] The recent study by Mausz et al. likewise showed that making sense of the OHCA experience is challenging for bystanders, who experience uncomfortable emotional reactions to the event.[33]

1.2.3 Legal implications and neglect of duty to assist

One of the underlying reasons for bystanders' provision of CPR is the profound feeling of duty and moral obligation to people in need of emergency help.[23] In Norway, this moral obligation is supported by several legislations. According to section 287 of the penal code, it is punishable not to provide assistance to the best of the bystander's ability to a person at obvious risk of losing his or her life or suffering considerable harm to body or health.[34] Section 12 of the Road Traffic Act states anyone who, with or without guilt, is involved in traffic accidents or who are nearby and present must help injured persons and animals.[34] In cases where bystanders search for information regarding the state of cardiac arrest victims to whom they may have provided CPR, healthcare professionals are restricted from sharing information about people's physical or medical conditions or other personal circumstances.[34]

1.2.4 Bystanders and barriers to CPR provision

Despite major public campaigns to increase the attention to cardiac arrest and CPR some bystanders choose not to provide CPR because of fear of infection, being incapable, legal implications, causing damage and fear in general.[35, 36] Other barriers are distrust of law enforcement, language concerns, lack of recognition of cardiac arrest,[37] physical limitations,[38] lack of confidence and ambivalence of duty to act in a large group.[39] Recent studies have shown the association of OHCA neighbourhood characteristics (income and racial disparities) with bystander CPR rate.[12, 40] Barriers to dispatcher-guided CPR (T-CPR) are distributed differently across public and residential locations.[41] The inability to calm callers and difficulty to move a patient to a hard flat surface for CPR are more frequent barriers in residential locations than in public locations.[41] The barrier of callers not being with patients was more frequently observed in public compared to residential areas.[41]

1.2.5 Media coverage of cardiac arrest and CPR

Public awareness campaigns, in particular toward COCPR provision, have attempted to conceptualise CPR as important, safe and easy to perform.[33, 42] Also, television programmes for entertainment purposes show survival rates significantly higher than the most optimistic survival rates in the medical literature. This discrepancy may convey unrealistic impressions of CPR and chances for success.[43, 44] Thus, it is questioned whether such programmes and campaigns simplify the provision of CPR and leave the public unprepared for the physical, emotional and logistical challenges of an actual cardiac arrest victim.[45, 46]

1.2.6 Provision of CPR and automatic external defibrillator use across populations

The variations of bystander CPR rate between regions and countries can be differentiated by neighbourhood characteristics. Sasson et al. found

that cardiac arrest patients in high-income white neighbourhoods in the United States were more likely to receive bystander CPR compared with those in low-income black neighbourhoods,[12] and several studies have supported these results.[47, 48] An Asian study concluded that OHCA patients in low-socioeconomic areas versus high-socioeconomic areas are less likely to receive bystander-initiated CPR and have worse survival outcomes.[49] A Swedish study found that the proportion of people living alone, the proportion of white people and the proportion with a high school degree or higher were associated with bystander AED use.[50]

1.3 Sudden cardiac arrest

Understanding why CPR by bystanders is important for survival the term 'sudden cardiac arrest needs to be addressed'. Sudden cardiac arrest is defined as 'the cessation of cardiac mechanical activity as confirmed by the absence of signs of circulation'.[51] The cardiac arrest victim will appear unresponsive and will not be breathing normally.[20] Sudden OHCA is an unexpected cardiac arrest that occurs outside a hospital setting. The phrase 'sudden' has been challenging to define.[52-54] Thus, for the purposes of uniformed reporting of OHCA data, no reporting on 'suddenness' is recommended.[55] However, the phrase indicates immediate actions by alarming the EDC and providing CPR before the arrival of EMS.

Sudden cardiac arrest occurring outside a hospital will be referred to as OHCA in this thesis.

1.3.1 The aetiology behind cardiac arrest

The causes for OHCA are mainly divided into two major subgroups: cardiac aetiology and non-cardiac aetiology. In the cardiac aetiology group, the cause is related to conditions in the heart, for example, ischemic heart disease, cardiomyopathy and arrhythmia. A recent report from the Norwegian National Advisory Unit on Prehospital Emergency

Medicine (NAKOS) showed that 69% of all OHCA events in Norway originated from cardiac causes, which is a similar incidence level compared with other reports from Norway.[8, 56, 57] The most frequent cause of cardiac aetiology is ischemic heart disease.[58]

In the non-cardiac aetiology group, the cause of the cardiac arrest is related to conditions outside of the heart. The term non-cardiac aetiology includes a variation of causes both medical in origin and not, for example, lung disease, pulmonary embolism, drowning, sudden infant death syndrome and drug overdose.[55]

1.3.2 The arrhythmia behind cardiac arrest

Certain core variables are of fundamental importance when comparing OHCA outcomes between regions. Some of the core variables are presented in the following paragraph.

OHCA patients with an initial monitored heart rhythm presenting a shockable rhythm (ventricular fibrillation [VF] or ventricular fibrillation [VT]) are more likely to survive to hospital discharge compared with patients who have non-shockable rhythms (asystole or pulseless electrical activity [PEA]).[7, 59-61] In Norway, the incidence of initial shockable rhythms between regions is varying from 12% to 29%.[56] Also, in international reports, the incidents of shockable rhythm vary, but are declining.[14, 62, 63] Although VF/VT is a manifestation of severe coronary artery disease, PEA is a brief phase in clinical death that occurs after loss of consciousness, ventilatory drive and circulation, but before decay to asystole.[64] Even so, the VF will deteriorate into asystole if no intervention is provided.[20] CPR delay the deterioration of the VF.[65]

1.3.3 Gender and age related to OHCA

Approximately one-third of all OHCA are females,[66, 67] and some recent reports show even higher incidents of females experiencing OHCA. [56, 68] In general, OHCA and the proportion of OHCA with a cardiac etiology

increase with age. [56, 61, 69] Patients with a cardiac aetiology found in ventricular fibrillation (VF) decrease with age.[69]

1.3.4 Factors predicting patient outcomes

The chance of survival to hospital discharge is higher when the patient receives CPR, when the OHCA occurs at a location other than a private residence, when the OHCA is witnessed by a bystander or an emergency crew, when the patient is found with a shockable rhythm and when the patient has achieved return of spontaneous circulation (ROSC) in the field.[7, 70-73] Older age,[74] and chronic health conditions[75] lower the chance of survival to hospital discharge. In adult OHCA victims (≥18 years) there is a negative association between increasing age and survival.[69] Also, a good quality of life prior to cardiac arrest has been shown be a predictor of good quality of life after the cardiac arrest.[76]

As increasing interval between the call for and arrival of the EMS, there is a negative association of elapsing time before bystander CPR, defibrillation and patient survival.[77-80] In witnessed VF OHCA, the chance for survival decreases by 6–10% for every minute elapsed without CPR [77, 79, 81] there is a 3–4% decrease when CPR is provided.[77]

1.4 The mechanism of CPR

In cardiac arrest, the blood flowing to the brain is reduced to zero. CPR is an attempt to restore spontaneous circulation by performing chest compressions with or without ventilations and defibrillation.[20, 51] CPR can buy time by generating blood flow for temporary sufficient organ perfusion.[82] This is why health authorities and organisations worldwide encourage people to take action by alarming the EDC and initiating CPR when involved in OHCA incidents.[35, 83]

1.4.1 The history of CPR

There is an extensive history of CPR. [20] Though efforts to restore life have been attempted since ancient times,[84] it has been in the past 58 years when the modern CPR concept has evolved.[1, 85] In 1976 Safar delivered the first report describing how CPR provided by lay people before ambulance arrival increases survival after cardiac arrest.[1, 2] Defibrillation prior to ambulance arrival improves survival after OHCA.[86-89] Today, defibrillation by lay rescuers and first responders is also considered a part of basic life support (BLS).[20]

1.4.2 Bystander CPR by chest compressions and ventilation vs chest compressions only

The optimal ratio of chest compression versus ventilation is an ongoing discussion based on findings showing no significant difference in survival between patients having received conventional bystander CPR and COCPR.[90-94] Several reports emphasise the benefits of COCPR because COCPR is a less complicated procedure and may reduce bystanders' fear of contraction of disease.[94] However, these studies are often based on witnessed OHCA with a cardiac cause. Critics state that training the public in COCPR might decrease the survival chance of OHCA victims because conventional CPR, including rescue breathing, would be more effective for children [95] and patients who sustain an asphyxia cardiac arrest.[96] To date, significant differences in the demographic and prognostic factors in the studies between COCPR and conventional CPR complicate the interpretation of the data.[97] Thus, the ERC 2017 guidelines recommend that 'all CPR providers should perform chest compressions for all patients in cardiac arrest'.[97] CPR providers trained and able to perform rescue breaths should perform chest compressions and rescue breaths.[20, 97]

1.4.3 International CPR guidelines

The International Liaison Committee on Resuscitation (ILCOR) coordinates members of guideline-producing organisations worldwide[98] and has become the authoritative voice on the consensus on science behind national and international guidelines on resuscitation.[1, 99] The European Resuscitation Council's (ERC) and the American Heart Association's (AHA) 2015 guidelines for adult basic life support and automated external defibrillation (AED) are based on the ILCOR 2015 Consensus on Treatment Recommendations.[20, 100] The Norwegian Resuscitation council's (NRC) facilitates resuscitation guidelines in Norway.

1.4.4 CPR training for the public

The focus on resuscitation in media and widespread educational initiatives have increased bystander CPR.[101-103] In general, the willingness to provide CPR is high among CPR-trained individuals.[104] CPR training increases the chances of providing CPR in real OHCA incidents.[105, 106] Traditionally, training includes manikins, which have been modified over the years.[1] To increase training efficiency, new and various learning methods have been developed. [1, 107-112]

When it comes to CPR training, Norway has a long history of first aid and compulsory CPR training in schools.[1] Bakke et al. reported that approximately 90% of the Norwegian population is CPR trained, and the workplace is stated as the most common source of CPR training.[113]

1.4.5 Bystander CPR quality

Effective bystander CPR (CPR in conformity with AHA guidelines) is found to be independently associated with a three- to fourfold proportionate increase in survival when compared with ineffective CPR.[114] Despite the detailed guidelines available for providing CPR,

bystander adherence to these guidelines varies with deviations from the guidelines affecting the patient's outcomes.[115-118] First, the bystanders need to initiate CPR. Second, longer arrest-to-bystander CPR intervals decrease survival.[115] Third, bystanders deliver poorer CPR quality regarding compression depth and the pre-shock pauses are longer than recommended by guidelines.[117] Linderoth et al. found that barriers to effective interventions by bystanders in OHCA was a lack of situational awareness, inexpedient communication and lack of taking a team approach.[119]

1.4.6 Automatic external defibrillators

AED is an electronic, lightweight and portable device for treating life-threatening cardiac rhythms. When activating the device, a built-in computer uses the adhesive pads placed on the OHCA victim's chest to calculate whether defibrillation is needed. If so, the AED supplies electricity to the heart, allowing the heart to re-establish an effective rhythm. AED has been widely used by trained EMS personnel and first responders and is considered a part of BLS.[20, 120] Because of the portability and audible prompts that guide the user through the process, available AEDs have also become available for members of the public (public access defibrillator, PAD). Bystanders' use of PADs has shown to be beneficial for victim survival rate after OHCA,[20, 121] particularly when placed in environments where there are numerous people.[78, 122]

1.5 The emergency medical services in the Stavanger region

The Stavanger region comprises the area of most of the current study's participants and OHCA patients. Situated on the southwest coast of Norway, the Stavanger region covers 5,700 km2 and constitutes 18 urban and rural municipalities (Figure 1). Four municipalities, including the cities of Stavanger and Sandnes, constitute the most densely populated areas. The population has been increased by approximately 358,000

inhabitants in 2015, which is the final year of the 10-year period for OHCA data in Paper IV of the current project.

1.5.1 Emergency medical dispatch center (EMDC)

Stavanger University Hospital (SUH) is the only receiving hospital for OHCA patients in the Stavanger region. The emergency dispatch centres in Norway (EMDC) are manned by registered nurses who answer emergency calls and ambulance personnel who coordinate the ambulance fleet.[123] The EMDC in Stavanger is responsible for coordinating 17 ambulance units that are allocated to eight ambulance stations. One hospital-based anaesthesiologist-manned (EMS physician) rapid response unit uses a helicopter for remote assignments or a car for local assignments. In addition, fire brigades equipped with automated external defibrillators are often dispatched by the EMDC in OHCA events. Since 2015, the responsibility for taking emergency calls and providing care in the Lund municipality was transferred to the EDMC covering the area of Sørlandet.

Unlike several other countries, the EMDC has one nationwide alarm emergency telephone number (113) and can easily be re-directed from other emergency numbers. The direct number to the EMDC shortens the access time by about 20 seconds. [124] The direct EMDC number may also reduce the fear of bystanders in becoming involved with law enforcement personnel.[37] Currently, an application available for mobile phones will connect with the EMDC and automatically provide the position of the caller by using GPS.[125] In OHCA incidents, the EMCD initiates a response by one or two ambulances, an EMS physician-manned rapid response unit and the local GP on call, ensuring at least one physician and two ambulance units arrive at the scene. In cases where resuscitation do not lead to the return of spontaneous circulation (ROSC), the OHCA assignments are terminated at the scene, or the patient is transported to the hospital with ongoing resuscitation.

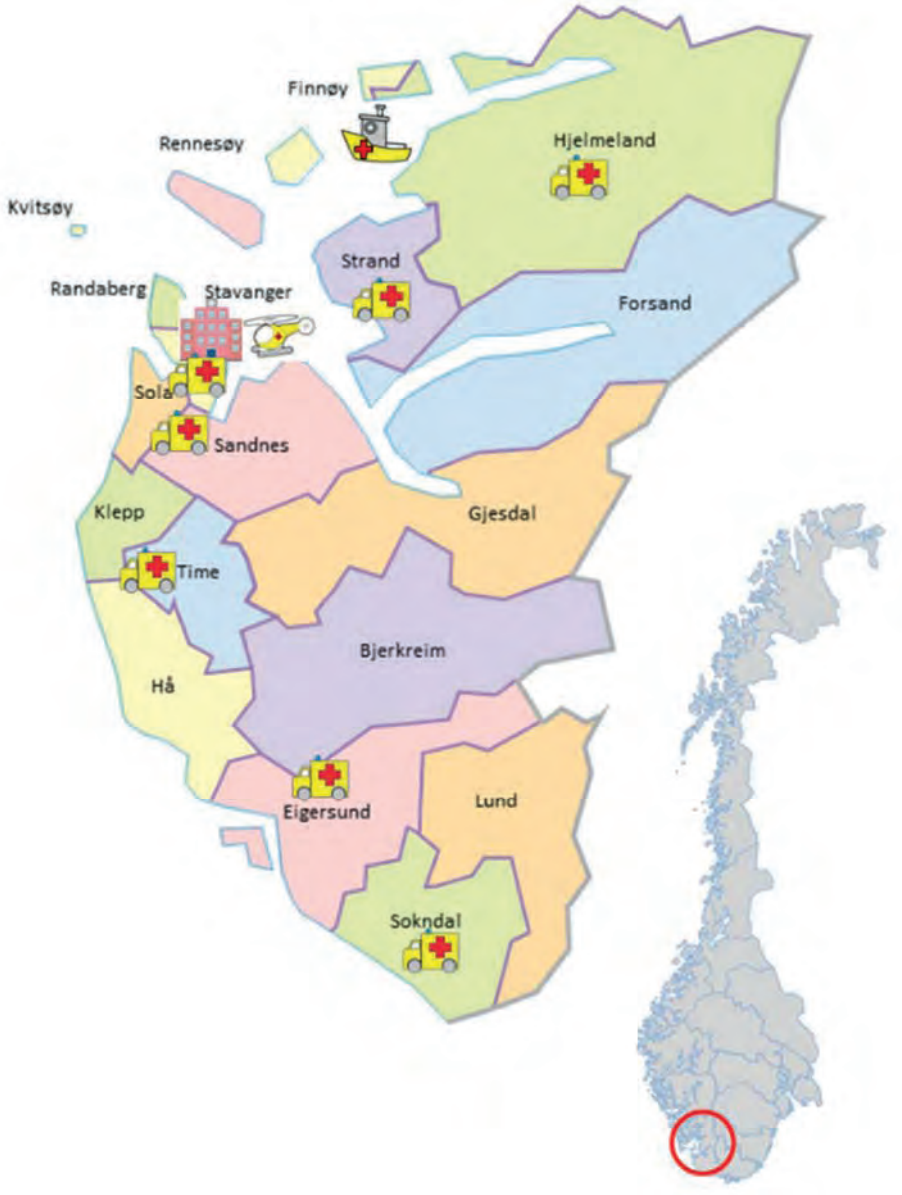

Figure 1: Eighteen municipalities constituting the Stavanger region with illustrations representing the deployments of ambulance-stations, helicopter-base, rescue-boat and hospital.

1.5.2 Norwegian Index for Medical Emergency Assistance

Most of the emergency calls in Norway are managed using the Norwegian Index for Medical Assistance, an index criteria-based guideline that aims to assist the dispatcher in securing the correct response as quickly as possible by supplementing medical knowledge and experience for the individual dispatcher.[126] The criteria-based approach allows for a dynamic interaction between the caller and dispatcher, but it has been criticised for inadequacies in monitoring the dispatch process and determining guideline adherence.[126] Prior to 2017, in cases of suspected cardiac arrest, the EDC would instruct the bystander to provide chest compressions for 10 minutes before including mouth-to-mouth resuscitation.[127] In cases of suspicious asphyxia, mouth-to-mouth resuscitation was recommended from the start.[127] In the upcoming recommendations during 2018, the dispatcher will start instructing continuous chest compressions for untrained bystanders and conventional CPR for trained bystanders.[128]

1.5.3 Bystanders and dispatchers; interactions and challenges

EMS represent a system of resources that are ready to be dispatched when needed. Thus, dispatchers play a critical role in the recognition of cardiac arrest.[20] Key information from callers are ‘unresponsiveness’ and ‘not breathing normally’, and these pieces of information help EMS dispatchers identify OHCA incidents.[20] Dispatchers have an influential role in OHCA incidents when it comes to guiding lay rescuers over the telephone on how to provide CPR (T-CPR). This role requires specific training to deliver clear and effective instructions. [129] Regarding bystander non-technical skills, there is a strong emphasis on resuscitation training in the 2015 ERC guidelines for resuscitation.[130] However, incorporating communication with dispatcher in CPR training is rare.[112]

Although T-CPR has been associated with improved survival outcomes,[131, 132] studies have shown conflicting findings on the effectiveness.[133-135] Abnormal breathing is the most common barrier for dispatchers when it comes to identifying cardiac arrest.[136, 137] Also, how breathing is reported by the caller may cause delays.[138, 139] Oman et al. stated that many callers are willing to attempt T-CPR, but the questioning/instruction process causes significant delays.[140] Lewis et al. stated that delays in the delivery of T-CPR are common and occur because of a mixture of dispatcher behaviour and factors beyond the control of the dispatcher.[141] In addition, delays can be caused by the co-operation of the bystander, the quality of the telephone line, the skill of the dispatcher, ambient noise and distraction for the caller and the clarity of the instructions given.[139, 140, 142]

1.6 Local and national cardiac arrest registries

To ensure a national and international agreement of a structured framework for reporting OHCA incidentsincluding bystander CPR, hence ensuring valid cross-community comparisons, a consensus meeting at the Utstein Abbey, Rogaland, Norway was held in 1991 and later updated in several follow-up meetings.[19, 55] Uniform terms and definitions were agreed upon, allowing for a better understanding of the epidemiology of cardiac arrest, facilitating system comparisons, enabling a comparison of different system approaches, acting as driver for quality improvement and identifying gaps in knowledge and supporting clinical research.[19]

Since 1996, all EMS attended OHCA missions that cover the 18 municipalities in the Stavanger region, have been registered in the local hospital-run Utstein registry.[8] Since 2013, the National Advisory Unit on Prehospital Emergency Medicine (NAKOS) has established a national cardiac arrest registry for Norway.[143]

1.7 Utstein template for style and reporting

The recommendations at Utstein Abbey in 1991 have been called the 'Utstein template'.[144, 145] Since the meeting, 16 consensus papers have been issued, and Utstein has now become the standard template for reporting OHCA data in scientific reports.

The 2015 Utstein template's variables are detailed and grouped according to five domains: system, dispatch, patient, process and outcome.[19] When EMS personnel perform chest compressions or attempt defibrillation, this is recorded as a resuscitation attempt by EMS personnel.[19] OHCA cases where resuscitation is not attempted by the EMS because of a 'do not resuscitate order' or 'obvious signs of death' are generally excluded from further analysis in most studies on OHCA. However, in cases where signs of life after bystander CPR or defibrillation occur preventing the EMS from further resuscitation, the cardiac arrest victim is included.

The separation of the most likely primary cause of cardiac arrest into a cardiac or non-cardiac cause has been essential for comparisons of groups and standard reporting procedures. However, the separation of these events has proven to be subjective assessments, with the possible affection of the comparability of study results.[19, 146, 147] Given this variation, the 2015 ERC guidelines for reporting OHCA was changed into medical causes (meaning presumed cardiac or unknown cause or other medical causes, e.g. anaphylaxis, asthma and gastrointestinal bleeding) and other causes (e.g., traumatic, drug overdose, drowning, electrocution, asphyxia and not recorded).[19] Unknown causes are deemed medical causes.[19]

1.8 Out-of-hospital cardiac arrest, incidences and outcomes

OHCA is a major cause of death in industrialised countries (there is still limited knowledge of OHCA incidences in developing countries), and survival rates differ substantially from 2–25%.[8, 11, 62] The reported

incidence of EMS-treated sudden cardiac arrest in the United States is approximately 55 per 100,000 people per year, and there is an 8.4% survival rate for all-rhythm arrests.[5] The equivalent incidence in Europe is approximately 38 per 100,000 people per year and 10.7% survival rate for all-rhythm arrests.[4] In 2003, Langhelle et al. reported the percentage of patients discharged alive from hospital to be 20% in the Stavanger area versus 10–12% in the other three Norwegian regions studied.[148] In 2011, the good survival rate in the Stavanger region was confirmed in a report by Lindner et al.[8] Using these reports, the Stavanger region was acknowledged as one of the leading regions in the world for OHCA survival.

For decades, some leading researchers within the field of OHCA have been encouraging stakeholders in acknowledging that it takes a system to save a life; these researchers have systematically been improving the steps required to save lives after an OHCA incident, including training CPR to the public.[149] Despite these efforts, worldwide reports confirm low CPR rates and dismal survival rates after OHCA incidents.[7, 150] However, lately some reports have shown improved survival rates that are significantly associated with a concomitant increase in bystander CPR (Table 1).[103, 151] The improvements have resulted in a threefold increase in survival rates over the past 15 years in Denmark.[103, 151] A 5-year study from London concluded that the observed increased CPR rate has, among other important changes made and contributed to the rapid increase in OHCA survival.[13] Improvements in all four links in 'the chain of survival' could explain the doubling of long-time survival in Sweden.[14]

Table 1: Bystander CPR rate and patient survival rate in selected countries and regions

Country/ region	Bystander CPR rate, %	Patient survival to hospital admission, %	Patient survival to hospital discharge, %
Norway[152]	83	29*	14**
Denmark[153]	65.8	24	12.7**
Sweden [154]	74	25	11**
Victoria ambulance (Australia)[155, 156]	68.6	34***	12.1***
USA[157]	34.4		9.6
Seattle/ King county (USA)[158]	73		22
Japan[150]	40.2	27.3	5.2
Korea[150]	40.9	20.4	8.5
Singapore[150]	24.3	17	2.5

CPR: cardiopulmonary resuscitation
*Sustained return of spontaneous circulation or patient survival to hospital admission
**30-day survival
***Cardiac cause

The use of the cerebral performance category (CPC) is recommended for reporting the neurological status at hospital discharge and/or at 30 days and at 1 year.[19, 159] For most patients who survive after hospital discharge, the neurological outcomes are generally favourable.[160] In a long-term perspective, resuscitation of OHCA victims are favourable in terms of years lived after incident.[161]

2 Theory

2.1 Theoretical framework

When studying a phenomenon, it is assumed that subjective knowledge is useful and informative, and there is meaning and understanding which reflect various views of the phenomenon.[162] These various views are fundamental to the way in which individuals act, understand, form our beliefs and view the world.[162] The work in the current thesis is built on the acceptance that each bystander will experience an OHCA incident differently. The following theories of chain of survival, the Utstein formula for survival, phenomenography, risk perception and how bystanders perceive their cardiopulmonary resuscitation serve as the theoretical framework for exploring the implications of bystander CPR.

2.2 Philosophical considerations

Social research is often conducted against the backdrop of traditional theoretical and methodical ideas that have been developed over the years and are referred to as research paradigms.[163] Research paradigms are the source of ontological ideas (i.e., the nature of what exists), epistemological assumptions (i.e., how we know what we know) and methodology (how knowledge can best be learned).[163] In contrast to the position of positivism, where the view of reality is based on what can be perceived by the senses,[163] the overarching philosophical position in the current thesis is based on social constructivism, meaning that a major premise for human behaviour takes place in the specific sociocultural, political and historical contexts in which the research occurs.

Social constructivism states that although the material and social worlds are experienced by most individuals as objective and pre-existing realities, meaning and knowledge are reproduced through social interaction and socialisation and hence rely upon shared definition.[3] The following three assumptions are central to this approach:[164]

1. The social reality is not stable but rather changes continuously.
2. There is no objective social reality but rather different understandings of reality.
3. The understanding of reality can only be mapped by taking into account how people interpret and perceive specific social phenomena.

Intersubjectivity is a central concept in social constructivism. Although the ontological assumption is that all knowledge is subjective, the position also recognises that several individuals may perceive the same phenomenon in the same way. Thus, the perception and understanding are similar across individuals.[164]

Applying the social constructive perspective to the current project implies the direction of interpretation of the data, how experiences are understood and how foundations for choices are being made by individuals. Because the aim of the current project is to investigate the preconditions for and consequences of bystander CPR, the social constructivism perspective allows us to capture the complexity of how members of the public are prepared for and how they experience a CPR intervention. Social constructivism is also the overarching philosophical position applied while studying the general publics' knowledge and expectations regarding dispatchers in an OHCA setting and when studying how the deployment of EMS resources interacts with the outcome of bystander behaviour.

Critics of social constructivism argue the position of social structures emerge from the actions of individuals. [165] Because individuals have the ability to act back on structures and because structures can condition agents' behaviour in different ways, social reality is an open system.[165] However, it is in the interest of the current project to investigate both how structures affect bystanders' behaviour during OHCA incidents and also their critical stands toward the structures. Thus, we use a pragmatic stance as the chosen position in this research.

2.3 Phenomenography

The current project entails two qualitative and two quantitative studies. In the qualitative studies, we applied phenomenography as the research approach. Created from educational psychology of Marton et al., phenomenography has developed into a distinctive qualitative research approach for studying a broad range of phenomena, including health care.[162] Marton claimed that we cannot separate the social and cultural structures and the content of an experience from one another.[166] Thus, the phenomenography research approach is in line with the research position of social construction taken in the present thesis.

Phenomenography aims to describe a span of various human experiences by identifying the similarities and differences, emphasising collective meaning.[162] The aim of the approach is to find and systematise forms of thought in terms of which people interpret significant aspects of reality.[166] Thus, phenomenography aims at the description, analysis and understanding of people's experiences of various aspects of the world (also called the second-order perspective) rather than describing the world as it is (first-order perspective).[166] In the first-order perspective, a statement is considered to be a statement about a specified situation and is judged in the light of other statements of the same situation.[167] In the second-order perspective, the same statement can be considered as reflecting the individual's way of experiencing and making sense of the phenomena and having skills related to them. In the current PhD project, using phenomenography as a research approach allows us to find variations in the bystanders' perceptions of the OHCA incidents. Phenomenography deals with what is culturally learned and with what the individually developed ways of relating ourselves to the world are.

Several alternative qualitative research approaches to phenomenography could be used for the qualitative studies in the current project. The philosophy behind the often-applied phenomenology in social research is the assumption that there exists an essential, perceived reality with common features.[168] The notion of individuals' pre-understanding of a

phenomena is an important concept from phenomenology that is used in the hermeneutic research tradition.[169] Because providing CPR in real OHCA incidents is rarely experienced, most people do not share a common perceived reality of this phenomenon. Thus, this research approach has limited value in this project. The use of a grounded theory to develop an explanatory theory of basic social processes requires an unknown and continuous addition of participants who must reach theoretical saturation.[168] This requirement did not fall within the resources of the qualitative studies in the current project.

2.4 The chain of survival

Survival after OHCA depends on a series of particular sequences of interventions that must be conducted as rapidly as possible. The sequences are integrated in a concept model called 'the chain of survival', which launched in 1991, has been twice revised,[18] and has become an important tool in CPR training and clinical health care (Figure 2).[144, 170, 171] In the latest revised model, the role of dispatcher-assisted CPR is emphasised and is thus more applicable for the current thesis.[144] With its four pre-hospital links – early access, early CPR, early defibrillation and early advanced care – and one in-hospital care link, the chain of survival emphasises dependence and connection in every link (Figure 2).[144] Weakness or delay in any link decreases the chance of survival.[144, 170] It has been estimated that the survival probability falls 6% to 10% each minute without any CPR provided.[77, 79, 81] Thus, early recognition of cardiac arrest is critical.[20]

Figure 2: The chain of survival [144]

1. The first link in the chain of survival is called 'Bystander calls for help and starts CPR'. Because the EMS witnesses only about 7% of all OHCA incidents,[103] bystanders are the most prominent group that observes unresponsiveness and abnormal breathing in cardiac arrest victims and then alarm the emergency dispatch centre.[20] Early initiation of CPR is of pivotal importance. Defibrillation attempts to correct any abnormal activity in the heart can be achieved by public access or on-site AED.[86, 88, 172, 173]

2. Dispatchers are emphasised in the second link: 'Dispatchers activate resources and coaches quality T-CPR'.[144] The EMS dispatcher plays a critical role in the early recognition of cardiac arrest, supporting bystanders in initiating CPR, and supplying information of AED and PAD locations. [20, 97, 131, 132, 174]

3. The third link is '1st responders/emergency medical teams providing high-performance CPR and defibrillate'. Mobile-phone positioning systems used to dispatch lay volunteers for CPR and AEDs increase survival.[175, 176] Any delay of defibrillation will reduce the chance of the return of spontaneous circulation (ROSC).[20]

4. The fourth link is 'Paramedics provide advanced life support'. This link includes advanced life support (ALS) given by EMS personnel that is executed according to current guidelines and with high-quality CPR and timely defibrillations. Paramedics can provide ALS, including advanced airway management, intravenous medications, manual defibrillations and so forth.[18, 177]

5. The fifth link is 'Hospital provides post-resuscitation care'. The last link involves in-hospital advanced post-resuscitation care for continued diagnosis, monitoring and treatment. Securing the airway, breathing, circulation (while assessing the need for coronary invasive management) maintaining normoglycemia and controlling body temperature are key interventions required to optimise the outcomes of cardiac arrest patients. [57, 178-181]

Although the chain of survival illustrates the steps needed to save a cardiac arrest victim, a well-functioning chain rests on preparedness. However, bystander CPR training is not included in the model, nor any follow-up for bystanders who have provided CPR.

2.5 The Utstein formula for survival

Many key factors associated with survival in an OHCA incident have been identified, yet a full explanation for the worldwide variances in survival has not been found.[182] Differences regarding the quality of local 'chains of survival' may be a contributing factor to the variability.[182] It has been stated that patient outcomes depend not only on the validity of the treatment guidelines, but also on the quality of education and on a well-functioning chain of survival.[183] These factors are presented in a model integrating medical science, educational efficiency and local implementation and form multiplicands in determining survival after resuscitation (Figure 3).[182] The components of the formula for survival entails guideline quality, efficient education of caregivers and a well-

function local chain of survival. When optimising all three factors in the formula of survival, an idea of the potential for improvements is given.[182]

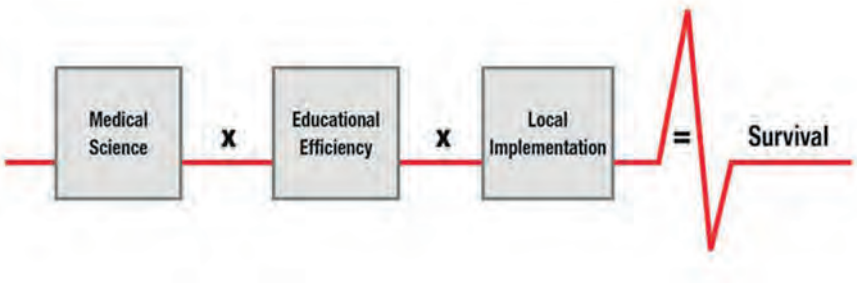

Figure 3:The Utstein formula of survival[182]

The model points to the need of focusing on communities as a whole system of care, involving clinicians, stakeholders and the public to increase survival chances.[182] Lower rates of CPR training are associated with lower CPR rates.[184] Some systems have a long history of acknowledging this by establishing community approaches to improve resuscitation after cardiac arrest.[1, 149, 185] Lay person CPR training is an important strategy in this approach and has a long-standing tradition in Norway.[113]

2.6 Risk perception

Extensive CPR training by lay people is an important part in improving CPR rate by bystanders in OHCA incidents. However, even CPR-trained bystanders omit the provision of CPR for different fear-related aspects.[36, 37] The term 'risk' refers to the uncertainty about and severity of the consequences (or outcomes) of an activity regarding something that humans value.[186] When 'risk' is mostly used as an expected value, the term 'risk perception' has a distinct contextual aspect connected to it, meaning that people respond to their own risk constructs and images.[187]

How people think about the seriousness and acceptability of risks and how they make judgments are influenced by their knowledge, values, feelings and judgments of others and are constantly moderated through social and cultural learning (Figure 4).[187]

According to Renn, 'risk perception' denotes the processing of physical signals and/or information about potential harmful events or activities and the formation of a judgement about the seriousness, likelihood and acceptability of the respective event or activity.[187] The inevitable implication of a cardiac arrest is that a human life is at stake, and different aspects of fear are reported as barriers to providing CPR.[36, 38] When applying the risk perception theory to bystanders, the choice of intervening in an OHCA incident could have both positive and negative implications, including loss of life and being recognised. Thus, a risk perception perspective is pertinent when studying how barriers in providing CPR are overcome.

Renn purposes a multi-dimensional model of risk perception that comprises psychological, social and contextual factors for how individuals perceive risk (Figure 4).[187] The first level contains heuristics of information processing that apply to how individuals use common-sense reasoning for judging the seriousness of the risk in question. The second level of cognitive and affective factors refers to what people believe to be true and to the feelings about what is good or bad in terms of the causes and consequences. The third level refers to social and political institutions, that is, trust in organisations, personal and value commitments and media. The fourth level refers to cultural factors that govern many of the lower levels of influence. In conclusion, to understand risk perception, one needs to study the psychological, social and cultural components and their mutual interactions.[187]

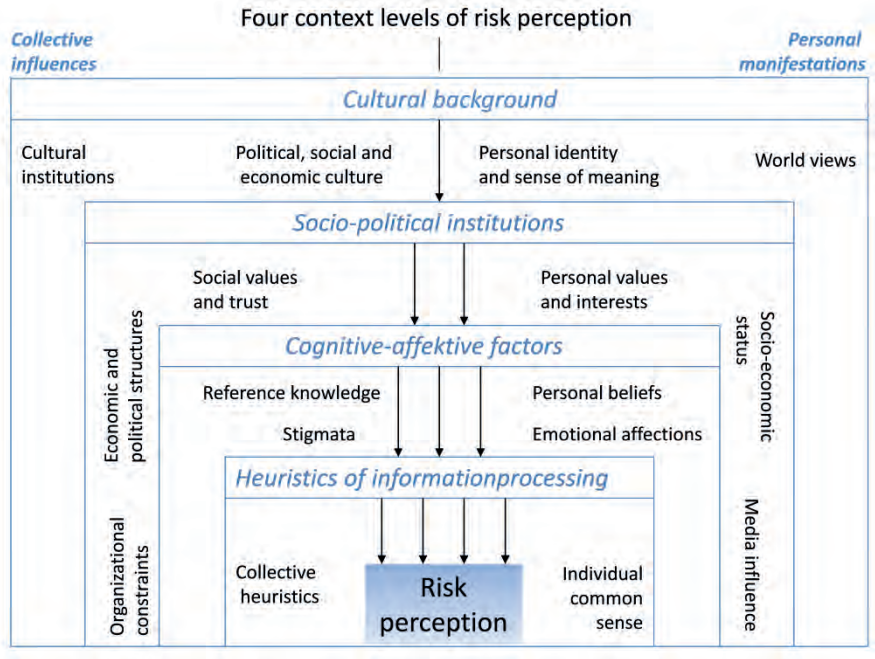

Figure 4: Four context levels of risk perception by Renn and Rohrmann[187]

2.7 Decision making

Psychological dimensions add important knowledge for understanding bystander behaviour in an OHCA incident. Kahneman stated that the following:

> 'The study of decisions addresses both normative and descriptive questions. The normative analysis is concerned with the nature of rationality and the logic of decision making. The descriptive analysis, in contrast, is concerned with peoples' beliefs and preferences as they are, not as they should be. The tension between normative and descriptive considerations characterizes much of the study of judgement and choice.'[188]

Because we understand bystander CPR as a dichotomous action (CPR provision versus no CPR provision), this action can be illuminated by the following theories. Samuelson et al. have shown that people frequently adhere to status quo choices in decision making under uncertainty because individuals weigh the potential losses of switching from the status quo more heavily than the potential gains.[189] Thus, the status quo situation implies doing nothing or maintaining one's current or previous decision.[189] Delayed or omitted actions because of ambiguity in the incident can be a reason for individuals not acting in rational ways.[190] Fear increases the desirability to withdraw behaviour.[191] Because of diffusion of responsibility (the need to intervene in a situation decreasing as the number of other witnesses increases), where groups are gathered, individuals are less likely to help victims in emergencies.[192]

2.8 The CPR intervention

Except for CPR training, limited research is available on how factors influence CPR provision. In an effort to improve the dismal CPR rates in Sweden, Axelsson et al. conducted a qualitative study where they identified five main categories that describe the bystanders' perceptions of the initial phase of their CPR intervention.[23] These five perceptions – to have a sense of humanity, to have competence, to feel an obligation, to have courage and to feel exposed – served as a framework in Paper II. Thus, we used the knowledge of how bystanders perceive their CPR intervention when studying how lay rescuers overcome barriers to provide CPR.

3 Methodology

3.1 Study design

The current project entails both qualitative and quantitative research methods. By combining the methods, we aimed to merge the strengths of both approaches for developing a stronger understanding of the research question.[193] Regardless of the various methods, for example, 'mixed methods',[194] 'triangulation,'[195, 196] 'multiple method study'[193] and 'multi-strategy design'[197] the idea behind a mixed methods approach is more or less the same: to provide an explanation or insight that is based on several methods but with different approaches.[194, 195]

To obtain a deeper understanding of the research question, we started the investigation using qualitative methods and followed up by using quantitative methods for larger sampling, enabling us to generalise the findings to a broader population. [193]

In the qualitative studies described in Paper II and Paper III, we aimed at obtaining data of bystanders' experiences of OHCA incidents. Semi-structured in-depth interviews seemed feasible because they facilitate detailed descriptions of the bystanders' experiences and mutual clarifications between the bystander and interviewer.[198] The quantitative methods used in Paper I are based on the findings of both the qualitative studies, while in Paper IV, the study concept is within the frames of a registry where the variables are set.

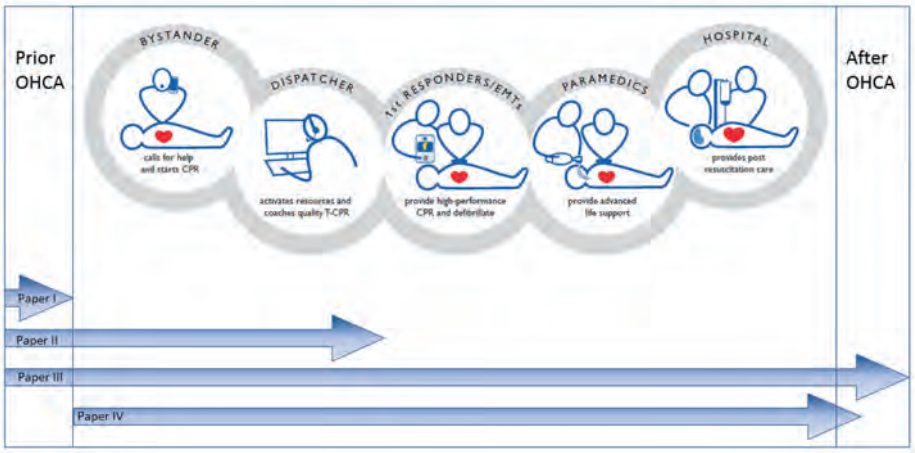

Figure 5: Illustration of intervals each study refers to according to activation of the chain of survival

The findings in the studies using qualitative methods are directional for how the studies using quantitative methods are structured. In this way, explicit results from the qualitative methods are brought into the quantitative studies.

We use a descriptive and exploratory design, as well as a cross-sectional design, in the four studies. The qualitative and quantitative approaches are used separately for each study, yet in the overall discussion, they are combined. The two qualitative studies entail data from interviews while the quantitative approaches use survey and registry data.

Table 2: Overview of methods, participants, and recruitment processes and data analysis methods

	Paper I	**Paper II**	**Paper III**	**Paper IV**
Aim	To assess the knowledge and expectations among the general public towards the assistance of dispatchers in an OHCA incident	To gain a better understanding of how barriers to providing CPR are overcome	To explore the reactions and coping strategies in bystanders after providing CPR to OHCA victims	To examine how bystander CPR, EMS response time and EMS physician attendance influence survival at different points of care and to what extent this differs between rural and urban areas
Design and data collection method	Cross sectional survey, individual interview of public citizens	Observational, individual in-depth interview of bystanders having provided CPR	Observational, individual, in-depth interview of bystanders having provided CPR	Observational, retrospective analysis of OHCA registry data
Recruited from/ by	Public space	Intensive care unit, SUH and local cardiac arrest registry	Local newspaper, ambulance, personal network	Quantitative, statistical analysis
Analysis	Quantitative, statistical analysis	Qualitative content analysis	Qualitative content analysis	
Number of participants/ patients	500	10	20	1138
CPR, cardiopulmonary resuscitation; EMS, emergency medical services; OHCA, out-of-hospital cardiac arrest; SUH, Stavanger University Hospital				

3.2 Data collection in the qualitative studies

3.2.1 Sample size

In the qualitative studies, we planned for the participant sample size according to the aim of the studies. Malterud et al. proposed that the

choice of the sample size must rely on the contribution of how much 'information power' the sample holds.[199] The information power is built using a set of aspects: study aim, sample specificity, established theory, quality of dialogue and analysis strategy.

A narrow study aim requires a smaller sample size.[199] In Paper II, we aimed at gaining a better understanding of how barriers to providing CPR are overcome, which means the focus of the study was the participants' preparedness in the pre-cardiac arrest stage and experiences during the initial phases of the chain of survival (Figure 5). In Paper III, we aimed at exploring the participants' preparedness in the pre-cardiac arrest stage, experiences during the initial phases of the chain of survival and reactions and coping strategies following CPR provision (Figure 5). As so, we aimed to cover a broader perspective in Paper III compared with Paper II and thus requiring fewer participants for the latter study. In both studies, we ensured sample specificity by including only, except for one, participants who had provided chest compression and/or ventilation to the cardiac arrest victim.

In Paper II, we used established theory, allowing for fewer participants compared with Paper III, where we have limited support regarding the theoretical perspectives used. We strived to establish good quality dialogues in the interviews by conveying our sincere wish for obtaining insights into the participants' experiences. In both qualitative studies, we used the content analysis approach,[200] where the interviews of 10 participants in Paper II and 20 in Paper III, provided descriptions that are sufficient in illustrating the various aspects within our research question.[199] We tried to continuously evaluate the information power during the research process. In Paper III, we reduced the dominating population of bystanders involved in incidents with positive outcomes by declining to include three participants, and we particularly searched for participants involved in incidents where death was the outcome.

Another way of judging the sample size in qualitative research is by using 'data saturation', meaning the point when the researcher no longer

receives information that develops the study's theory.[199] The term originates from Glaser and Strauss' 'theoretical saturation' and has spread to most qualitative environments.[201] The term is connected to Grounded Theory, which is a constant comparative method for qualitative research.[202] However, the assumption that sampling a definite set of variations obtained and covered by saturation may contradict to most qualitative research,[203]and thus not applied in this project.

3.2.2 Inclusion criteria and procedure in Paper II

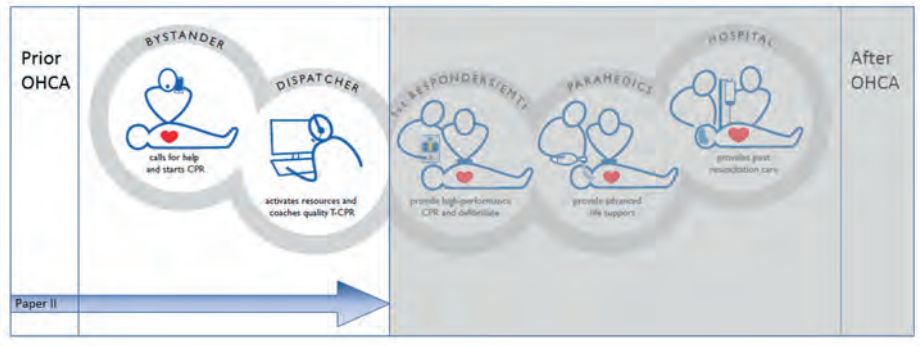

Figure 6: Paper II – The area of investigation: Participants' experiences prior to and during the two first links of activation of the chain of survival

The inclusion criteria in Paper II were as follows: participants 18 years or older who had provided CPR to a witnessed or unwitnessed, non-traumatic, adult OHCA incident with no professional obligations. We also included one bystander who communicated with the EMS and provided assistance in the incident.

Because most OHCA incidents happen in homes, we assumed that most potential participants would be family members. This knowledge led us to approach family members of OHCA patients registered in the local cardiac arrest registry and who survived to hospital discharge. We invited these people to participate in the study. One family member of an OHCA

patient was approached directly in the intensive care unit. In six of the cases where CPR was provided by a person outside the family, the invitation to the study was forwarded by the family to the person who provided CPR. In sum, 10 lay rescuers involved in eight OHCA incidents were included. Seven interviews were carried out in a designated room in the hospital area, two in the participant's residence and one in a workplace. All interviews were conducted face to face by one interviewer (WTM).

3.2.3 Inclusion criteria and procedure in paper III

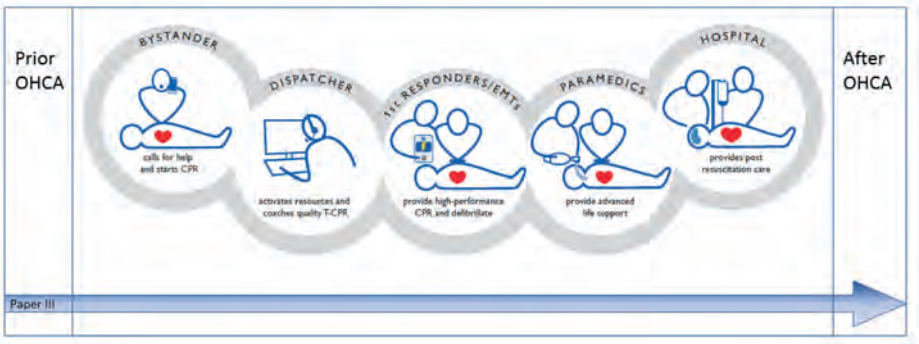

Figure 7: Paper III – The area of investigation: Participants' experiences prior to, during and after activation of the chain of survival

In Paper III, the inclusion of participants was initially designed as a prospective research strategy where bystanders having provided CPR would be approached by attending ambulance personnel at the OHCA scene with an invitation to participate in the study. By this strategy, we recruited only one rescuer. This observation led us to alternative ways of including participants. A purposive snowball strategy starting with the researchers' personal network and bystanders who contacted WTM after a study feature in the local newspaper wanting to participate led to an additional retrospective angle. In sum, 20 bystanders participated in the study. Eighteen interviews were conducted face to face while two were

telephone interviews. All interviews were conducted by one or two interviewers (WTM, CAB).

3.3 Data collection in the quantitative studies

3.3.1 Sample size

In Paper I, we aimed at assessing the knowledge and expectations among the general public towards the assistance of dispatchers in an OHCA incident. In the data set, we reflect the composition of the general population in the Stavanger region, with two-thirds living in urban areas and one-third in rural areas. We estimated the sample size for the survey according to the general population density in the Stavanger region. For the purpose of the quantitative studies, we regarded the most densely populated areas as urban municipalities if they have over 200 inhabitants per km2 and less than 200 inhabitants as rural areas. To ensure a variation of both men and women at all ages over 16 years, different education levels and having attended CPR training or not in both the urban and rural group, we assumed that approximately 167 interviews in the rural group and 333 in the urban group (a sum of 500) would attain a +/- 4.3% within the true value of the general population and entail a sufficient number of interviews for mapping public knowledge and expectations to dispatcher assistance in OHCA incidents. However, adding more participants would strengthen the reliability. Because the trends and attitudes among the public toward dispatcher assistance in OHCA incidents was the aim of the current study, we regarded this estimate to be acceptable.

In Paper IV we aimed to examine how bystander CPR, EMS response time and EMS physician attendance influence survival at different points of care and to what extent this differs between rural and urban areas. The number of available subjects for inclusion in the study was within the limitation of the local Utstein registry. Since 1996, the registry has been on going and contains data from more than 4,000 OHCA incidents. We considerd 10 years (2006–2015) of the registry data as suitable for

analysis. In general, the data in OHCA registries reflect changes in the factors affecting patient survival, such as CPR guidelines, pre-hospital and in-hospital patient treatments, causing a potential confounding bias. However, the last major change in the guidelines for advanced life support in the current system was in 2005, and the guidelines were implemented in the local EMS in the same year.[8, 204] There have been no major changes in pre-hospital, in-hospital OHCA patient treatment or in the data collection routine during the study period.

3.3.2 Inclusion criteria and procedure in Paper I

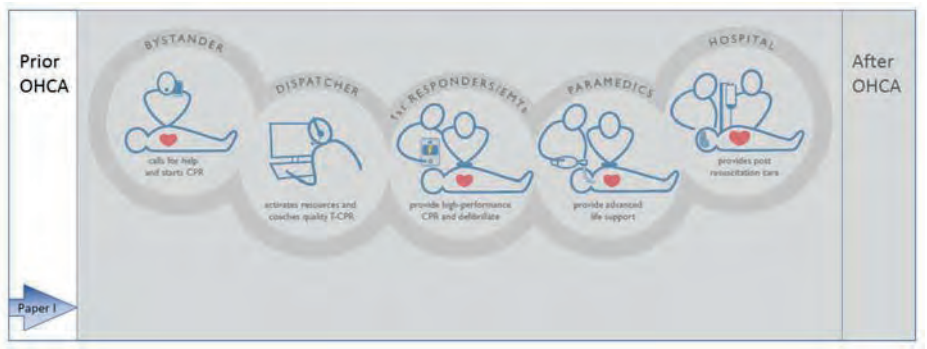

Figure 8: Paper I – The area of investigation: Participants knowledge and expectations prior to activation of the chain of survival

We constructed a questionnaire suitable for answering our research question. The questionnaire was readjusted several times in an internal audit process conducted by the researchers. A pilot experiment with 10 participants served as a base for the final evaluation. In the day, we approached adult members (≥16 years) of the general public. We chose a discretionary selection strategy, meaning the interviewers chose participants who seemed to be suitable for answering the aim of the study.[164] The inclusion criterion was the ability to be able to communicate in a Scandinavian or English language. Individuals at 12 different sites in both urban and rural at ferry, railway and bus stations

were approached. Also, we approached individuals outside grocery stores and in public places where people of all ages and social statuses are expected to frequent. In sum, 500 interviews were executed. The participants were presented to a hypothetical OHCA scenario followed up by the questionnaire (Figure 8). All data were directly or indirectly handwritten and then later entered into a SurveyXact database (Rambøll Management Consulting, Århus, Demark 2017).

3.3.3 Inclusion criteria and procedure Paper IV

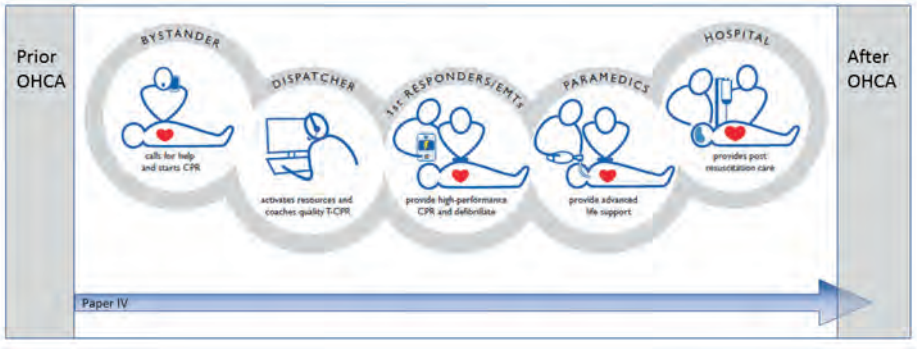

Figure 9: Paper IV – The area of investigation: OHCA patient outcomes according to the entire chain of survival

In paper IV we used data from the local Utstein template based[19] OHCA database run by SUH since 1996. Data are collected from the ambulance, the rapid response unit and the EDC and are cross-checked before being entered by a designated nurse into the database. In the current study, we assessed all prospective datasets of individuals aged ≥18 years collected between 1 January 2006 and 31 December 2014. For OHCA incidents in 2015, data were collected from the Norwegian National Advisory Unit on Prehospital Emergency Medicine (NAKOS). All data retrieved from the

local hospital- managed OHCA registry were entered into a FilemakerPro6 database (Filemaker, Inc., USA).

3.4 Data analysis in the qualitative studies

3.4.1 Methodological research approaches

In Paper II, we used a combined deductive and inductive research strategy. A deductive strategy is used when the questions or categories used for data collection are derived from theory or prior research.[205] Also, a deductive strategy is useful for explaining any social regularity that has been discovered but is not understood.[163] Axelsson et al. proposed five main categories for bystanders' perceptions of providing CPR.[23] Using these categories as a framework for Paper II, we investigated further preconditions for providing CPR. Data not relating to the purpose of the study were excluded from further analysis.

In Paper III, we mainly used an inductive research strategy. Using this research strategy, we let the participants decide which aspects of the phenomenon they wished to focus on by starting the data collection with open, non-directional questions.[205] We looked for similarities and differences in the data and then described them in categories and themes on various levels of interpretation.[200] All data were included in the analysis. However, because the bystanders repeatedly turned their answers toward how they experienced life after the OHCA incident, we selected the predominant findings concerning consequences for further analysis.

3.4.2 Qualitative content analysis

The analysis process conducted in Paper II and Paper III are adapted by the qualitative content analysis of Graneheim and Lundman (Figure 8), which is a research procedure for achieving trustworthiness throughout the research procedure.[200]

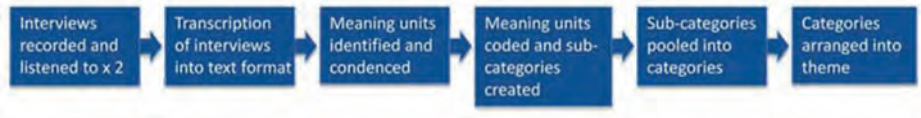

Figure 10: The quality content analysis illustrated by a stepwise process

The qualitative content analysis used in Paper II and Paper III involves a stepwise approach to interpret both manifest and latent content, including the abstraction of text (Figure 8). After the interviews were conducted, they were transcribed into text and read through several times. Words and sentences containing aspects related to each other in their content and context were considered meaning units (codes).[200] The meaning units were then condensed, which is a process of shortening the text while still preserving the core meaning.[200] By comparing and contrasting characteristics, we grouped the codes into sub-categories and then pooled the sub-categories into categories.[206] Finally, we captured the overarching theme that represented the 'meaningful essence' that brought meaning to recurrent experiences.[206, 207] We kept each step to a logical and congruent level of abstraction and interpretation degree.[206]

3.4.3 Interpretation degree and abstraction level

Graneheim and Lundmans' presumption when analysing text is that there will be the involvement of multiple meanings and interpretation when approaching the text.[200] A basic issue is to decide whether the analysis should focus on manifest or latent content or both. A manifest content analysis deals with the visible, obvious components of the text, while the latent content deals with the relationship aspect, involving an interpretation of the underlying meaning of the text. Latent content may be distanced from the text but is still close to the participants' lived experiences.[206] In Paper II and Paper III, the position chosen for the data analysis were high abstraction level and high interpretation degree, although we resisted drawing the interpretations too far to avoid

generalising the findings.[200, 206] Using a low abstraction level and a low interpretation degree means there will be an analysis with close adherence to the text.[206] Because the texts in the qualitative studies varied in their manifest and latent content, the interpretation level varied. Thus, we were pragmatic about the research position.

Table 3: Examples of interpretation and abstraction of meaning units

Paper	Meaning unit	Condensed meaning unit, description close to the text	Condensed meaning unit, interpretation of the underlying meaning
II	'I believe we have a responsibility to our fellow human beings. I think so. We have, anyhow. So we are a community which interacts. I believe that having a helping attitude makes us better humans'.	Taking responsibility as a citizen of a community.	Feeling obligated to provide CPR.
III	'I was very concerned about dying, to die just like that, so horrible and in public and because of my mistakes. That he died because I made mistakes. I was obsessed about this'.	Self-blaming for having not provided sufficient CPR.	Self-criticising the quality of the CPR.

3.4.4 Trustworthiness

Any interpretation is inevitably an essential issue when discussing trustworthiness in qualitative research [200] because the analysis of the findings can be interpreted in various ways and can give more than one meaning.[208] Malterud stated that relevance, validity and reflexivity are essential standards when discussing the scientific quality of qualitative research.[209]

The relevance of the research is thoroughly described in the articles and in the current thesis. To ensure validity, we have provided descriptive reports on the research settings and participants. We included participants who differed in gender, age, relation to the cardiac victim and outcome. Despite limited success with our inclusion strategies, the number of

participants is sufficient for representing various experiences to clarify the research questions.[206] We also declined three interviews to reduce the dominating population of lay rescuers in OHCA incidents with positive outcomes.

Malterud defined reflexivity as the attitude of systematically attending to the context, in particular to the effect of the researcher on knowledge construction.[209] Two of the authors responsible for the interviews and for interpreting the data (WTM and CAB) read and re-read the interviews independently and discussed the choices made during the analysis process until a consensus was reached. Acknowledging that the researchers' preconceptions of the phenomena in qualitative studies influence their interpretations, some positions need to be mentioned. In particular, WTM's knowledge on social trust may have influenced the research process in Paper II. CAB's experiences as a pre-hospital physician with experiences encountering bystanders in OHCA incidents may have influenced the interpretations of the findings in Paper III. Rich quotations from various participants are given in the results section to show the validity of the codes, sub-categories, categories and themes. [200] However, the underlying notion in qualitative research is that the data and interpretations of the data are co-creations of the researchers and participants during the interviews, and that interpretation during the analysis phase is a co-creation of the researchers and the text.[206] Thus, the choices made during the research projects were unique to the current project.

Ellingsen et al. added an ethical dimension when discussing the trustworthiness of qualitative research, in particular regarding very personal and sensitive topics discussed during the interviews that may challenge the integrity of the participants and induce feelings of vulnerability.[169] The Helsinki declaration §17 states,

> 'All medical research involving human subjects must be preceded by careful assessment of predictable risks and burdens to the individuals and groups involved in the research in comparison

> with foreseeable benefits to them and to other individuals or groups affected by the condition under investigation'.[210]

Referring to the qualitative studies in the current project, we were aware of the sensitive nature of the interviews. Thus, we tried to carefully meet the bystanders without imposing our professional position on them, instead emphasising our research roles with the aim of catching their experiences. Also, all the interviews were conducted by an intensive care nurse (WTM) and many of the times together with a physician (CAB), both of whom have extensive experience in communicating with family members of OHCA patients. We offered an opportunity, with no time constrains, to talk in detail about their experiences. Thus, we regarded the interviews as beneficial to the participants. After the interviews, we answered any questions raised by the participants. When experiencing bystanders who questioned the value of their CPR, we tried to emphasise their contributions in the OHCA incident and adjust their expectations to entail more of a realistic patient outcome.

3.5 Data analysis in the quantitative studies

3.5.1 Methods for data analysis

In both Paper II and Paper IV, all data were edited in Microsoft Office® Excel 2010 (Microsoft Corporation, USA).

In Paper II, the statistical analyses were performed using IBM SPSS 24 (IBM, Armonk, NY, USA). We used several methods for exploring the data sets. To explore the distribution of the frequency in the data, we present continuous variables as medians with interquartile ranges and categorical variables as numbers and percentages. Proportions are reported as percentage with 95% confidence intervals (CI), which were calculated using the adjusted Wald method.[211] The Wald test can be used to test the true value of the parameter based on the estimate of the sample. Also, multivariate logistic regression analyses were performed to

evaluate the associations between the answers (dependent outcomes) and gender, age, residing municipality, CPR training, years since CPR training, health education and level of education (independent variables). Logistic regressions can be used to test the predictive power of each individual variable and assess the relative contribution of each individual variable.[212] Using a logistic regression provided us with a statistical model to predict whether some participants were more likely to respond similar to or different than others based on the observed characteristics.

In Paper IV, the data were edited in Microsoft Office®Excel 2010 (Microsoft Corporation, USA) and entered into Statistical Package for the Social Sciences version 23 (IBM) and R version 3.3.2[213] for statistical analysis and plotting. Continuous variables are reported the same as in Paper I. We tested for difference in the median distribution scores of continuous variables between the urban and rural groups by using the Mann-Whitney test. Chi-square tests assess the differences in the distribution of categorical variables between groups. OHCA incidence rates were calculated, and age and gender were adjusted according to the general Norwegian population.[214] The Poisson regression analysis was used to test for differences in incidence rates between urban and rural areas. By using a Kaplan-Meier type plot, we show the estimated survival probabilities from five consecutive stages of care. Hazard plots were constructed to show the estimated mortality probability between the consecutive stages of care by using chi-square tests. A logistic regression analysis was used to study the impact of urban and rural areas and other factors on survival to the consecutive stages of care and at 1 year. In all tests, p-values <0.05 were considered statistically significant.

3.5.2 Internal validity

Internal validity is defined as whether the means of the measurement are accurate and whether they are actually measuring what they are intend to measure.[215] In Paper I, we did not obtain any appropriate validated research instrument, which led us to construct a questionnaire suitable for

answering our research question. We readjusted the questionnaire several times and conducted a pilot experiment with 10 participants.

The 10-year registry data in Paper IV was entered into the database by a local designated nurse. We executed several steps to prevent errors and hence secured the internal validity. Data were cross-checked with air-ambulance records, with EMCC records and with in-hospital patient records. If data were conflicting, data from the first-on-scene personnel were prioritised. In the statistical analysis, outliers were checked for accuracy. When we were in doubt whether real cardiac arrest had occurred (i.e., pulse as first monitored rhythm without being defibrillated), the patients were excluded.

3.5.3 External validity

External validity is defined as whether an account is believed to be generalisable.[215] In Paper I, our sample was collected with the discretionary selection of participants. The sample was not proportional to the composition of the Norwegian population regarding gender and education. However, we assume that similar results could be found in other settings with equivalent EMS-systems.

Because both OHCA incidence and survival rates in Norway vary between regions,[56] the results measured in Paper IV may not be generalisable to other regions. However, showing the effects of modifiable prehospital factors on survival after OHCA in rural versus urban areas could be valuable in other settings when building community preparedness and pre-hospital systems for improving OHCA survival rates.

3.6 Ethical issues

For Paper I and Paper III a requirement for approval from the Regional Committee for Research Ethics was not needed. Paper II was approved by

the Norwegian Social Science Data Services in Bergen, Norway. Paper IV was regionally approved for scientific purposes by the Regional Committee for Research Ethics in Bergen, Norway. All studies were locally approved by the Institutional Review Board at Stavanger Hospital Trust, Norway.

In Paper I, II and III, the participants joined the study voluntarily. For the two latter studies, the participation requirements and ethical considerations were stated in an invitation letter/flyer; this also contained the form for the confirmed written consent, which was given at the time of the inclusion. The consent was based on both written and verbal information. The participants were assured that all data connected to them would be treated confidentially and that they could withdraw from the studies at any time. Also, all participants were given the contact information of the project leader (WTM). None of the participants contacted the research team after the interviews. Digital voice recordings and transcripts of the interviews were available only to WTM, CAB and a secretary employed in the research department at SUH. The recordings have been stored on a research server at SUH and deleted from the voice recorder. After completion of the study all recordings were deleted.

We took several steps in the qualitative studies to meet the challenges in the inclusion process. These steps contain ethical aspects that need to be further addressed. We found that the inclusion strategies of intensive care nurses and ambulance personnel distributing invitations to the studies were unsuccessful. By approaching family members and bystanders of OHCA patients in the ICU and at the OHCA scene, these individuals were being approached at a critical phase in their lives. Thus, one must assume that the approached participants were in a particularly vulnerable state. In hindsight, for these reasons, it is understandable that intensive care nurses and ambulance personnel obviously were reluctant to distribute the study invitations.

It has been stated that the optimal time point for sampling data for studies of this type of population is from 30–90 days after the OHCA

incident.[216] However, the argument was based on practical arguments, not ethical ones. Studies have shown that the experience of being interviewed after providing CPR is related to their potential for debriefing.[23, 26, 216] The interviews in the qualitative studies in the current project were not of a debriefing or a therapeutic nature, although similarities between the two types are apparent.

As interviewers, we did not experience any unwanted reactions from the participants. However, after having completed the two qualitative studies, we realised from the data collected that experiencing OHCA incidents caused some participants major emotional challenges. For this reason, we urge that further research show caution in approaching bystanders who have provided CPR and family members of cardiac arrest victims in the early periods after an OHCA incident.

4 Results

Four papers constitute the current thesis. The main findings are presented here. Paper I is the survey on public expectations for dispatcher assistance in cardiac arrest situations. Paper II is the qualitative study that investigated the barriers to providing bystander CPR. Paper III is the qualitative study where we explored the reactions and coping strategies of bystanders after having provided CPR. Paper IV is the findings from the registry study.

4.1 Paper I

Public knowledge and expectations to dispatcher assistance in out-of-hospital cardiac arrest

(Mathiesen, Birkenes, Lund, Ushakova, Søreide & Bjørshol, 2018)

The aim of this survey was to assess the knowledge and expectations among the general public toward the available assistance of dispatchers in OHCA incidents.

Presented with a hypothetical OHCA scenario, 500 participants were interviewed about their expectations regarding dispatcher assistance. Most participants (75%) expected the dispatcher to provide CPR guidance, while some (26%) expected the dispatcher to 'help in deciding what to do'. More than half of the participants (58%) regarded the bystanders present in the OHCA incident to be responsible for the decision to initiate CPR. The participants who had taken CPR training at some point in the last 5 years were more likely to state the bystanders' responsibility for deciding CPR provision (adjusted odds ratio [AOR] 3.7) when compared with other participants. Most participants (78%) were able to provide the correct emergency medical telephone number, and most participants (68%) knew that the emergency call would not be terminated until the ambulance had arrived at the scene. Only a third of

the participants (36%) knew that the emergency telephone number was operated by a trained nurse.

4.2 Paper II

Exploring how lay rescuers overcome barriers to provide cardiopulmonary resuscitation: a qualitative study

(Mathiesen, Bjørshol, Høyland, Braut & Søreide, 2016)

The aim of this study was to gain a better understanding of how the barriers to providing CPR are overcome. The overarching theme was as follows: 'Overcoming individual and contextual barriers to provide cardiopulmonary resuscitation', which encompasses five categories.

The first category, 'valuing life itself', describes the bystanders' profound attitude of protecting and valuing life itself by providing CPR to anybody and at any location. The second category, 'comprehension and coping', describes the participants' attempts to understand and manage the cardiac arrest incident. By tying together unusual breathing and abnormal skin colour with knowledge from CPR training, the seriousness of the situation became apparent to them, though the feeling of helplessness and the fear that they could hurt the cardiac arrest victim were present. The third category, 'normative obligation', describes the participants taking action in accordance with what they believed was expected of them as responsible community citizens. Fearing self-criticism more than the negative reactions from others if they did not provide CPR led them to take action. The fourth category, 'confidence', describes the influence of dispatchers' encouragement and the support from other bystanders who were present in the OHCA incident. The fifth category, 'context-specific CPR', describes the participants' trust in having EMS assistance come quickly and the mutual confidence in other community citizens' ability to provide CPR. Also, the feeling of being safe without expecting unwanted repercussions was an underlying reason for providing CPR.

4.3 Paper III

Reactions and coping strategies in lay rescuers who have provided CPR to out-of-hospital cardiac arrest victims

(Mathiesen, Bjørshol, Braut & Søreide, 2016)

The aim of this study was to explore reactions and coping strategies of bystanders who had provided CPR to OCHA victims. The overarching theme of 'emotional and social challenges and the struggle to cope in life after providing CPR' encompasses three categories.

The first category, 'concern', describes the participants' concern for the condition of the OHCA victims and the fear of having provided insufficient CPR. The incident was emotionally challenging for all involved, and for some participants, it led to unwanted bodily and emotional changes and alterations in their family and work lives. In contrast, some participants experienced persistent mental recurrences of the OHCA incident. However, some participants felt proud and happy for having provided CPR. The second category, 'uncertainty', described the participants' search for the patient's outcomes and their reactions when receiving information or the lack of receiving this information. Unknown or fatal outcomes often caused feelings of guilt and were difficult to handle. The third category, 'coping strategies', described the participants' emotional and social processing of the OHCA incident. Several participants reported the need to be acknowledged for their CPR attempts by health care professionals. A common coping strategy was confiding in close relations and in health-educated individuals who were in their personal network. Some required professional help to cope with the OHCA incident.

4.4 Paper IV

Effects of modifiable prehospital factors on survival after out-of-hospital cardiac arrest in rural versus urban areas

(Mathiesen, Bjørshol, Kvaløy & Søreide, 2018)

Here, we aimed to study how the modifiable prehospital factors – CPR, EMS response time and attendance by an EMS physician – affected short- and long-term survival for OHCA patients in urban and rural areas.

Data from 1,138 OHCA incidents were analysed. Patient characteristics, such as age, gender, initial shockable rhythm and witnessed OHCA, did not differ between the rural and urban areas. Also, bystander CPR, cardiac location at home and EMS physician attendance did not differ between the two groups. However, the median EMS response time was 2 minutes longer for the rural area group. Also, the ROSC rate was significantly lower for patients in rural areas compared with urban areas (30% vs. 37%, p=0.017) When comparing the two groups, we found a significantly higher probability for survival at hospital admission (OR: 1.84), at hospital discharge (OR: 1.51) and at 1 year (OR: 1.58) for OHCA patients in urban areas. In patients having received bystander CPR before EMS arrival, the odds of survival at hospital discharge increased more than threefold (OR: 3.05). However, bystander CPR was associated with increased survival at hospital discharge only for OHCA patients in urban areas. EMS-response time more than or equal to 10 minutes was associated with decreased survival (OR: 0.61), which was only the case for OHCA patients in urban areas. In rural areas, patients with EMS physician attendance had a significantly better survival rate at hospital discharge compared with patients in urban areas. When adjusted for the modifiable factors, the significant differences in OHCA patient survival between rural and urban at hospital admission, at hospital discharge and 1 year after the OHCA incident remained similar. However, in all patients admitted to the hospital, there were no differences in mortality between the groups.

5 Discussion

The purpose of this PhD project was to discover areas where improved efforts could influence survival after OHCA. We aimed to study the preconditions for and consequences of bystander CPR by 1) acquiring more knowledge from the bystanders' perspective regarding their preparedness and reactions of CPR provision in OHCA incidents and 2) measuring the effect of bystander CPR on patient outcomes in rural and urban areas. To achieve this, four studies were conducted. In Paper I, we conducted a survey to study the expectations of dispatcher assistance among the general public. In Paper II, we applied a risk perception perspective to study how barriers to providing CPR are overcome. In Paper III we comprised an explorative design that was used to study bystanders' reactions and coping strategies after providing CPR. Paper IV was an observational registry study of how modifiable prehospital factors, such as CPR, EMS response time and EMS physician attendance, can influence survival rates after OHCA incidents in rural and urban areas. The findings from the studies are discussed in this chapter.

5.1 Discussion of paper I

Most participants in this survey expected CPR instructions from the emergency medical dispatcher and regarded bystanders present in the OHCA incident as being responsible for the decision to initiate CPR. The correct emergency medical telephone number was stated by most participants, as well as expecting the emergency call to be terminated upon ambulance arrival. Only one-third of the participants knew that the emergency telephone number was operated by a trained nurse.

The results from this survey indicate that most participants regard themselves as able to make the appropriate decisions in OHCA incidents on their own. This attitude of independence is also seen in their view of bystanders as being responsible for the decision to initiate CPR. This

finding is surprising considering that only a small number of bystanders are able to recognise cardiac arrest before calling the EMDC,[217] but may reflect an attitude retrieved from traditional CPR-training.[112, 130] Thus, a closer adherence to real life OHCA in CPR training could improve the quality of the first and second link in the chain of survival.

Deakin stated that the contribution of each of the four links in the chain of survival diminishes rapidly, resulting in rapidly decreasing numbers of patients at each stage, and that the best way to improve patient outcomes can be achieved by focusing on enhancing care in links where there are the greatest number of patients.[73] Thus, the first link including bystanders appears as the most obvious area for improvement. However, acknowledging that abnormal breathing in cardiac arrest victims can be challenging to determine,[135, 218] key bystander observations should be limited to unresponsiveness for calling the EDC. Regardless of a possible increased number of calls to the EMDC by this change, most cases of sudden, unexpected unresponsiveness would still need medical assistance from the EMDC.

The current study shows that community citizens need to learn and be assured of the professional knowledge and instructions being given to them by dispatchers until ambulance arrival. Thus, clarifying expectations regarding both the bystander's and dispatcher's role in CPR training is important for increasing the quality of communication in emergency calls. This is in line with the finding stated by Linderoth et al. who states that dispatchers' identification of OHCA partly depends on bystanders' situational awareness.[118] Also, bystanders must also learn to usually leave the decision of initiating CPR to the dispatcher. Unrealistic expectations in terms of coping with difficult tasks in the OHCA incident may leave the bystander with the feeling of inadequacy, which may later be a heavy burden to carry.[219]

The challenges of real OHCA incidents need to be addressed in CPR campaigns, a point which is emphasised in the report by Skora and

collegues.[22] Such an approach means integrating the formula for survival in public communication and may increase the confidence between public citizens and health authorities.[182]

5.2 Discussion of paper II

By using a qualitative approach, we studied how risk perceptions influence bystanders in providing CPR in OHCA incidents. We found that having a general willingness to provide CPR, being able to comprehend and cope, acting in accordance with what is expected as a responsible community citizen, enhancing confidence because of dispatchers' instructions and relying in other bystanders' support and trusting personal safety were factors that influenced the bystanders in providing CPR.

The provision of CPR entails actions by chest compressions and mouth-to-mouth ventilations on a human being which, for most individuals, are unfamiliar behaviours and may create fear of undesirable consequences, including hurting the cardiac arrest victim.[220, 221] Thus, it is comprehendible that some bystanders omit the provision of CPR. In decision-demanding situations, maintaining a status quo alternative is well known.[189, 190] By weighing the potential loss of being responsible for someone's death against letting nature decide the outcome, deferring to provide CPR is understandable. Although the motivation of acting as a responsible community citizen is a strong motivational factor for providing CPR, the fear of having ended somebody's life may be stronger. When assuming that fear is more or less a universal feeling in OHCA by causing natural barriers to providing CPR, the statement by Axelsson et al. – that individuals initiating CPR have the feeling of responsibility and the personal courage to handle the situation and confront death – seems to be pertinent.[222] Thus, dispatchers' CPR instructions could be seen as a way of weakening the natural barriers to providing CPR by empowering bystanders.

If barriers must be overcome, a trust in the dispatcher is a requisite for providing CPR. The dispatcher represents the EMS. The public's trust in social institutions, as well as in fellow community citizens, may be an underestimated factor in the scientific debate of the worldwide differences in the rate at which citizens provide CPR. Conversely, distrust in social institutions has been noted as a reason for not alerting emergency medical services in OHCA incidents.[220, 221]

The bystanders in the current study noted they would provide CPR in one setting but omit doing so in another. This finding confirms that the social and cultural context plays a pivotal role in human behavior in OHCA incidents.[219] Thus, adequate CPR knowledge and skills are not sufficient enough to encourage bystanders to provide CPR. Factors such as mutual trust, normative obligations and the feeling of safety are also important.

5.3 Discussion of Paper III

This qualitative study showed that bystanders differ in how they experience and process an OHCA incident. However, some factors influence their experiences more than others. For some bystanders, the uncertainty of the patient's outcome led to concern for having severely injured the patient as a result of providing CPR. This concern influenced some bystanders' emotional and social quality of life in a challenging and negative way. Others, and in particular health care workers, felt proud of having provided CPR. The processing of the incident seemed to be affected by the ability to initiate contact with health care workers in their private social network and then talk about the incident.

When CPR by bystanders can alter the patient outcome, a logical question following a fatal patient outcome is why the cardiac arrest victim died, and who is responsible for the outcome. The current study showed that many bystanders linked the outcome to their CPR-provision. By doing that, the bystanders established a causal relationship between the CPR provided and patient outcome. Few seemed to be aware that influencing

factors beyond the bystander's control, such as shockable or non-shockable rhythm, witnessed or un-witnessed arrest, EMS response time and patient age, contribute to patient outcomes.[7, 8] This finding is in line with the study by Axelsson et al. which claims that fatal outcome have negative influence in bystanders' reactions after providing CPR to OHCA victims.[30] Also, the studies by Genest et al. and Skora et al. imply that the aftermaths of providing CPR may be complexed and challenging to many bystanders.[22, 32]

Bystander CPR in OHCA is encouraged by health authorities. Because of the urgency and importance of CPR, this action is the single medical treatment that the entire population attempts to be trained in. Thus, to prepare for OHCA incidents, substantial resources are invested in promoting CPR training in the public. In OHCA incidents, a considerable amount of costly prehospital EMS staff, vehicles and equipment are used. In sum, major investments are taken for the effort of saving lives after the OHCA incident. In contrast, no resources are allocated to the bystander. Perhaps by focusing of the value in saving lives, the human cost of CPR provision has been neglected. Thus, the results of the current study raise ethical questions concerning peoples' emotional burdens when they try to save lives. When individuals act on the request of health authorities, some kind of follow-up should be offered to bystanders after providing CPR. This stand contradicts the statement from Zijlstra et al. who claims that lay rescuers do not need a professional to talk with after a resuscitation effort.[31] We argue that for most bystanders, a follow-up could close the experience by having relevant questions answered by professionals who have thorough knowledge. Some bystanders would also need even additional attendance from medical health care systems. Thus, leaving the follow-up to bystander-initiated contact with random health care workers within the bystander's social network is a potentially damaging strategy when it comes to a sound processing of the incident. Also, the importance of the bystander's role in the chain of survival would be, in this follow-up scheme, taken as a sign of appreciation when in line with organised

follow-up systems for professional EMS crew.[222] Such an approach could ensure the mutual trust between bystanders and health authorities, a trust that is imperative for the future willingness of bystander CPR and for the chain of survival to work.[171]

By proper preparation we may avoid some of the negative effects of bystander CPR. Mauz et al. state that current CPR training programs do not adequately prepare bystanders for the reality of an OHCA.[33] Axelsson et al. stated that if the aim of CPR training was to include preparing the rescuer for the intervention and his or her reactions, this might increase the number of people being able to take action in the OHCA incident.[23] Thus, including the influences of non-amenable factors in on patient outcome in CPR training could be beneficial to the bystanders when processing the OHCA incident.

5.4 Discussion of Paper IV

In this study, we found a significantly higher probability of OHCA patient survival at hospital admission, at hospital discharge and at 1 year in urban areas when compared with rural areas. The association of bystander CPR, EMS response time being under 10 minutes and EMS attendance differed between urban and rural areas. When adjusting for bystander CPR, EMS physician attendance and EMS response time, the significant difference in survival at hospital admission, at hospital discharge and at 1 year between rural and urban OHCA patients remained.

The results of the current study reveal major challenges when it comes to improving survival after OHCA incidents that occur in rural areas. We did not find any significant factor to explain the difference in survival rates between urban and rural areas. However, the median EMS response time in the urban group was 2 minutes shorter compared with the rural group and may still explain the higher survival rate. In patients receiving bystander CPR, the odds of survival at hospital discharge increased more than threefold. However, we found that bystander CPR only had a

significant impact in urban areas. This finding is in line with the recent study by Goto et al., who showed that when EMS response times exceeded 11–13 minutes, significant differences in 1-month neurological intact survival in OHCA cases with and without bystander CPR provision ceased to exist.[223] Goto et al. stated that despite strategies to improve bystander interventions, the rate of survival cannot improve if the EMS response time is poor.[223]

The distribution of ambulance stations in Norway is proportional to the country's population density. Thus, an attempt to reduce the time interval between call receipt and ambulance arrival without any changes made to EMS responder deployment is difficult. However, an intention to reduce the time from call receipt to the time the ambulance is dispatched may be accomplished in EMS systems by a direct EMSDC telephone number,[124] enhancing the dispatcher's ability to identify cardiac arrest and optimising emergency medical dispatcher processes.[20]

The current study showed that attendance by an EMS physician in an OHCA incident was associated with survival for rural OHCA patients in all stages of care while only with survival at hospital admission for OHCA patients in the urban group. This difference may be caused by a selection bias. The EMS physicians may have a higher threshold to attend in time-consuming OHCA assignments in rural compared with urban areas. This may cause a selection of OHCA victims who have a greater chance of survival. When comparing age in both the EMS-physician attended patients and the non-EMS-physician attended patients, we found no statistical differences between the urban and rural groups. However, other selection biases could be witnessed or not cardiac arrest or whether bystander CPR was provided or not.

For further efforts in improving survival after OHCA incidents, establishing community response systems seem to be the obvious strategy for mobilising a competent public for providing CPR, improving dispatcher assistance quality and establishing local networks of

rescuers.[224, 225] Community response systems may be locally initiated; however, a national approach to ensure quality would be preferable.

5.5 Overall discussion

With this PhD project we aimed to acquire more knowledge from the bystander perspective by studying the preconditions for and consequences of CPR by bystanders in OHCA. Certain findings in the Papers are discussed in the following paragraphs.

The profound feeling of bystanders' obligation to save lives, hence encouraging them to provide CPR that was found in Paper II supports the findings in Paper IV, where OHCA patients who received CPR before the arrival of EMS the odds of survival to hospital discharge increased more than threefold compared to those who did not receive CPR.

In Paper I, the findings show that the public expects a substantial amount of responsibility to be placed on them when handling and deciding on the OHCA incident. When interviewing bystanders in Paper II, we found that the bystanders were surprised of the extent of the dispatcher's assistance that they had received when intervening in an OHCA incident. These findings could indicate a gap between public preparedness for and expectations of dispatcher assistance and the assistance received. This topic needs to be addressed in CPR training and in public campaigns.

In Paper I, the results indicate that public citizens overestimate their ability to handle the OHCA incident on their own. Having high expectations regarding his or her own ability to decide and handle an OHCA incident could be the reason behind the extensive disappointments in bystanders when fatal or uncertain outcome found in Paper III. If so, this finding supports our theory in Paper III: bystanders establish a causal relationship between the CPR they provided and the outcome of the patient.

The findings from this project shows that the mutual trust between community citizens and toward social institutions seems to be an important precondition for providing CPR, while the cost of saving lives may be emotional challenges to bystanders.

5.6 Methodological considerations

Combining the qualitative and quantitative methods could provide a more accurate description by better being able to look at the different perspectives of a problem.[226] The qualitative research method provides in-depth knowledge, while the quantitative method provides a more broader perspective. However, in every step taken during research may influence the data or the analysis of data. The following section will elaborate on the limitations of the methods applied in each study.

5.6.1 Limitations of paper I

In this survey, we wanted to sample a subset of data that could accurately represent the public. The sampling method in the current study was done by consecutive sampling, where subjects meeting the criteria of inclusion were selected until the required sample size had been achieved.[164] The participants assigned to this study were picked because of the researchers' discretion, creating a non-probability sample. Generalisations built on data from non-probability samples are weaker compared with randomly sampled data because the researchers approaching certain participants and avoiding others may bias the sample.[227] Alternative methods to avoid this kind of bias may be telephone interviews performed by telemarketing companies that use random sampling methods. However, studies similar to the current one have been carried out by telephone interviews but have shown only 28% of the participants being willing to answer questions.[113] Unlike randomly selected subjects for telephone interviews, we executed face-to-face interviews , ensuring the bystanders' apparent ability to provide CPR, an assumption impossible to make by a telephone survey. Also, telephone interviews may not be applicable when the questions are

of a complex nature, which may be the case for some questions in the current survey. Also, the face-to-face interview entails the mutual opportunity between the interviewer and the participant to clarify misunderstandings in the questions and answers by interpreting body language.

Most data were obtained via handwriting on paper, which then was entered into a SurveyXact database. In this process, the possibility for data being lost, changed or misinterpreted is present.

The present study was executed in the Stavanger region, Norway, an area where high survival rates after OHCA incidents have previously been shown.[8] The close connection to the oil industry, with many inhabitants trained in health, environmental and safety training, may have affected the answers. Also, our sample was not proportional to the composition of the Norwegian populace regarding gender and education. We ensured diversity regarding population density (urban and rural communities, which were defined as over and under 200 inhabitants km^2, respectively). Because CPR training is similar through the country and because the EMDCs use identical guidelines for assisting callers and dispatching resources, we believe that the results could be generalised to the Norwegian public.[126] The results in the current study imply public's trust in dispatcher assistance in OHCA incidents. The level of trust among Scandinavian citizens toward social institutions has been found to be high.[228] Thus, we believe that the results could be generalised to the Scandinavian population. The levels of trust in other countries and regions will most likely influence the CPR rate. However, unknown factors and social systems are constantly in change, which challenges the effort of understanding the underlying factors behind CPR provision.

5.6.2 Limitations of paper II

In Paper II, we applied a framework when designing the study and analysed the data from a risk perception perspective. The use of a

framework led the work in a deductive direction, while exploring the bystanders' experiences through the risk perception perspective went more in an inductive direction. Although this dualistic combination of research strategies is applicable,[163] it could also create confusion. Deductive research strategies are associated with testing theories, which we did not attempt in Paper II. Because the explorative dimension of the study was constrained by the applied framework, the inductive research strategy was also limited. An abductive strategy aims to discover individuals constructions of reality, their ways of conceptualising and giving meaning to the social world and their tacit knowledge.[163] Thus, an abductive research strategy would possibly be more an appropriate term used for the current study compared with calling it a deductive/ inductive strategy.

The inclusion strategy of the participants for Paper II was initially invitations distributed by intensive care nurses to the family members of OHCA patients in the intensive care unit at SUH. By limiting the contact to family members of recovering patients, we tried to minimise the burden of participating in the study that would be in addition to the strain of having a dying family member. However, we only managed to recruit one participant using this strategy. There could be several reasons why this was the case. Despite the introduction of the study to the staff and approval from the ward management, we noticed that only one invitation was distributed. We interpret this lack of distribution of study invitations as hesitation by the intensive care nurses to approach family members of OCHA victims where they, despite positive signs for patient recovery, had experienced a crisis. Thus, the nurses might have considered that participation in the study would be an additional burden on the family.

Because there are no registries of bystanders who have provided CPR to OHCA victims available in Norway, there were limited avenues of recruiting this group. Also, we did not include participants involved in unsuccessful resuscitations. This choice may have biased the results. The participants were asked how they would be handling an OHCA incident

in an unfamiliar setting. These answers were, at most, an expression for how the participants would handle the situation, more than a reflection of the actual situation. The results and discussion are related to the cultural and political context of Norway and might not be applicable to other settings.

5.6.3 Limitations of paper III

In Paper III, flyers with the invitation to participate in the study were distributed to bystanders in OHCA incidents by ambulance personnel in two different ambulance stations (Stavanger and Sandnes). In one of the two ambulance stations, we presented the project directly to the ambulance personnel, while in the other group, we clarified the project only with the management. In the first case, the ambulance personnel distributed 50 flyers, while the latter case distributed none. This discrepancy shows the importance of anchoring this kind of research project both at a managerial and staff level.

Despite the persistent effort by the personnel in one of the ambulance stations, we did not succeed in recruiting more than one participant. The difficulties in recruiting bystanders has previously been described by Skora et al.[22] who stated that 'guilt' is a feeling found in bystanders after providing CPR. The feeling of guilt may also have been a reason for bystanders not wanting to participate in the current study. The connection between the researchers, the local hospital (SUH) and the Air Ambulance Foundation stated in the flyers should have indicated the researchers' expertise in the field of CPR. We assume some bystanders might have feared having their actions being scrutinised by experts and hence refused to participate.

Abrams addressed the challenges related to sampling in 'hard to reach populations' and recommend indirect recruitment strategies (i.e., distribute flyers), meaning that potential participants must initiate the contact with the researchers.[229] In Paper III, we did not succeed when using this approach. However, a study feature in the local newspaper did

lead to unintentional contact with bystanders who had provided CPR to OHCA victims. This feature shared similarities with flyers, and together with a snowball sampling strategy, showed to be an important recruitment strategy. Compared with a random selection of participants, the recruiting process in Paper III could have led to a selection bias by including particularly vulnerable individuals. Thus, we do not whether our findings may generalize to most bystanders. However, an impression of predominant vulnerability in the participants was not seen by the researchers.

The creation of a single theme when using a quality content analysis may contradict the phenomenographic stand taken in the current paper on describing various experiences of a phenomenon.[162, 200] The code 'feeling proud and happy for having provided CPR', may seem little integrated in the overarching theme: 'Emotional and social challenges and the struggle to cope in life after the CPR provision'. However, none of the bystanders were unaffected after providing CPR although some seemed to process the incident in a more positive way.

5.6.4 Limitations of paper IV

Gathering data for the local OHCA registry was carried out manually using paper-based documentation provided by ambulance personnel. The compiled data were then forwarded to a designated nurse who was responsible for entering the data into the database. In this process, the possibility for data being lost, changed or misinterpreted is present.

The OHCA incident reported in the current study is low when compared with other Norwegian regions.[56] This difference may indicate a deficiency of OHCA cases in the dataset. However, the age- and gender-adjusted OHCA incidence rates matches the OHCA rates of the general Norwegian population. We did not assess the patient's neurological status or where the surviving patients were discharged to. Thus, the current

study cannot report any measurement that indicates the patients' quality of life after hospital discharge.

There is a limitation in the registry study per se. Even though the Utstein guidelines imply that there are similar methods and rationale for aggregating data registries, the differences and outcomes in OHCA incidents between regions cannot fully be explained by the Utstein variables.[230, 231] One way of compensating for this limitation is the updates of the Utstein Resuscitation Registry Templates for reporting OHCA data, which aims at improving data collection.[19] Because of the complexity of social systems, it is unrealistic that all factors contributing to CPR rate and OHCA survival rate can be measured.

6 Conclusion

We found that most participants were prepared to receive CPR instructions from the dispatcher. However, a common public expectation considers bystanders as responsible for the decision to initiate CPR which contrasts real OHCA incidents where most CPR by bystanders is initiated during the EMDC call.

In OHCA incidents, the barriers that bystanders face in providing CPR may be overcome by mutual trust between community citizens and social institutions. A normative obligation to act, regardless of CPR training and without facing any adverse legal repercussions, is essential for providing CPR. To overcome the natural reluctance to provide CPR, the ensured support from emergency medical dispatchers is of vital importance.

Providing CPR to OHCA victims may cause serious and persistent fears in bystanders. The mechanism behind these fears may be the bystanders' establishment of a causal relationship between the provided CPR and patient outcomes, leading to concerns regarding whether their CPR provision led to severe injury or death and without assessing the contributing factors to patient outcomes. Experiencing a positive patient outcome and being a health-educated bystander seem to mitigate fears. Common coping strategies in bystanders were directed toward reducing uncertainty about patient outcomes and obtaining assurance regarding the bystanders' CPR quality.

When investigating OHCA survival rates according to population density, we found higher survival rates in urban compared with rural areas. The impact of the following prehospital modifiable factors – bystander CPR, EMS response time and EMS physician attendance – differed between urban and rural areas. The main differences were because of a lower ROSC rate and hospital admission rate of OHCA patients in rural areas. In patients who were alive when admitted to the hospital, the survival rates did not differ between rural and urban areas.

7 Future perspectives

7.1 Implication for practice

To increase public awareness of the importance of beneficial communication in OHCA incidents between callers and dispatchers, an increased focus on pertinent decision making should be emphasised in CPR training and in public information campaigns. The identification of how bystanders' barriers to providing CPR is overcome could be used in future community campaigns that aim to improve bystander CPR rates. Public campaigns should focus on dispatcher-instructed CPR and the obligation to help individuals in need, as well as helping fellow citizens in providing CPR. However, the current project reveals that CPR provision may lead to deep concerns in bystanders because of fear of having injured or caused death to the OHCA victim. Thus, an organised follow-up may mitigate the concerns and adverse reactions of bystanders. Community-based interventions such as CPR training, first-responder programs and public-access defibrillation can be valuable strategies in further efforts to improve OHCA survival rates.

7.2 Future research

The current thesis has contributed to the body of knowledge on the preconditions for and consequences of CPR given by bystanders in OHCA incidents. Future research on how to increase situational awareness between bystanders and dispatchers to minimise the time taken to give CPR could be beneficial for improving OHCA survival rates. Also, the benefits and disadvantages of a strict adherence to the Norwegian Index for Emergency Medical Assistance need to be investigated.

When aiming for all citizens to have access to T-CPR, multinational and marginal groups as children and minorities in society, force new

approaches on how socio-cultural differences affect CPR-training, CPR provision and communication with dispatchers.

The current project revealed that bystanders, who had provided CPR, suffered a considerable strain in searching for information about the outcome of the cardiac arrest victim. The gain and loss of revealing the outcomes of OHCA patients to bystanders in terms of legal implications and ethical considerations are thus an apparent issue for future research.

Using a validated research instrument for assessing unwanted reactions in bystanders after having provided CPR could clarify the extent of the burdens that follow CPR provision.

The current project investigated the effect of bystander CPR, EMS response time and EMS physician attendance on OHCA survival rates. However, these factors are only a few of the numerous prehospital modifiable factors contributing to patient outcomes. Defibrillation, time from collapse to alarm, time from collapse to CPR and CPR quality are all factors that could provide important knowledge for understanding the prehospital sequence effect on survival.

The present project revealed that several bystanders did not have a clear idea that a cardiac arrest was the cause of the collapse. Based on the findings in the current project, the value of training the public in recognising cardiac arrest seems to be limited. Thus, whether bystander key observations should be simplified to unresponsiveness only for contacting the EDC should be investigated for saving time and lives.

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Paper I

Public knowledge and expectations to dispatcher assistance in out-of-hospital cardiac arrest

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Key words: dispatcher, nurse, emergency call, emergency medical service, cardiac arrest, bystander, lay rescuer, communication, cardiopulmonary resuscitation, prehospital

Abstract

Aim. To assess the knowledge and expectations of the general public regarding the emergency medical assistance provided by dispatchers in out-of-hospital cardiac arrest incidents.

Background. In medical dispatch centres, emergency calls are frequently operated by medically trained nurses as dispatchers. In cardiac arrest incidents, efficient communication between the dispatcher and the caller is required for prompt recognition of cardiac arrest. However, few callers are trained in communicating with dispatchers, and they may be unaware of the available dispatcher assistance.

Design. A cross-sectional observational survey.

Method. From January to June 2017 we conducted standardised interviews among 500 members of the general public.

Results. Most participants expected cardiopulmonary resuscitation instructions, while few expected "help in deciding what to do". More than half regarded the bystanders present to be responsible for the decision to initiate cardiopulmonary resuscitation. Most participants were able to provide the correct emergency medical telephone number. The majority knew that the emergency call would not be terminated until the ambulance arrived at the scene. However, only one-third knew that the emergency telephone number operator was a trained nurse.

Conclusion. Cardiopulmonary resuscitation instructions are a frequent public expectation of an emergency medical dispatcher's assistance in cardiac arrest incidents. However, a common public expectation is to consider the bystander responsible for the decision to initiate cardiopulmonary resuscitation. An increased focus on the role of the emergency medical dispatcher as team leader of the first resuscitation team in cardiac arrest incidents should be emphasised in cardiopulmonary resuscitation training and in public information campaigns.

Introduction

Out-of-hospital cardiac arrest (OHCA is a major cause of death in industrialised countries.[1-3] Survival after OHCA depends on a series of particular sequences of interventions conducted as rapidly as possible known as the Chain-of-Survival concept.[4] Bystanders represent a pivotal role in the Chain-of-Survival as the public is the most prominent available group for calling for medical assistance and providing cardiopulmonary resuscitation (CPR.[5] The CPR training offered to the public about how to think and decide in an OHCA is mainly presented as a straightforward issue including being able to recognise cardiac arrest. However, a cardiac arrest may not be a clear case, but ambiguous, complex and with unpredictable outcome.[6] International CPR guidelines emphasize the role of emergency medical dispatchers in instructing bystanders to initiate and provide CPR.[5] The knowledge concerning bystanders' preparedness for communicating with dispatchers in OHCA incidents is extremely sparse.

Background

Minimising the time from cardiac arrest to cardiopulmonary resuscitation (CPR is essential for survival.[5] Thus, early emergency calls from bystanders present in the OHCA incident is important. In medical dispatch centres, emergency calls are frequently operated by specially trained nurses as dispatchers. Instructions in CPR by telephone (T-CPR to bystanders by emergency dispatchers increase survival.[7-10] Based on information from bystanders present at the OHCA, the dispatcher aims to recognise symptoms of cardiac arrest, to provide T-CPR and dispatch emergency medical resources.[5] However, delays in delivery of T-CPR are common and attributable to a mixture of dispatcher behaviour and factors beyond his or her control, including bystander behaviour. [11] Public preparation for the bystander role has usually been acquired through CPR training, usually without T-CPR having been incorporated

into the training.[12] Further, the public service messages in traditional campaigns about bystander involvement have been to "call the emergency telephone number" and "start CPR", without providing information about dispatcher assistance in decision making and CPR instruction.[13] Thus, the general public may be unaware of the extent of support offered by dispatchers during OHCA incidents. Linderoth et al. state that we should think of the dispatcher and bystander as "the first resuscitation team" at the scene.[14] However, we do not know whether bystanders share this team concept, nor if the knowledge and expectations regarding dispatcher assistance in OHCA incidents are well known.

The study

Aim

The aim of this study was to assess the knowledge and expectations among the general public regarding the assistance of the dispatcher in an OHCA incident.

Design

We designed a cross-sectional survey to be carried out in public places at which we assumed we could meet members of the general public.

Participants

We estimated 500 participants to be a suitable number for mapping public knowledge and expectations about dispatcher assistance in a hypothetical OHCA. We chose a discretionary selection of participants for a non-probability sample. This approach allowed the interviewers to choose participants who seemed to be representative for the survey.[15] Suitable participants for this study were individuals 16 years of age or older, who appeared to the interviewers interviews to be capable of providing CPR and were willing to be interviewed in a Scandinavian language or English. We approached individuals using transportation means, such as a

ferry and a railway, and in public places where people of all ages can be expected to frequent, such as in bus stations and outside grocery stores. In sum, we established 12 different sites covering 7 of the 18 municipalities in the region.

Setting

We conducted the present study in the Stavanger region, an area where previous reports have shown high bystander CPR rates and high survival rates after OHCA.[16, 17] The Stavanger region is situated on the southwest coast of Norway, and it comprises 18 urban and rural municipalities. The region covers an area of 5.700 km2 and is populated by approximately 360,000 inhabitants. Four municipalities cover the most densely populated areas, which for the purpose of this study constitute the urban area, while the remaining 14 municipalities constitute the rural area. The emergency medical dispatch centre (EMDC is located at Stavanger University Hospital, the only receiving hospital in the region for OHCA victims. Training in basic life support (BLS has been given in the school systems, compulsory military service and voluntary organisations as well as in health, environment and safety training in the local oil industry.[18] The EMDC is reached by one nationwide emergency telephone number (113 but can be redirected from other emergency numbers, such as the police (112 or the fire and rescue services brigade (110. Incoming calls to the EMDC are received by specially trained nurses (dispatchers. In cases of cardiac arrest, the dispatcher will instruct the bystander to start CPR and initiate a response that usually consists of one or two ambulances, an anaesthesiologist-manned rapid response unit and the local general practitioner on call.

Data collection

Data were collected using a questionnaire designed to consist of as few questions as possible within the aim of the study, and with an estimated time of 5 to 10 minutes to answer. The survey was carried out between January and June 2017 by three interviewers (WTM, HL, TSB. The interviews were held face to face by one interviewer and were conducted in the day-time. The interviewers presented themselves as employees or collaborators at the local hospital, conducting an anonymous survey without any intention of asking questions about personal health conditions. The participants heard an oral presentation describing a hypothetical scenario in which somebody had collapsed, was unresponsive and not breathing. Referring to the scenario, the participants were asked whom and which telephone number they would call for help, what kind of assistance they would receive when calling 113, who they expected would respond and when they assumed the emergency call would be terminated. The interviewer ticked off the answers, without prompting or suggesting, on a list of preset categories that were unavailable for the participants. The questions were asked consecutively. If "ambulance" or "an emergency telephone number" were answered in question 1, question 2 was given (Fig. 1. Before asking question 3, participants were informed that 113 was the correct emergency medical telephone number if they had not stated this (Fig. 1. Answers that did not fit into any preset category were noted in writing and later categorised, some in new categories. For all questions, single answers were approved, except when asking what kind of help the participant expected from the dispatcher. In cases where the participants gave several answers when only one was required, the most correct answer was chosen. The most frequent reasons for not participating in the study were lack of available time or language barriers.

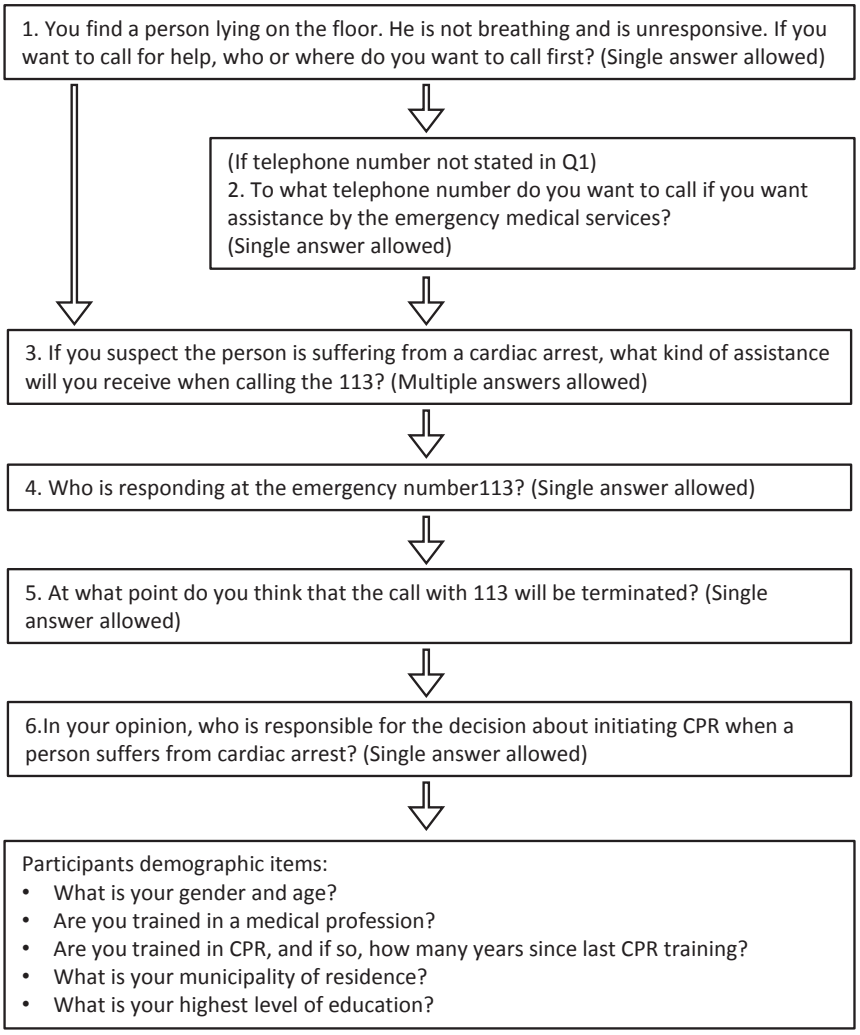

Fig. 1: Questionnaire flowsheet

Ethical considerations

As this study employed anonymous participation and no sensitive questions, any ethics committee approval was not required. The study was approved by the Institutional Review Board at Stavanger Hospital Trust, no. 2016/226, Norway.

Data analysis

All data were directly, or indirectly via handprint on paper, entered into a SurveyXact database (Rambøll Management Consulting, Århus, Demark 2017, edited in Microsoft Office® Excel 2010 (Microsoft Corporation, USA and statistical analyses were performed using IBM SPSS 24 (IBM, Armonk, NY, USA. Continuous variables are represented as medians with interquartile ranges, categorical variables as number and percentage. Proportions are reported as percentage with 95% confidence intervals (CI which were calculated using the adjusted Wald method.[19] Multivariate logistic regression analyses were performed to evaluate the associations between the answers (dependent outcomes and gender, age, residing municipality, CPR training, years since CPR training, health education, level of education (independent variables.

Validity, reliability and rigour

The questionnaire was repeatedly readjusted in an internal audit process by the researchers before recruiting participants. A pilot experiment with 10 participants served as a base for the final evaluation. After interviewing 113 participants, we experienced a limitation in the questionnaire, which led to the addition of one question (number 6(Fig. 1. The participants were stratified according to gender, age, the municipality in which they resided, whether they were trained in CPR or not, years since their last CPR training, whether or not they were schooled in medical or health-related education, and their highest level of

education. Two-sided P-values of < 0.05 were considered statistically significant.

Results

Five hundred people participated in this study. Most of the participants were female (55%, the median age was 44 years, 65% resided in urban areas and 79% were trained in CPR. The characteristics of the participants are summarised in Table 1. Among the participants, 78% knew how to connect with the EMDC by calling the correct emergency medical telephone number (113. When asked "What kind of assistance will you receive when calling 113?" the most frequent answers were "by being provided with CPR-instructions" (75%, "by helping in deciding what to do" (26%, and "by dispatching an ambulance" (24% (Fig. 2. Few participants answered "by dispatching a physician" and "by providing information about public automated defibrillators" (Fig. 2. When asked who is responsible for the decision about initiating CPR, 58% of the participants stated that it was the responsibility of "the bystander(s present at the incident", 23% stated "the dispatcher", and 9% stated "both the bystander and the dispatcher in cooperation" (table 2. Participants with CPR training were more likely to state that the CPR decision rested with the bystander, compared with participants who had no CPR training (odds ratio (OR 2.93, $p < 0.001$ (Table 3. Participants who had received CPR training in the last five years were even more likely to state that it was the bystanders' responsibility for deciding CPR provision (Table 3. When asked who is responding at the emergency telephone number, only 36% of the participants answered "nurse". However, 65% stated the dispatcher had some kind of medical competence (nurse, physician, ambulance staff or medical professional, while the remaining 35% presumed a non-professional dispatcher (secretary, switch-board operator, other or did not know. When asked when the participants would expect the emergency call to be terminated, 68% stated "not until ambulance

arrival". When adjusted for all other factors, the level of education was not significant for any of the main questions (Table 4).

Table 1: Characteristics of survey participants

	N = 500
Female gender, n (%)	276 (55)
Median age in years (25th –75th IQR)	44 (30–60)
Urban area of residence, n (%)	326 (65)
CPR-trained, n (%)	393 (79)
Median years since CPR training (25th –75th IQR)	4 (1–10)
Health education, n (%)	61 (12)
University degree, n (%)	234 (47)
CPR = cardiopulmonary resuscitation; IQR = Interquartile range	

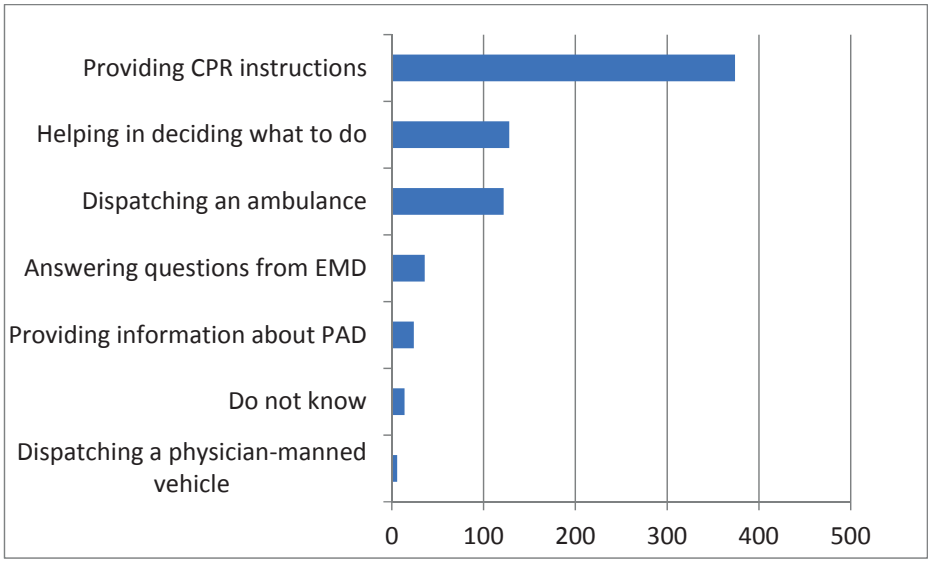

Figure 2: The proportion of answers from all survey participants to question 3: "What kind of assistance will you receive when calling 113?" (Multiple answers allowed)

Table 2: Selected answers for each question by grouped participants

Stratified by		**Questions 1, 2:** Answering "113" to: "What telephone number would you call when witnessing an unresponsive person?" % (95% CI)	**Question 4:** Answering "nurse" to: "Who is responding at the emergency number? " % (95% CI)	**Question 5:** Answering "when the ambulance arrives" to: "When do you think that the contact with 113 will be terminated?" % (95% CI)	**Question 6:** Answering "The bystander" to: "In your opinion, who is responsible for the decision to initiate CPR when a person suffers from cardiac arrest?" % (95% CI)
All		78 (75, 82)	36 (32, 40)	68 (64, 72)	58 (53, 63)
Gender, Female (F), Male (M)	F	84 (79–88)	43 (37–49)	73 (67–78)	57 (50–64)
	M	73 (65–77)	27 (21–33)	64 (56–69)	59 (51–66)
Age in years, grouped	≤ 30	79 (71–85)	19 (13–27)	74 (66–81)	55 (45–65)
	31–59	78 (72–83)	44 (38–50)	72 (66–77)	62 (55–69)
	60–90	82 (70–84)	39 (29–46)	59 (50–67)	54 (42–61)
Area of residence: Urban (U), Rural (R)	U	79 (74–83)	42 (37–47)	71 (66–76)	61 (55–67)
	R	81 (62–76)	25 (16–28)	63 (56–71)	53 (36–54)
Level of education: Secondary school (S), High school (H), University (U)	S	70 (52–84)	27 (14–45)	56 (39–72)	38 (20–59)
	H	78 (72–83)	27 (22–33)	66 (60–72)	57 (49–64)
	U	81 (74–84)	45 (39–52)	74 (66–78)	62 (53–67)
Health education: Yes (Y), No (N)	Y	92 (81–97)	67 (54–78)	79 (66–87)	57 (43–70)
	N	77 (72–80)	32 (27–36)	67 (62–71)	58 (53–63)
CPR-trained: Yes (Y), No (N)	Y	82 (78–85)	38 (33–43)	73 (68–77)	63 (57–68)
	N	70 (55–73)	30 (20–37)	55 (46–65)	37 (25–47)
Years since CPR-training: ≤ 5, > 5	≤ 5	81 (76–86)	38 (32–44)	76 (71–81)	69 (62–75)
	> 5	80 (73–86)	37 (29–45)	66 (58–74)	53 (43–62)

Table 3: Unadjusted odds ratios (OR) of categorical variables associated with answers

	Questions 1, 2: Answering "113" to: "What telephone number would you call when witnessing an unresponsive person?"			**Question 4:** Answering "nurse" to: "Who is responding at the emergency number 113?"			**Question 5:** Answering "when the ambulance arrives" to: "When do you think that the contact with 113 will be terminated?"			**Question 6:** Answers "the bystander" to: "In your opinion, who is responsible for the decision to initiate CPR when a person suffers from cardiac arrest?"		
Variable	**OR**	**95% CI**	**p**	**OR**	**95% CI**	**p**	**OR**	**95% CI**	**p**	**OR**	**95% CI**	**p**
Gender												
Female	——	——	——	——	——	——	——	——	——	——	——	——
Male	0.5	0.33–0.79	0.003	0.49	0.33–0.71	< 0.001	0.64	0.44–0.94	0.02	1.05	0.7–1.58	0.8
Age in years, grouped												
16–29	——	——	0.7	——	——	< 0.001	——	——	0.01	——	——	0.3
31–59	0.97	0.58–1.65	0.9	3.2	1.93–5.31	< 0.001	0.88	0.54–1.43	0.6	1.34	0.82–2.19	0.2
60–90	1.2	0.65–2.22	0.6	2.6	1.48–4.56	0.001	0.49	0.29–0.83	0.008	0.99	0.56–1.72	0.9
Area of residence												
Urban	——	——	——	——	——	——	——	——	——	——	——	——
Rural	1.12	0.7–1.81	0.6	0.46	0.3–0.7	< 0.001	0.71	0.47–1.06	0.1	0.73	0.46–1.16	0.2
Level of education												
University	——	——	0.3	——	——	< 0.001	——	——	0.045	——	——	0.08
High school	0.84	0.54–1.33	0.5	0.46	0.31–0.67	< 0.001	0.68	0.46–1.02	0.06	0.81	0.54–1.24	0.3
Secondary school	0.54	0.24–1.21	0.1	0.44	0.2–0.97	0.04	0.45	0.22–0.95	0.035	0.38	0.16–0.9	0.03
Health education												
No	——	——	——	——	——	——	——	——	——	——	——	——
Yes	3.3	1.29–8.46	0.01	4.46	2.52–7.89	< 0.001	1.78	0.94–3.4	0.8	0.97	0.53–1.77	0.9
CPR training												
No	——	——	——	——	——	——	——	——	——	——	——	——
Yes	1.93	1.19–3.1	0.008	1.4	0.9–2.3	0.1	2.14	1.37–3.34	0.001	2.93	1.73–4.95	< 0.001
Years since CPR training												
No CPR training	——	——	0.04	——	——	0.3	——	——	< 0.001	——	——	< 0.001
≤ 5	1.96	1.15–3.32	0.01	1.44	0.88–2.34	0.2	2.63	1.62–4.26	< 0.001	3.56	2.05–6.19	< 0.001
> 5	1.77	0.99–3.15	0.06	1.36	0.8–2.31	0.3	1.61	0.97–2.68	0.07	1.8	1.0–3.24	0.051

Table 4: Adjusted odds ratios (OR) of categorical variables associated with answers

	Questions 1, 2: Answering "113" to: "What telephone number would you call when witnessing an unresponsive person?"			**Question 4:** Answering "nurse" to: "Who is responding at the emergency number 113?"			**Question 5:** Answering "when the ambulance arrives" to: "When do you think that the contact with 113 will be terminated?"			**Question 6:** Answers "the bystander" to: "In your opinion, who is responsible for the decision to initiate CPR when a person suffers from cardiac arrest?"		
Variable	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p
Gender												
Female	—	—	—	—	—	—	—	—	—	—	—	—
Male	0.56	0.34–0.9	0.016	0.53	0.35–0.83	0.005	0.68	0.45–1.03	0.07	0.88	0.56–1.37	0.6
Age in years, grouped												
16–29	—	—	0.27	—	—	< 0.001	—	—	0.3	—	—	0.3
31–59	1.17	0.65–2.08	0.6	4.1	2.27–7.36	< 0.001	0.96	0.57–1.62	0.8	1.48	0.86–2.57	0.2
60–90	1.74	0.87–3.5	0.1	4.0	2.06–7.9	< 0.001	0.68	0.38–1.22	0.2	1.46	0.77–2.77	0.3
Area of residence												
Urban	—	—	—	—	—	—	—	—	—	—	—	—
Rural	1.26	0.75–2.11	0.4	0.4	0.24–0.65	< 0.001	0.77	0.5–1.2	0.2	0.86	0.51–1.43	0.6
Level of education												
University	—	—	0.5	—	—	0.5	—	—	0.4	—	—	0.56
High school	1.02	0.62–1.7	0.9	0.8	0.5–1.2	0.3	0.74	0.48–1.16	0.1	0.89	0.55–1.44	0.6
Secondary school	0.6	0.24–1.5	0.3	0.8	0.31–2.0	0.6	0.77	0.34–1.73	0.5	0.58	0.22–1.57	0.3
Health education												
No	—	—	—	—	—	—	—	—	—	—	—	—
Yes	2.0	0.73–5.41	0.2	5.1	2.52–10.3	< 0.001	1.28	0.62–2.66	0.5	0.77	0.38–1.54	0.5
Years since CPR training												
No CPR training	—	—	0.02	—	—	0.3	—	—	0.006	—	—	< 0.001
≤ 5	2.32	1.26–4.26	0.007	1.5	0.84–2.69	0.2	2.4	1.39–4.1	0.002	3.7	2.0–6.9	< 0.001
> 5	1.93	1.02–3.62	0.042	1.08	0.6–1.99	0.8	1.5	0.86–2.59	0.2	1.8	0.96–3.39	0.07

Discussion

We investigated public knowledge and expectations regarding dispatcher assistance in a hypothetical OHCA scenario. While CPR guidance was the most frequent expected help from the dispatcher, most participants regarded the bystander present at the OHCA to be solely responsible for the decision to initiate CPR. Although most participants stated the correct emergency medical telephone number and expected the emergency call to be terminated upon ambulance arrival, only one-third knew that the emergency telephone number was operated by a trained nurse.

The availability of T-CPR seems to be well incorporated in public knowledge. This is of vital importance as dispatchers are essential for bystander provision of CPR in the majority of OHCAs.[20] Few participants expected help in deciding what to do, which could indicate that most participants felt confident they would be able to take appropriate decisions in an OHCA by themselves. This finding is surprising considering that only a minority of bystanders recognise cardiac arrest before calling the EMDC.[20] Further, as most participants regarded the bystanders as responsible for the decision to initiate CPR, an exaggerated trust in bystanders' ability to independently initiate CPR is exhibited. In particular, participants who had received CPR training in the last five years were more likely to state the bystanders' responsibility for deciding to initiate CPR, which could be a reflection of traditional CPR training that did not incorporate dispatcher assistance.[12] According to current guidelines, bystanders should recognise cardiac arrest by identifying unconsciousness and abnormal breathing, which in a real OHCA is shown to be difficult. [21-23] Thus, the results in our study may indicate a mismatch between the public' expectations of themselves, what they are trained to do and what they manage to do in reality in OHCA incidents. It is likely that this could be a reason for delayed contact with the EMDC, ineffective communication with dispatchers and delayed recognition of OHCA.[24, 25] This aspect highlights the importance of effective communication between the bystander and the dispatcher. By

calling 113 in an OHCA, the bystander and dispatcher instantly constitute a team wherein the dispatcher should take the role as the team leader. [14, 26] Dispatcher recognition of cardiac arrest makes T-CPR possible and leads to the earlier arrival of the ambulance crew and an increased rate of survival. [27-29] With proper training, dispatchers can recognise 95% of cardiac arrests. [30] Training in CPR should include communication with the dispatcher, as this is an essential element of real-life resuscitation. [12]

Most participants in this study knew how to contact the EMDC in a suspected OHCA, indicating that the emergency medical telephone number 113 in the general Norwegian population is well known.[31] The direct number to the EMDC shortens the access time by about 20 seconds.[32] However, one-third of the participants expected that the emergency call would terminate prior to the arrival of the ambulance. As CPR provision requires the courage to confront death,[33] it is of paramount importance for the public to be ensured of the support of a professional dispatcher until the emergency medical services arrive. This strategy may increase the feeling of safety and sharing the responsibility for the cardiac arrest victim.

The connection between high levels of trust in social institutions and bystander behaviour in cardiac arrest incidents have previously been pointed out.[21] This trust may also refer to an expected dispatch of ambulance and physician, although it is not explicitly stated by the participants in this study. Only a few of the participants expected dispatcher information about the nearest location of a public automated defibrillator (PAD (5%, which is probably due to the recent establishment of the national automated external defibrillator (AED registry.[34] To prepare the public for PAD use, wide-scale public information campaigns [35] and AED training incorporated into CPR training are required. [36] The fact that only one-third of the participants answered “nurse” when asked who is responding to the emergency telephone number may indicate that the public is not aware that they will receive highly competent assistance when calling 113. However, two-

thirds assumed health care workers operate the emergency telephone number. When trusting professional assistance in OHCA, education may be irrelevant to the public and it could be more of a system issue in allocating adequate competence to the dispatcher role. Family members, friends, colleagues and caregivers are the most prominent available groups for potential rescuers in OHCA. [37] In the current European Resuscitation Council guidelines, the role of dispatcher support to the bystander is emphasized. [5] Clarifying the dispatcher assistance, particularly the decision to initiate CPR, may be an important issue for public communication and in CPR training. This may be relevant to all systems with emergency medical dispatch centres. Members of the general public need to learn to expect dispatchers' assistance in decision making, not only in CPR instructions.

Limitations

The questionnaire is not a validated instrument. The questions were repeatedly evaluated and adjusted, so as to achieve at clarity and unambiguousness. During the study, we added one question concerning decision making to the questionnaire, leaving this question unanswered by approximately one-fifth of the participants. However, the remaining participants were chosen randomly and we do not suspect any selection bias caused by this step. Our sample was carried out by discretionary selection of participants and is not proportional to the composition of the Norwegian population with regard to gender and education. The risk of a non-probability selection is that the sample may deviate systematically from the total population, and thus the generalisation possibilities are weakened. The inherent limitation to this survey is whether the participants' answers reflect their knowledge and expectations; moreover we cannot verify that they would act according to their statements in a real OHCA incident. We did not systematically register the number and reason for not wanting to participate in this study. The participants in our study had a higher percentage of university-level education than the

general population in Norway (47 % vs. 33 %).[38] However, we measured ongoing education and suspect that not all will complete their university education.

Conclusion

The public expects to receive assistance from dispatchers in OHCA, in particular by dispatchers providing CPR instructions. However, a common public expectation is to consider bystanders as responsible for the decision to initiate CPR. To increase public awareness of the team interaction between a caller and a dispatcher, an increased focus on dispatchers' assistance in CPR decision making should be emphasised in CPR training and in public information campaigns.

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Paper II

Exploring How Lay Rescuers Overcome Barriers to Provide Cardiopulmonary Resuscitation: A Qualitative Study

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Keywords: attitude; cardiopulmonary resuscitation; emotions; fear; out-of-hospital cardiac arrest

Abbreviations:
CPR: cardiopulmonary resuscitation
EMS: Emergency Medical Services
OHCA: out-of-hospital cardiac arrest

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Abstract

Background: Survival rates after out-of-hospital cardiac arrest (OHCA) vary considerably among regions. The chance of survival is increased significantly by lay rescuer cardiopulmonary resuscitation (CPR) before Emergency Medical Services (EMS) arrival. It is well known that for bystanders, reasons for not providing CPR when witnessing an OHCA incident may be fear and the feeling of being exposed to risk. The aim of this study was to gain a better understanding of why barriers to providing CPR are overcome.

Methods: Using a semi-structured interview guide, 10 lay rescuers were interviewed after participating in eight OHCA incidents. Qualitative content analysis was used. The lay rescuers were questioned about their CPR-knowledge, expectations, and reactions to the EMS and from others involved in the OHCA incident. They also were questioned about attitudes towards providing CPR in an OHCA incident in different contexts.

Results: The lay rescuers reported that they were prepared to provide CPR to anybody, anywhere. Comprehending the severity in the OHCA incident, both trained and untrained lay rescuers provided CPR. They considered CPR provision to be the expected behavior of any community citizen and the EMS to act professionally and urgently. However, when asked to imagine an OHCA in an unclear setting, they revealed hesitation about providing CPR because of risk to their own safety.

Conclusion: Mutual trust between community citizens and towards social institutions may be reasons for overcoming barriers in providing CPR by lay rescuers. A normative obligation to act, regardless of CPR training and, importantly, without facing any adverse legal reactions, also seems to be an important factor behind CPR provision.

Mathiesen WT, Bjørshol CA, Høyland S, Braut GS, Søreide E. Exploring how lay rescuers overcome barriers to provide cardiopulmonary resuscitation: a qualitative study. ***Prehosp Disaster Med*****. 2017;32(1):1-6.**

Introduction

Out-of-hospital cardiac arrest (OHCA) represents a major health problem, and survival rates vary considerably among communities and regions.[1] The chance of survival after cardiac arrest increases two- to three-fold when lay rescuers provide cardiopulmonary resuscitation (CPR) before the Emergency Medical Services (EMS) arrives.[2] However, common barriers to providing CPR are fear of infection, legal repercussions, causing damage, and feeling incapable of providing CPR.[3,4] The ability to overcome the fear of confronting death is required to provide CPR.[5] Consequently, an OHCA incident can create a feeling of being exposed to risk, which may influence the lay rescuer's decision to intervene or not. Perception of risk varies according to psychological, social, and cultural factors.[6] Such factors may explain some of the divergent CPR rates between different regions and countries.[1]

To improve OHCA survival, initiatives have to be holistic, inclusive, and based in the society.[7] To study how real-life lay rescuers have perceived risk while providing CPR would be beneficial in gaining a better understanding of why barriers to providing CPR are overcome.

The aim of this study was to explore how risk perception influences lay rescuers in providing CPR in an OHCA incident.

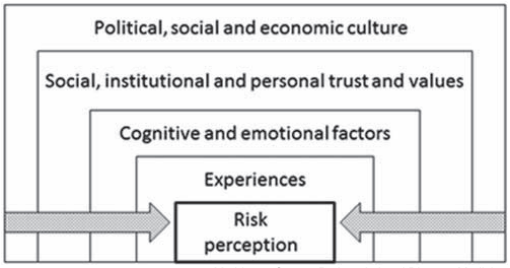

Figure 1. Four Context Levels of Risk Perception; An Adapted, Simplified Model.[6]

Theory

A risk perception perspective was utilized for studying how the lay rescuers experienced the OHCA incident (Figure 1). Risk perception means how humans process information about harmful events or activities and form judgments about the seriousness, likelihood, and acceptability of the respective event or activity.[6] Risk perception implies weighing opportunities and risks involved in challenges and is influenced by knowledge, values, emotions, and a sense of being judged by others.[6]

Methods

Setting

The Stavanger (Norway) region is populated by 330,000 inhabitants, with Stavanger University Hospital (SUH) as the only receiving hospital for OHCA victims.[8,9] The Emergency Dispatch Center coordinates the EMS and has provided telephone-guided CPR for the past 24 years. The prehospital emergency response system has been described in detail elsewhere.[8] High bystander CPR rates in the community are reported previously.[8] It is assumed that the reasons for the high bystander CPR rate in the Stavanger region are related to the long-lasting, ongoing, national and local focus on CPR training for school children and lay people.[8] Also, the local offshore and medical industries focus on health, safety, and the environment.

Study Design

A retrospective design was used by identifying lay rescuers from the local Utstein-style reported OHCA registry.[10] Inclusion criteria were bystanders over 18 years of age who had provided CPR or alerted the EMS at a witnessed or unwitnessed, non-traumatic, adult OHCA with no professional obligations in the incident. Also, they had to be residing in the Stavanger region and be able to communicate in a Scandinavian or English language.

In this qualitative study, a combined deductive and inductive research strategy to explore the psychological, social, and cultural factors that might influence lay rescuers in providing CPR in an OHCA incident was used. The deductive strategy is useful for explaining any social regularity that has been discovered, but not understood.[11] Conversely, also exploring new understandings/patterns that emerged in the data with an inductive (bottom-up) research strategy.[12]

Data Collection and Sampling

Nine family members of nine patients that underwent cardiac arrests and survived to discharge from the hospital were invited by mail, and one was approached in the intensive care unit, to participate in the study. Two OHCA were excluded due to the lay rescuers' inability and rejection to participate. In sum, 10 lay rescuers involving eight OHCAs participated in the study (Table 1). In six of the OHCA, the invitation to the study was forwarded to lay rescuers outside the family of the cardiac arrest victim. All lay rescuers provided CPR, except for one, who only communicated with the EMS and assisted another bystander.

The study was conducted between March 2012 and January 2013. An in-depth, open-ended, semi-structured interview guide (Supplemental Material; available online only), to be used in interviews with lay rescuers to OHCA victims, was designed and implemented. The study was approved by the Norwegian Social Science Data Services (Bergen, Norway).

The interview guide was based on the study by Axelsson et al. who stated that in order to provide CPR, a bystander needs CPR training and skills, psychological preparedness, and the personal courage to overcome fear and repugnant feelings that may be generated.[13] Axelsson et al. also proposed five main categories of perceptions: (1) a sense of humanity; (2) having competence; (3) to feel an obligation; (4) to have courage; and (5) to feel exposed.[13] These types of perceptions served as a framework for the interview guide.

Data Analysis

Qualitative content analysis was used to facilitate a deeper understanding of the OHCA experiences by the bystanders.[14] The interviews lasted between 29 and 56 minutes, were audio recorded, and then were transcribed verbatim by the interviewer (WTM). To capture the overall meaning, each interview was read through several times. The analysis process was started by coding meaning units with the aim of capturing the lay rescuers' risk perception of the OHCA incident. Meaning units were defined as constellations of statements that related to the same central meaning.[14,15] Further, the codes were sub-categorized. Based on the sub-categories with similar content, categories and one overarching theme were developed: overcoming individual and contextual barriers to provide CPR. During the analysis process, two of the authors (WTM and CB) discussed the choices until a consensus was reached. The text was organized using a computer program, Atlas.ti (6.2, free trial version; Scientific Software Development GmbH; Berlin, Germany).[16]

Results

The results are presented by congregating the similarities and differences that were obtained through the interviews and exemplified in selected statements. Table 2 shows the study's progression from a deductive to an inductive (codes, sub-categories, categories, and theme) research approach and with an overview of findings revealed during the analysis process. The overarching theme, "overcoming individual and contextual barriers to provide cardiopulmonary resuscitation," describes the findings in this study which illuminates the complexity of CPR provision. All the participants described the OHCA incident to have influenced their lives, though some were affected more than others.

Valuing Life Itself

All the lay rescuers considered life as invaluable, took action in accordance with what they believed to be expected by any responsible community citizen, and stated that they would provide

Participant No.	Lay Rescuer Gender	Lay Rescuer, Age (Years)	Location of Cardiac Arrest	Age of Patient	Relationship	Months between OHCA Incident and Interview	Time Since Last CPR Training and OHCA
1	Female	59	Home	60-69	Relative	1	No CPR training
2	Male	61	Private place	50-59	Relative	14	7 years
3	Male	63	Private place	50-59	Acquaintance	14	1 year
4	Male	24	Public, rural	40-49	Stranger	11	No CPR training
5	Female	45	Public, rural	40-49	Stranger	11	12 years
6	Female	69	Home	60-69	Relative	12	20 years
7	Male	60	Public, rural	50-59	Stranger	17	8 years
8	Female	36	Public, urban	70-79	Stranger	12	6 months
9	Male	28	Home	50-59	Relative	16	6 years
10	Male	55	Public, urban	40-49	Stranger	18	9 months

Table 1. Characteristics of Lay Rescuers and OHCA Victims
Abbreviations: CPR, cardiopulmonary resuscitation; OHCA, out-of-hospital cardiac arrest.

CPR to anybody, anywhere, regardless of appearance or socio-economic status:

> Participant No. 1: "It is a human being, whether he is an alcoholic, drug-addict, or businessman. In the end, there are no differences between us. Everybody has the same right to help. What if I had greasy hair and wore trainers and fell on the street, and somebody had judged me for being someone other than I am, and passed by because I did not look as though I was worthy of help? No. That was not in my thoughts. A human being is a human being to me."

Several lay rescuers described how they had been affected emotionally by the uncertainty of outcome of the OHCA victim:

> Participant No. 7: "I was thinking and dreaming a lot about him. He was always in my head. Until the day he came with flowers and a card. Then I stopped thinking about him."

Comprehension and Coping

Both trained and untrained rescuers stated that they intuitively provided CPR without prior reflection. Few had, however, imagined they would ever witness a cardiac arrest in real-life:

> Participant No. 5: "I never imagined or thought of finding a person in cardiac arrest while I was outdoors jogging."

Generally, the lay rescuers had comprehended the unusual breathing and abnormal skin color of the OHCA victim to represent a critical condition, but without necessarily realizing that a cardiac arrest was the cause:

> Participant No. 2: "I saw he was turning bluish, and that indicated that he wasn't getting any air. So, that was the reason for starting CPR."

Unintentionally watching CPR being performed on television had helped one untrained lay rescuer by showing her where to put her hands and how to compress the chest. Rescuers with CPR training within the last year made independent decisions with less need for advice from the dispatchers. Several lay rescuers considered the quality of their CPR provision to be improved by the dispatcher's instructions:

> Participant No. 4: "But, as the dispatcher said to me on the phone, when you are alone, concentrate on the chest compressions, and only that. So, I did. But of course, if I had not had her on the line, I don't know; I suppose I would have started chest compressions, anyway. But I wouldn't have known if it was right or not. I felt I had control, because I had a competent person on the phone."

Normative Obligation

For the lay rescuers, being a community citizen and able to help, it was self-evident to act in the OHCA incident:

> Participant No. 1: "I believe we have a responsibility to our fellow human beings. I think so. We have, anyhow. So, we are a community which interacts. I believe that having a helping attitude makes us better humans."

They all feared that doing nothing would have led to feelings of guilt for not trying to save a life. They expected others present in the OHCA incident to assist, and were disappointed if help was not offered. Still, most of the lay rescuers were reluctant to judge them by explaining that they possibly were not capable to provide CPR.

Because the lay rescuers believed there was no reason for extraordinary praise for fulfilling an obvious responsibility, they stated that any extensive attention would have been disturbing to them:

> Participant No. 3: "But I didn't want all this. Some flowers would have been fine. It was enough for me to know that he is alive today."

Confidence

Communicating with the dispatcher was important to several of the lay rescuers in contributing to decision making, being assured

by the approaching EMS-personnel, supervising CPR, and reducing the sense of solitude:

> Participant No. 1: "It was certainly an enormous help to me. The calm voice that told me what to do. Of course, it was fantastic help in that situation. For one thing, you don't feel so alone; and you have a voice that gives you instructions without increasing the intensity by even a small amount; and she hears the panic in me. Do you see? Of course she does. So, she was a fantastic help. All my respect goes to her."

Some CPR-trained rescuers took the lead in the OHCA incident and organized others by assigning who should do what:

> WTM: "You had no doubt about that your mates would help you?"
> Participant No. 10: "Oh no, I had no doubt about that. I wasn't the only one there. There were three of us."
> WTM: "So, you simply expected them to help in the incident?"
> Participant No. 10: "Yes, I did. It was not an issue. We didn't talk about it."

Context-Specific CPR

Assuming a high, local, public CPR awareness and knowledge, they were confident that other citizens would have the ability and willingness to provide CPR to them, if needed. In addition, they were certain that the EMS would assist them in an urgent and professional way. When the lay rescuers were asked to imagine an OHCA incident in their own neighborhood, with themselves not providing CPR, this was considered to be a strange and remote alternative. However, when questioned about providing CPR in an unfamiliar and unclear setting, the lay rescuers revealed more hesitation. If doubting whether the incident was a genuine cardiac arrest, or a situation with their own safety at stake, a clear reply was hard to give:

> Participant No. 5: "The fact that it was night-time would have stayed in the back of my mind. Perhaps I wouldn't have dared to stop, because of my own fear that somebody might not really need my help, but rather might want to attack me."

The lay rescuers did not fear any legal consequences when providing CPR. However, one rescuer was very specific about not providing CPR in a foreign country without knowing all the possible implications, as he would not take any action that might threaten himself or the safety of his family:

> Participant No. 9: "I want to help people. But I do not want to go to prison. They may even kill me later. They will simply say that I have killed him."

Discussion

A qualitative approach was used to study how real-life lay rescuers, in a community with a high CPR rate,[8] perceive risk in OHCA incidences. This could help to better understand which psychological, social, and cultural factors influence lay rescuers in providing CPR. Overall, a general willingness to provide CPR to anybody, anywhere was found. Cardiopulmonary resuscitation provision was regarded to be the expected behavior in OHCA incidents. Mutual trust between community citizens, and towards social institutions as the dispatchers, enhanced the confidence to provide CPR. This may be interpreted as a function of the general expectation of great availability to public health services in the Norwegian population. In imagined unfamiliar OHCA settings, hesitation about providing CPR because of uncertainty concerning safety was revealed.

Providing CPR to an OHCA victim demonstrates the willingness and ability to protect life. However, studies have shown great willingness to provide CPR, but with a distinct discrepancy between the willingness and the actual behavior.[17] This discrepancy may indicate that other circumstances hinder bystanders in acting according to their values and might well be associated with a feeling of risk.

Several lay rescuers in this study provided CPR, but without comprehending the cause for the life-threatening incident to be a cardiac arrest. In addition, two lay rescuers had never been trained in CPR. Thus, unlike the study by Axelsson et al,[13] the findings in the present study demonstrate the potential for providing CPR, even without CPR knowledge, training, and mental preparation. This study also shows that unintentional learning through television programs featuring CPR can be a way of acquiring CPR knowledge. However, the importance of CPR training for bystanders cannot be ignored.[18,19] Knowledge may reduce the feeling of uncertainty.[6] The telephone instructions by the dispatchers can be seen as communicating knowledge to lay rescuers and creating a possible potential for CPR provision, as well as reducing the feeling of risk.

The lay rescuers felt obliged to provide CPR and were certain of receiving help from other bystanders present during the OHCA incident. This confidence in others was interpreted as some form of mutual trust in the general population. The level of trust among Norwegian citizens is found to be high in several studies.[20,21] Mutual dependence was also reflected when the lay rescuers used phrases as "should" or "must" provide CPR when needed. This attitude was taken as a normative obligation, or a common, expected behavior. This norm may, to some extent, explain the high CPR bystander rate in the region where the study was conducted, as social interactions can heighten or attenuate perceptions of risk and influence risk behavior.[6,22] Thus, protecting life is likely to be more an expression of mutual dependence in communities rather than a particular altruistic behavior.[23,24] Accordingly, an effective strategy for influencing people to provide CPR might be to emphasize the mutual dependency between community citizens.

Although Bohm et al. stated that there is limited evidence to support any benefit from dispatch-assisted CPR instructions,[25] lay rescuers in this study followed and appreciated the dispatcher's guidance. The trust and acceptance can be interpreted as obeying a command to act. Providing the recommended CPR to an OHCA victim is not necessarily a natural thing to do, as it includes both compressions of the chest and mouth-to-mouth contact with a stranger. Thus, it is understandable that some bystanders might be afraid to cause damage or contract a disease.[3] Citizens in Scandinavian countries commonly exhibit a high level of trust in social institutions (ie, public offices, services, or agencies, organizations, and the political system) and in fellow community citizens,[26] and this trust also may transfer into the high CPR bystander rate.[8] Conversely, distrust in local government authorities has been noted as a reason for not alerting health services in an OHCA, due to the fear of undesirable consequences.[4,27] This

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means that a bystander may provide CPR in one setting, but omit to do so in another. This can explain why the lay rescuers in this study initially insisted in the interviews that they would provide CPR anywhere and for anyone, but later modified their statements to include conditions for providing CPR. To understand the behavior of individuals, the cultural context, and the context within the life of a human being, is particularly important to know.[28] As people are risk-averse if the stakes for losses are high,[29] this study shows that adequate CPR knowledge and skills are not sufficient to achieve a high degree of CPR provision,[30] but that this probably also depends on factors like mutual trust and normative obligations.

Limitations

There are several limitations to this study. First, use of qualitative risk perception assessments in lay rescuers is a novel approach, with limited supportive research available. This could also be considered to be a strength in the present study, as a new approach may bring out new information. Secondly, all respondents in this study had taken part in successful resuscitations. This may have affected their answers. Rescuers who have taken part in unsuccessful resuscitations might have presented other risk perception perspectives. This may have biased the results. Still, based upon successful resuscitations, information at least about a minimum set of possible important barriers is gained. Further, hypothetical questions about how the lay rescuers would have handled an OHCA situation in unfamiliar settings were asked. Their answers may not reflect their actual actions in such an event. At last, findings and discussion are related to a Norwegian cultural and political context and may therefore not be applicable to other settings.

Conclusions

Mutual trust between community citizens and towards social institutions may be reasons for overcoming barriers in providing CPR by lay rescuers. A normative obligation to act, regardless of CPR training, and importantly, without facing any adverse legal reactions, also seems to be an important factor behind CPR provision. Ensuring support from the dispatchers is of vital importance in helping community citizens to overcome a natural reluctance to provide CPR. Future community campaigns directed at improving bystander CPR rates should focus on dispatcher-directed CPR, and at the same time, the obligation to help a fellow citizen.

Supplementary Material

To view supplementary material for this article, please visit https://doi.org/10.1017/S1049023X16001278

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Theme	Overcoming Individual and Contextual Barriers to Provide CPR							
Category	Valuing Life Itself	Comprehension and Coping		Normative Obligation		Confidence	Context-specific CPR	
Sub-Category	Protection of all lives.	Comprehending the severity of illness.	Having competence.	Doing what is right.	Fearing guilt.	CPR provision by teamwork.	Trust in appropriate assistance.	Being secure in safety of the process.
Codes	Wanting to save a life. Valuing life itself. Helping by taking action. Providing CPR to anybody, anywhere. Being emotionally affected by uncertainty of outcome.	Feeling unprepared. Experiencing unusual breathing and seriousness. Struggling to comprehend the situation. Little resemblance to CPR training. Feeling helpless. Fear of hurting the victim.	Experiencing CPR as something natural to do. Acting instinctively. Having CPR knowledge and skills. Retrieving competence by dispatchers. Utilizing knowledge from media.	Being able to provide CPR. Volunteering to do a job. Taking responsibility as a citizen of a community. Being a role model. Acting in accordance with expectations from others. Solidarity.	Fearing self-criticism. Fearing negative reactions from others. Reluctance to judge others who do not provide CPR.	Being encouraged by the dispatcher. Taking the initiative to provide CPR. Providing CPR together with other bystanders.	Expecting EMS to act urgently and professionally. Having confidence in community citizens' ability to provide CPR.	Hesitating to provide CPR in unclear settings. Expecting no legal repercussions.

Table 2. Overview of the Overarching Theme Categories, Sub-Categories, and Codes
Abbreviations: CPR, cardiopulmonary resuscitation; EMS, Emergency Medical Services; OHCA, out-of-hospital cardiac arrest.

Paper III

BMJ Open

Reactions and coping strategies in lay rescuers who have provided CPR to out-of-hospital cardiac arrest victims: a qualitative study

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ABSTRACT

Objective: Cardiopulmonary resuscitation (CPR) provided by community citizens is of paramount importance for out-of-hospital cardiac arrest (OHCA) victims' survival. Fortunately, CPR rates by community citizens seem to be rising. However, the experience of providing CPR is rarely investigated. The aim of this study was to explore reactions and coping strategies in lay rescuers who have provided CPR to OHCA victims.

Methods, participants: This is a qualitative study of 20 lay rescuers who have provided CPR to 18 OHCA victims. We used a semistructured interview guide focusing on their experiences after providing CPR.

Setting: The study was conducted in the Stavanger region of Norway, an area with very high bystander CPR rates.

Results: Three themes emerged from the interview analysis: concern, uncertainty and coping strategies. Providing CPR had been emotionally challenging for all lay rescuers and, for some, had consequences in terms of family and work life. Several lay rescuers experienced persistent mental recurrences of the OHCA incident and had concerns about the outcome for the cardiac arrest victim. Unknown or fatal outcomes often caused feelings of guilt and were particularly difficult to handle. Several reported the need to be acknowledged for their CPR attempts. Health-educated lay rescuers seemed to be less affected than others. A common coping strategy was confiding in close relations, preferably the health educated. However, some required professional help to cope with the OHCA incident.

Conclusions: Lay rescuers experience emotional and social challenges, and some struggle to cope in life after providing CPR in OHCA incidents. Experiencing a positive patient outcome and being a health-educated lay rescuer seem to mitigate concerns. Common coping strategies are attempts to reduce uncertainty towards patient outcome and own CPR quality. Further studies are needed to determine whether an organised professional follow-up can mitigate the concerns and uncertainty of lay rescuers.

Strengths and limitations of this study

- This study describes the experiences of lay rescuers who have provided cardiopulmonary resuscitation (CPR) to out-of-hospital cardiac arrest victims, which little previous research has focused on.
- The results presented in this study give an understanding of the unwanted aspects of providing CPR.
- This study may stimulate health authorities to organise follow-up systems to mitigate concerns and uncertainty in lay rescuers.
- In most of the resuscitations initiated by the persons interviewed in this study, the cardiac arrest victims survived. This does not reflect the survival rate in our area and may have biased the results.

INTRODUCTION

In Europe, ~275 000 persons experience out-of-hospital cardiac arrest (OHCA) annually.[1] Bystander cardiopulmonary resuscitation (CPR) increases the chances of survival twofold to threefold.[2] Bystander CPR rates differ substantially worldwide, ranging from 1.5% to 73%.[3 4] However, new studies have revealed that bystander CPR rates are rising, both in the UK and on a global scale.[5–8]

Though the main focus and concern in an OHCA incident is for the cardiac arrest patient, the existing data about the reactions of lay rescuers following CPR provision are sparse and divergent. Zijlstra *et al*[9] found that lay rescuers did not show post-traumatic stress-disorder-related symptoms 4–6 weeks after performing bystander CPR, while Genest *et al*[10] reported that unsuccessful CPR attempts lead to persistent adverse effects. Møller *et al*[11] found the debriefing of bystanders to be beneficial and found good coping

strategies and no severe psychological sequelae in the studied lay rescuers who had provided CPR during an OHCA. However, in the first two studies, the lay rescuers took part in a volunteer first responder system. Hence, they were probably prepared for and interested in responding to an OHCA incident. In the study by Møller *et al*, only about half of the bystanders had actually performed CPR, which, in addition to being debriefed shortly after the OHCA, may partly explain the positive results.

The few studies concerning lay rescuers' experiences and reactions following CPR provision show that the OHCA victim ultimately dying and a lack of debriefing influence lay rescuers in a negative way.[12 13]

Given this background, we wanted to explore the reactions and coping strategies of lay rescuers following the provision of CPR to OHCA victims.

METHODS

In this study, we chose a qualitative research method which is suitable for explorative studies.[14] Lay rescuer was defined as an individual having provided CPR with no professional obligations in the incident. We designed and used an in-depth, open-ended, semistructured interview guide (see online supplementary material for the interview guide), with the aim of exploring the lay rescuers' own experiences and avoiding imposing our assumptions as far as possible. The original interview guide was followed through the entire study. In addition, we increasingly emphasised the elaborated subjects by the lay rescuers in the following interviews. The study was conducted from September 2013 to October 2014.

Setting

We conducted this study in Norway, primarily with lay rescuers from the Stavanger region, an area that has been identified as having a high bystander CPR rate.[4] The organisation of the Norwegian emergency medical service (EMS) response to OHCA incidents has been described previously.[4] To the best of our knowledge, there is no organised follow-up system in Norway offered to lay rescuers after having provided CPR. Confidentiality regarding hospitalised or EMS-treated individuals is secured by explicit norms in Norwegian health legislation; thus, information about them is not readily available to the general public.

Data collection and sampling

The inclusion criteria were lay rescuers aged 18 years and above, being able to communicate in a Scandinavian language or the English language and having provided CPR with no professional obligations to a non-traumatic adult OHCA victim. We planned this study using a convenience sampling strategy, which means involving accessible subjects.[15] As one of the inclusion methods, the ambulance personnel distributed 50 flyers about the study to lay rescuers in OHCA settings. Only one lay rescuer contacted us. This unsuccessful way of inclusion led to alternative ways of including participants. Thus, we added a purposive snowball sampling strategy (study features in the local newspaper and proposed candidates who were recommended by individuals in the researchers' network), meaning that the researchers themselves assessed who would provide the best perspective on the phenomenon of interest.[16] We withdrew two bystanders who did not fulfil the inclusion criteria (did not provide CPR and provided CPR to a child). To reduce the dominating population of lay rescuers in OHCA incidents with positive outcomes, we declined interviews with three lay rescuers where this was the case.

We included 20 lay rescuers from 18 OHCA incidents, primarily from the Stavanger region. The lay rescuers were either 'related' (family or spouse), 'known' (colleagues or acquaintances) or 'unknown' (complete stranger) (table 1). They had all performed chest compressions and/or mouth-to-mouth ventilation. Five informants were health educated (three nurses, one paramedic, one nursing assistant), but without any professional or organised voluntary obligations in the OHCA incident. The time span from CPR training to the OHCA incident ranged from 1 week to 36 years. One lay rescuer had no prior CPR training. None of the lay rescuers had been offered any kind of formal follow-up, except for two who were contacted by EMS personnel shortly after the OHCA incident in what seems to have been ad hoc initiatives. With one exception, the outcome for the OHCA victims (12 survivors, three died in the hospital and two died at the scene) was known to all lay rescuers at the time of the interview. The time from experiencing the OHCA incident to participating in the interview ranged from 6 days to 13 years (median 5.5 years) (table 1). The interviews lasted from 21 to 107 min (median 40 min). Eighteen interviews were conducted in person, and two were conducted by telephone. All interviews were conducted by two interviewers (WTM and CAB) introduced as an intensive care nurse and physician, respectively. We collected data regarding lay rescuers' times from OHCA to interview, times from CPR training to OHCA, whether they were health educated or not and their relationship with the OCHA victim. Also, information about the cardiac arrest victims' approximate ages and outcomes was registered. The questions in the interview guide were designed to explore reactions and coping strategies following CPR provision. We encouraged the lay rescuers to discuss their feelings about CPR provision through the interview. Questions raised by the lay rescuers were answered in a discussion following the interviews.

Data analysis

We used a qualitative, inductive content analysis[17] to facilitate a deeper understanding of the lay rescuers' experiences of the OHCA. All interviews were audio recorded and transcribed verbatim. To capture the overall meaning, each interview was read through

Table 1 Characteristics of OHCA victims, outcome and times from OHCA to interview

Participant number	Approximate. age of OHCA victim	Relation between lay rescuer and OHCA victim	OHCA victim outcome	Time range from OHCA to interview in years
1	50	Unknown	Survived	0.04
2	80	Known	Died	0.19
3	50	Unknown	Survived	0.25
4	60	Unknown	Survived	6
5	50	Unknown	Survived	12
6	60	Unknown	Unknown	1.5
7	75	Unknown	Survived	7
8	65	Related	Survived	9
9	80	Unknown	Survived	9
10	45	Related	Survived	0.08
11	55	Known	Survived	1
12	55	Known	Survived	1
13	70	Known	Survived	8
14	35	Known	Survived	0.01
15	55	Known	Survived	5
16	30	Unknown	Died	8
17	70	Unknown	Survived	4
18	75	Unknown	Died	13
19	45	Known	Died	12
20	50	Known	Died	9

OHCA, out-of-hospital cardiac arrest.

several times. While endeavouring to stay close to the text, one investigator (WTM) extracted meaning units which were condensed and developed into codes. A meaning unit is considered as words, sentences or paragraphs containing aspects related to each other through their content and context.[17] An additional investigator (CAB) examined the collection of the statements and performed independent extractions of the same transcribed text.

During the interviews, the lay rescuers repeatedly turned their answers towards how they experienced life after the OHCA incident more than the actual incident. We interpreted the codes regarding this to be the predominant findings and chose these for further analysis. The codes were sorted into subcategories. Finally, based on the subcategories with similar content, we developed three categories: concern, uncertainty and coping strategies and one overarching theme (table 2). During the analysis process, two of the authors (WTM and CB) discussed their choices until a consensus was reached. The text was organised using Nvivo V.10 (QSR International, Victoria, Australia). The results have been reported in accordance with the consolidated criteria for reporting qualitative research checklist.[18]

RESULTS

All the participants described the OHCA incident as having influenced their lives, though some were affected more than others. The overarching theme, emotional and social challenges and the struggle to cope in life after providing CPR, describes the main findings in this study and also illuminates the complexity in reactions after providing CPR. Table 2 includes examples of the codes used to define subcategories and categories in the analytic process.

Concern

The first subcategory describes the bodily and emotional influence of the lay rescuers after providing CPR. Several reported the OHCA incident as a shocking and terrifying experience. Nightmares, flashbacks, recurrent and intrusive images of the cardiac arrest victim persisted. Tiredness, exhaustion, confusion, being emotional, being easily distracted and feeling alone about the OHCA experience were individual reactions which could vary in time from days to months. Unwanted weight reduction, anxiety, insomnia and temporary sick leave were experienced following the OHCA incident.

> Participant no. 3: I didn't sleep. I kept having nightmares, dreamt the same situation with different outcomes, and then, I went through the same dream with family and friends, and it was just tiring. I wasn't sleeping at all.

> Participant no. 6: I lost weight. I found it difficult to eat. Many things changed because of this.

Overall, the lay rescuers reported repetitive self-criticism regarding whether they could have carried out anything else to achieve a better outcome for the cardiac arrest victim. Their main concern was whether their actions had led to severe injury, a vegetative state or death. Except for the health educated, most lay rescuers strongly linked the quality of their CPR provision to the outcome.

Table 2 Overview of the overarching theme, categories, subcategories and codes

Theme	Emotional and social challenges and the struggle to cope in life after providing CPR							
Category	**Concern**			**Uncertainty**			**Coping strategies**	
Subcategory	Bodily and emotional influence	Self-criticism or proudness	Changed family and social behaviour	In search of information about patient outcome	Experiencing unavailable information about patient outcome	Receiving information about patient outcome	Processing the OHCA incident	Wishing follow-up by healthcare professionals
Codes	▸ Having nightmares and poor sleeping ▸ Experiencing unwanted weight loss ▸ Feeling unfocused and distracted ▸ Recurring the cardiac arrest incident in the mind ▸ Being anxious ▸ Feeling alone and deserted	▸ Self-blaming for having not provided sufficient CPR ▸ Worrying about having inflicted injury ▸ Feeling proud and happy for having provided CPR	▸ Wanting to be left alone ▸ Avoiding unwanted attention ▸ Frightening unexpected harm will happen to family members	▸ Struggling to acquire patient information ▸ Wanting to see and talk to the patient	▸ Being kept in ignorance because of the patient confidentiality legislation ▸ Finding it stressful not knowing patient outcome	▸ Experiencing great relief when positive outcome ▸ Experiencing sadness when cardiac arrest victim died or survived in an unfortunate state	▸ Talking to everyone who wanted to listen ▸ Communicate with health-educated individuals in their social network ▸ Consulting healthcare services ▸ Performing everyday activities	▸ Needing a professional, but optional approach from healthcare professionals to talk about the OHCA incident ▸ Missing reassurance of OK CPR performance ▸ Wanting acknowledgement of the CPR attempt by health professionals ▸ Wanting facts about the OHCA incident

CPR, cardiopulmonary resuscitation; OHCA, out-of-hospital cardiac arrest.

> Participant no. 6: I was very concerned about dying, to die just like that, so horrible and in public and because of my mistakes, that he died because I made mistakes. I was obsessed about this.

Health-educated lay rescuers were more able to feel proud of having provided CPR, even though the OHCA victim did not survive. Their reflection was more directed towards having managed the OHCA incident, without being in a professional setting and without having any medical equipment at hand.

> Participant no. 2: From one end to the other, this was a success story, although it did not go well.

Some lay rescuers described influence on work and family life. Unwanted attention after the CPR provision was perceived as stressful by some, while others felt neglected. Some lay rescuers were frightened that unexpected harm would happen to family members.

> Participant no. 19: I remember, during work, for a long time, I was always by myself, for many weeks.

Uncertainty

All the lay rescuers wanted to be informed about the outcome, and several would also appreciate seeing and talking to the OHCA victim. Sometimes, information about the outcome was provided by family, friends or colleagues, while others waited years before they received such knowledge. Health-educated lay rescuers attempted to obtain patient information by using their professional networks. Some lay rescuers put a considerable amount of effort into obtaining information about the outcome. However, the struggle of contacting the hospital, examining newspapers or looking for other signs of survival or death was often futile.

> Participant no. 13: I wondered about the outcome. I looked in the newspaper. I checked to see if the flag was flying at half-mast. Did we manage this, or did we not?

The lack of access to information about the outcomes seemed both stressful and unreasonable to several.

> Interviewer: What if the patient had actually died?
>
> Participant no. 3: I would rather have known. Because when you eventually find out, you go through an emotional dealing with it, which earlier would probably have prevented some of the mind torment.
>
> Participant no. 4: It doesn't mean that I want to know the name of the patient. That doesn't interest me, but if society wants me to help, they can't cut me off with banal statements about the duty of confidentiality.

Several lay rescuers linked the provided CPR to the outcome of the cardiac arrest victim, causing profound feelings of relief or guilt, depending on whether the victim had a good neurological outcome or not. In cases with poor outcomes, a range of emotions from acceptance to profound sadness was reported. Uncertainty about the outcome seemed to be difficult to deal with.

> Participant no. 14: I think about it all the time. I check my mobile phone and wonder when they will call, but they never do.
>
> Participant no. 7: It was an incredible relief when the flowers arrived. It was proof that he was alive and was doing all right.

Coping strategies

By performing everyday activities, some lay rescuers felt that a kind of normality was brought back in life. Although some lay rescuers wanted to avoid attention after the OHCA incident, they all repeatedly talked about the experience with family and friends. Some lay rescuers were particular about who they wanted to confide in, while others spoke to whoever wanted to listen.

> Participant no. 12: I spoke a lot about this incident to everybody I met. That was my way of doing it.

Four of the lay rescuers needed professional counselling to process the OHCA experience, while others contacted health professionals in their network. A few lay rescuers described deep sorrow, even several years after the incident.

Sometimes the EMS personnel provided some kind of feedback at the scene. Except for most of the health-educated lay rescuers, the need for acknowledgement and assurance regarding the adequacy of the CPR provision was reported by all. Most wanted a professional, but optional, follow-up from healthcare professionals to talk about the OHCA incident. They emphasised that they did not want any admiration but clear facts about the OHCA incident and a reassurance that there was nothing else they could have done that would have improved the outcome.

> Participant no. 5: It's about acknowledgement. It's about motivation. It's about being trained to save lives, and when we do, nobody cares.

DISCUSSION

This is one of the very few studies to explore the reactions and coping strategies of lay rescuers following CPR provision for OHCA victims. We used a qualitative research approach and went from coded meaning units to subcategories, further to the categories: concern, uncertainty and coping strategies. The created theme aims at describing the structure of the experience:[17] emotional and social challenges and the struggle to cope in life after providing CPR.

In general, we found the lay rescuers to have profound concern for the cardiac arrest victims. Uncertainty about the outcome led to various efforts to obtain information. Until knowledge was achieved, the lay rescuers often blamed themselves for inflicting severe injury or potential death on the OHCA victim. All lay rescuers talked through the OHCA incident with family and friends, and some talked with professional counsellors. Most lay rescuers would have appreciated follow-up by healthcare professionals.

By providing CPR, lay rescuers attempt to improve outcomes, which can be seen as taking moral responsibility for another human being's life. It is well known that some of the most frequently reported barriers to performing CPR are concerns about incorrect CPR provision and potential harm to the cardiac arrest victim.[19 20] It is plausible that these barriers, even if they are overcome, are strongly connected to the sense of responsibility for another human being's death. Thus, the feelings of guilt reported in this study are comprehensible.

The lay rescuers established a causal relationship between the CPR provided and the outcome and felt guilty when the effort failed. Coping in traumatic incidents has been shown to mitigate stress reactions.[21] The feeling of coping is closely related to the feeling of having achieved goals.[22] By regarding survival as the goal, the lay rescuers are at risk for not succeeding, because other influencing factors outside their control contribute to outcome, such as shockable or non-shockable rhythm, witnessed or unwitnessed arrest, EMS response time and age.[2 4] Conversely, the health-educated lay rescuers in our study seemed to focus more on how they had managed the CPR rather than the outcome of the OHCA victim, which was within their control and thus less dependent on influencing factors. Another explanation to the feeling of guilt in lay rescuers may be the exaggerated positive impact of CPR on OHCA outcome represented by the mass media or stakeholders.[23 24]

The emotional and social challenges reported in this study, such as reduced work capacity, weight loss, flashbacks and nightmares, were considerable. These findings are supported by Genest *et al*[10], who reported that an unsuccessful CPR attempt may lead to persistent adverse consequences. Zijlstra *et al*[9] did not find significant adverse effects for lay rescuers after providing CPR. However, all the interviewees in that study were connected with an OHCA text message alerting system. In addition, 42% of lay rescuers were off-duty professional rescuers. This means that the interviewees were mentally prepared for providing CPR to OHCA victims; the results may therefore not be applicable to the general population. Health-educated lay rescuers probably know that other circumstances than the quality of CPR also determine outcomes.

Even when the return of spontaneous circulation was achieved, some of the lay rescuers in this study reported major concerns while the cardiac arrest victim was in hospital care. They did not calm down until they were sure of the victim's survival with a favourable neurological outcome. Using phrases such as 'emotional roller coaster' and 'mind torment', it seemed as though several lay rescuers had experienced challenges in everyday life depending on the cardiac arrest victim's outcome. Thus, information about favourable outcomes was received with great relief, while being in ignorance sometimes generated despair. Acknowledging that CPR provision is challenging and can have consequences,[10] information about patient outcome may be beneficial to lay rescuers, but raises ethical and legal issues that must be addressed. Before a legislative approach is adopted, this issue should be explored further. Also, considering the emotional cost to lay rescuers providing CPR, the importance of outcome information should not be neglected, but rather carefully facilitated by healthcare workers within legal restrictions. However, if information about positive patient outcomes is essential for processing OHCA incidents in a beneficial way, lay rescuers are highly vulnerable because most OHCA victims do die.[4] Both a lack of debriefing and fatal patient outcomes are considered to be independent factors associated with a negative OHCA experience,[13] while debriefing is shown to positively influence the ability to cope with emotional reactions after CPR provision.[11] Debriefing can stimulate reflection and be valuable, even without involving information about patient outcomes.[11]

The European Resuscitation Council emphasises the importance of bystanders in the latest CPR guidelines.[25] Thus, lay people are urged to take responsibility for up to three of the four links in the chain of survival in OHCA incidents.[26] It is encouraging that the number of bystanders who provide CPR is increasing.[5 6] Still, we should acknowledge that lay rescuers are not a homogeneous population. They differ in their preparedness and vulnerability, and the coincidental OHCA factors vary as well. We may have underestimated the negative impact of providing CPR, perhaps because of the great value of saving lives.

This study has identified communication with family and friends as an important coping strategy for processing OHCA incidents, as are attempts to acquire information about the patient's outcome and the need for acknowledgement of the CPR attempt. All humans inevitably experience emotional challenges that they must face and process. Lay rescuers' reactions might reflect both how they cope with providing CPR and a reaction to the experience of witnessing a loved one suffer a cardiac arrest or die. However, public campaigns to save lives by providing CPR affect moral obligations in human beings. Our results show that such obligations can lead to concerns and adverse reactions. Until now, support and counselling have been directed more towards the patient and family.[27] Being a CPR provider does not necessarily imply the need for professional treatment, but we believe that some sort of an organised follow-up may mitigate concerns, reduce

uncertainty towards the CPR provided and promote coping strategies in lay rescuers. Also, a follow-up should entail mutual trust between healthcare systems and community citizens. Further studies should identify the extent of the adverse reactions after performing CPR.

LIMITATIONS

In most of the resuscitations initiated by the participants interviewed in this study, the cardiac arrest victims survived. This does not reflect the survival rate in our area and may have biased the results.

The large variation in time from CPR intervention to interview is a weakness in this study. To some participants more than others, time may have influenced the processing of the OHCA incident and affected the results. However, considering that most of the lay rescuers in this study were interviewed long after the OHCA incident, and the high rate of survival in this study, we expected less emotional reactions after providing CPR. This may indicate that CPR provision with both favourable and unfavourable outcomes causes emotional strain among lay rescuers. The participants volunteered to meet and discuss the OHCA incident up to 13 years after the occurrence and this could suggest that they were still in need of clarification. The selection method for inclusion of participants may have identified a sample of lay rescuers with more severe reactions than shown in other similar studies.

We also experienced a huge challenge in attempting to include CPR providers in the study, especially those who provided CPR to OHCA victims who did not survive. An avoidance of reminders of the OHCA incident could be a reason, which means that in an unselected population, the impact of providing CPR could be even more severe. Future studies should explore the relationship between patient outcome and lay rescuer reactions.

To ensure a diversity of participants, we used various techniques to recruit lay rescuers, which may seem of little consistency. However, to be responsive to real-world conditions, an adaptable sampling strategy was followed.[16] Our inclusion strategies resulted in various lay rescuers regarding gender, age and the relationship to the cardiac arrest victim, which we regard as a strength by allowing a diversity of perspectives on CPR provision.

We did not use any validated instruments for measuring adverse reactions. Thus, we have avoided any discussion regarding pathological versus normal reactions after experiencing OHCA. This also means that the assessment of the experiences reported by the lay rescuers was left to the authors' discretion.

The researchers of this study have previously conducted a study concerning lay rescuers regarding risk perception in OHCA incidents. The answers from the study may have influenced the researchers preunderstanding in the current study.

CONCLUSIONS AND IMPLICATIONS

Reactions after providing CPR to OHCA victims may cause serious and persistent concerns in lay rescuers. Non-health-educated lay rescuers seem to establish a causal relationship between the provided CPR and outcome, leading to deep concerns regarding whether their CPR provision led to severe injury or death, and without assessing other factors contributing to patient outcome. Experiencing a positive patient outcome and being a health-educated lay rescuer seem to mitigate concerns. Common coping strategies in lay rescuers were directed towards reducing uncertainty about patient outcome and obtaining assurance regarding their own CPR quality. An organised follow-up may mitigate concerns and adverse reactions in lay rescuers. Further studies should explore the prevalence of concerns and adverse reactions in lay rescuers.

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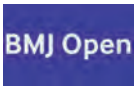

Reactions and coping strategies in lay rescuers who have provided CPR to out-of-hospital cardiac arrest victims: a qualitative study

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RESEARCH Open Access

Effects of modifiable prehospital factors on survival after out-of-hospital cardiac arrest in rural versus urban areas

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Abstract

Background: The modifiable prehospital system factors, bystander cardiopulmonary resuscitation (CPR), emergency medical services (EMS), response time, and EMS physician attendance, may affect short- and long-term survival for both rural and urban out-of-hospital cardiac arrest (OHCA) patients. We studied how such factors influenced OHCA survival in a mixed urban/rural region with a high survival rate after OHCA.

Methods: We analyzed the association between modifiable prehospital factors and survival to different stages of care in 1138 medical OHCA patients from an Utstein template-based cardiac arrest registry, using Kaplan-Meier type survival curves, univariable and multivariable logistic regression and mortality hazard plots.

Results: We found a significantly higher probability for survival to hospital admission (OR: 1.84, 95% CI 1.43–2.36, $p < 0.001$), to hospital discharge (OR: 1.51, 95% CI 1.08–2.11, $p = 0.017$), and at 1 year (OR: 1.58, 95% CI 1.11–2.26, $p = 0.012$) in the urban group versus the rural group. In patients receiving bystander CPR before EMS arrival, the odds of survival to hospital discharge increased more than threefold (OR: 3.05, 95% CI 2.00–4.65, $p < 0.001$). However, bystander CPR was associated with increased patient survival to discharge only in urban areas (survival probability 0.26 with CPR vs. 0.08 without CPR, $p < 0.001$). EMS response time ≥ 10 min was associated with decreased survival (OR: 0.61, 95% CI 0.45–0.83, $p = 0.002$), however, only in urban areas (survival probability 0.15 ≥ 10 min vs. 0.25 < 10 min, $p < 0.001$). In patients with prehospital EMS physician attendance, no significant differences were found in survival to hospital discharge (OR: 1.37, 95% CI 0.87–2.16, $p = 0.17$). In rural areas, patients with EMS physician attendance had an overall better survival to hospital discharge (survival probability 0.17 with EMS physician vs. 0.05 without EMS physician, $p = 0.019$). Adjusted for modifiable factors, the survival differences remained.

Conclusions: Overall, OHCA survival was higher in urban compared to rural areas, and the effect of bystander CPR, EMS response time and EMS physician attendance on survival differ between urban and rural areas. The effect of modifiable factors on survival was highest in the prehospital stage of care. In patients surviving to hospital admission, there was no significant difference in in-hospital mortality or in 1 year mortality between OHCA in rural versus urban areas.

Keywords: Out-of-hospital cardiac arrest, Rural, Urban, Survival, Cardiopulmonary resuscitation

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Background

Out-of-hospital cardiac arrest (OHCA) is a major cause of death in industrialized countries, and survival differs substantially, worldwide [1–3]. Survival is associated with certain OHCA patient factors, but these are generally non-modifiable [4]. However, some prehospital system factors in OHCA as bystander cardiopulmonary resuscitation (CPR), emergency medical services (EMS) response times, and the attendance of EMS physicians, are modifiable [4]. These factors represent opportunities for improvements in saving lives [4].

Bystander CPR is an essential intervention that increases the odds of survival of OHCA victims by two- to threefold [5]. As the effect of bystander CPR on survival declines rapidly over time, OHCA in remote areas with long EMS response times represent a particular challenge. Thus, a decrease in ambulance response times will lead to the annual saving of many additional lives [6]. In addition, some studies have shown that the attendance of an EMS physician is associated with improved survival [7, 8]. Thus, it is likely that bystander CPR, EMS response times, and the attendance of an EMS physician influence short- and long-term survival. Because some studies have shown that also population density is a predictor for survival, [9–11] the aim of this study is to examine how bystander CPR, EMS response time, and EMS physician attendance influence survival at different stages of care, and to what extent this differs between rural and urban areas.

Methods

Setting and design

The study region was that encompassed by the Stavanger Hospital Trust; it is situated on the southwest coast of Norway and constitutes 18 municipalities. The area covers 5700 km^2 and spans both urban and rural municipalities. A minority of the population are inhabitants on islands that can only be reached by boat or helicopter. The cities of Stavanger and Sandnes and two other municipalities are the most densely populated areas, with over 200 inhabitants per km^2 (218–1733 inhabitants per km^2). Geographically, these four municipalities constitute the Stavanger peninsula that, for the purpose of this study, constitutes the urban area. The other 14 municipalities have populations of less than 200 inhabitants per km^2 (1–148 inhabitants per km^2). In the present study, these municipalities constitute the rural area.

The population of the study area increased from approximately 300,000 inhabitants to approximately 358,000 inhabitants during the study period, from 1 January 2006 to 31 December 2015 [12]. In order to categorize rural versus urban municipalities, we used the mean population density during the study period.

Stavanger University Hospital (SUH) is the only receiving hospital for OHCA patients in the study region. The Emergency Dispatch Centre (EDC) is responsible for coordinating 17 ambulance units allocated to eight ambulance stations, and one hospital-based, anesthesiologist-manned (EMS physician) rapid response unit that uses a helicopter for remote assignments, or a car for local assignments. The ambulance staff constitutes two crew members, of which at least one is an advanced life support-certified paramedic. In addition, the EDC dispatches general practitioners (GPs) on call in the local communities [13]. From October 2013, an EMS physician-manned fast response car was made available for a rescue helicopter team, but operates only in the closest proximity to the helicopter base. In addition, fire brigades equipped with automated external defibrillators are often dispatched by the EDC and operate as first responders.

The EDC has one nationwide alarm emergency telephone number (113). The dispatch is criteria-based (using the Norwegian index of emergency medical assistance). In cases of suspected cardiac arrest, the EDC instructs the caller to start CPR, including mouth-to-mouth resuscitation if the bystander is trained in CPR. In the case of untrained bystanders, the instruction is to carry out continuous chest compressions. The EDC also initiates a response by one or two ambulances, the EMS physician-manned rapid response unit and the local GP on call. The EDC aims to ensure at least one physician and two ambulance units at the scene. There were no systematic changes in the response pattern throughout the study period, except for the rapid response car of the rescue helicopter team. In cases where resuscitation did not lead to the return of spontaneous circulation (ROSC), the OHCA assignments were terminated at the scene or the patient was transported to hospital with ongoing resuscitation.

In Norway, training in basic CPR is provided through school systems, compulsory military service and voluntary organizations [14]. The oil industry employs a major work force in the Stavanger area, so CPR has been a part of health, environmental and safety training for many inhabitants in the study region, and there are also an increasing number of public access defibrillators (PADs). However, the EDC does not have alerting routines for PAD locations. As a part of post resuscitation intensive care at SUH, an established in-hospital treatment for all OHCA patients who have not regained consciousness after hospital admission is targeted temperature management and standardized post resuscitation care [15, 16]. Throughout the entire study period, emergency percutaneous coronary intervention was available to OHCA patients with ST-elevation myocardial infarction.

Study population

The local registry for all EMS-attended OHCA cases has been managed by SUH since 1996; Utstein template data are collected from the ambulance, the rapid response unit, and the EDC and cross checked [17]. The present study assessed all prospective datasets of individuals aged ≥18 years, collected between 1 January 2006 and 31 December 2014. OHCA missions for 2015 were collected from the Norwegian National Advisory Unit on Prehospital Emergency Medicine (NAKOS). We used the 2015 Utstein Resuscitation Registry Templates for Out-of-Hospital Cardiac Arrest to register the most likely primary cause of OHCA, which includes cardiac and other medical causes [18]. The following groups were excluded from further analysis: patients for whom no resuscitation attempts were made by the EMS, patients with EMS- or first responder-witnessed OHCA, patients with OHCA of non-medical origin, and cases with missing data. A total of 25 patients had achieved ROSC before EMS arrival, but with no registering of initial rhythm. Nine of these patients had been shocked prior to EMS arrival and were included. During the 10-year study period, 171 patients were admitted to hospital with ongoing resuscitation, of whom nine survived to discharge. Of 2141 EMS-attended OHCA incidents, a total of 1138 patients met the inclusion criteria for analysis (Fig. 1). Survival was measured at the following stages of care: hospital admission, ED discharge, 24 h after hospital admission, hospital discharge, and at 1 year. To further elucidate the relationship between prehospital modifiable factors and outcome, we also calculated the hazard of mortality between each stage.

Study outcomes

The primary outcome was patient survival to hospital discharge. Secondary outcomes were survival to hospital admission, survival to emergency department (ED) discharge, survival to 24 h after hospital admission, and survival at 1 year after cardiac arrest.

Study variables

The patient characteristic variables were age, gender, initial cardiac arrest rhythm (categorized as non-shockable [asystole, pulseless electrical activity] and shockable [ventricular fibrillation, pulseless ventricular tachycardia]), medical cause of cardiac arrest (cardiac and non-cardiac), ROSC (yes, no), location of cardiac arrest (at home, in public), municipality (urban, rural), whether the cardiac arrest was witnessed, not witnessed, CPR initiated (by bystanders [bystander defined as a person who is not responding as a part of an EMS]), first responders/EMS), EMS response time (the time interval in minutes from the call to the EDC until the first emergency vehicle arrived at the patient's location) (< 10 min, ≥ 10 min), EMS physician attendance (yes, no), survival to hospital admission (yes, no), survival to ED discharge (yes, no), survival to 24 h after hospital admission (yes, no), survival to hospital discharge (yes, no), and survival at 1 year after cardiac arrest (yes, no).

Statistical analysis

All data retrieved from the local hospital-managed OHCA registry were entered into a FilemakerPro6 database (Filemaker, Inc., Santa Clara, CA, USA) and via Microsoft Office®Excel 2010 (Microsoft Corporation,

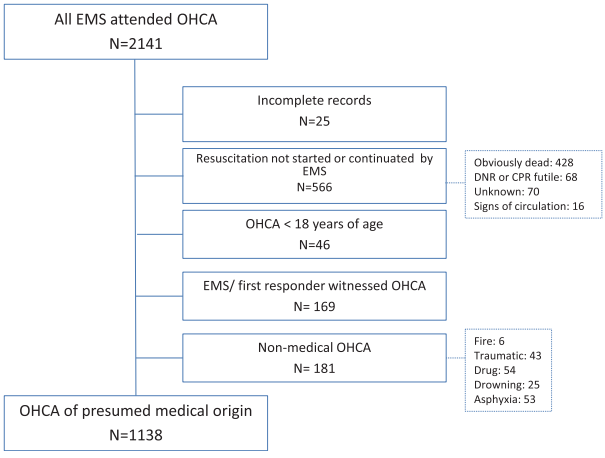

Fig. 1 Inclusion of patients with medical cardiac arrest. *EMS* emergency medical services, *OHCA* out-of-hospital cardiac arrest

Table 1 Incidence, outcome and characteristics of medical out-of-hospital cardiac arrest patients ($n = 1138$)

	Rural area ($n = 371$)	Urban area ($n = 767$)	*p*,value	Number of missing data
OHCA incidence/100,000/ year (adjusted rate)	49 (52)	47 (56)	0.45	
Survival to hospital discharge, n (%)	55 (14.8)	159 (20.7)	0.021	0
Median patient age in years, (IQR)	69 (56–80)	70 (58–81)	0.31	1
Median EMS response time in minutes, (IQR)	11 (7–16)	9 (7–12)	< 0.001	0
Male gender, n (%)	263 (71)	522 (68)	0.37	0
Attended by EMS physician, n (%)	308 (83)	658 (86)	0.20	3
Shockable rhythm, n (%)	129 (36)	310 (41)	0.11	26
Prehospital ROSC, n (%)	111 (30)	286 (37)	0.017	0
Witnessed OHCA, n (%)	258 (70)	528 (70)	0.75	14
Bystander CPR, n (%)	267 (73)	537 (71)	0.39	11
Cardiac arrest location home, n (%)	229 (62)	508 (66)	0.17	1
Survival to hospital discharge in bystander witnessed OHCA with shockable first rhythm	43 (41)	132 (50)	0.14	0

The *p* values are calculated by Poisson regression, The Mann-Whitney test, chi-square tests as appropriate
CPR cardiopulmonary resuscitation, *EMS* emergency medical services, *OHCA* out-of-hospital cardiac arrest, *ROSC* return of spontaneous circulation

Redmond, WA, USA) to Statistical Package for the Social Sciences version 23 (IBM Corp, Armonk, NY,USA) and R version 3.3.2 [19] for statistical analysis and plotting. Continuous variables are reported as medians and interquartile ranges (IQR), categorical variables as numbers and percentages. The Mann-Whitney test was used to test for difference in the distribution of continuous variables between the urban and rural groups. Chi-square tests for independence (with Yates' continuity correction) were used for assessing for differences in the distribution of categorical variables between groups. OHCA incidence rates were calculated, and age and gender adjusted according to the general Norwegian population, using data obtained from Statistics Norway [20]. Poisson regression analysis was used to test for differences in incidence rates between urban and rural areas. A Kaplan-Meier type plot was constructed to show estimated survival probabilities from after OHCA to five consecutive stages of care: Hospital admission, ED discharge, 24 h after admission, hospital discharge, and at 1 year. By focusing on these discrete stages of care rather than clock time we are able to do a detailed analysis of which factors are of importance for reaching these milestones. To further study the impact over time, hazard plots were also constructed. These plots show the estimated mortality probability between two consecutive stages of care, given survival to the start of the first stage. Chi-square tests were used to test for differences in mortality or hazards between groups for each stage of care. Logistic regression analysis was used to study the impact of urban and rural areas and other factors on survival to the different stages of care and at

Table 2 Odds ratios of key factors associated with survival

	Survival to hospital admission			Survival to hospital discharge			1 year survival		
	OR	95% CI	*p*	OR	95% CI	*p*	OR	95% CI	*p*
Urban vs. rural	1.84	1.43– 2.36	< 0.001	1.51	1.08– 2.11	0.017	1.58	1.11– 2.26	0.012
EMS response time ≥ 10 min vs < 10 min	0.69	0.55– 0.87	0.002	0.61	0.45– 0.83	0.002	0.57	0.41– 0.79	< 0.001
Age (one additional year)	0.97	0.97 –0.98	< 0.001	0.96	0.95– 0.97	< 0.001	0.96	0.95– 0.97	< 0.001
Gender, male vs. female	1.94	1.51 –2.51	< 0.001	3.15	2.10– 4.72	< 0.001	3.02	1.98– 4.61	< 0.001
EMS physician attendance vs. no EMS-physician attendance	2.63	1.86 –3.74	< 0.001	1.37	0.87– 2.16	0.17	1.39	0.86– 2.24	0.18
Witnessed arrest vs. non-witnessed arrest	4.12	3.12– 5.44	< 0.001	7.23	4.20–12.43	< 0.001	6.63	3.78–11.61	< 0.001
OHCA location in public vs. home	1.20	1.10– 1.30	< 0.001	1.31	1.20– 1.43	< 0.001	1.27	1.16– 1.39	< 0.001
Bystander CPR vs. no bystander CPR	1.98	1.52– 2.58	< 0.001	3.05	2.00– 4.65	< 0.001	2.84	1.83– 4.39	< 0.001
Shockable vs. non-shockable rhythm	8.25	6.21– 10.95	< 0.001	25.74	15.71–42.18	< 0.001	39.52	21.14–73.87	< 0.001
Cardiac vs. medical cause for cardiac arrest	1.31	0.92– 1.88	0.14	0.34	0.18–0.63	< 0.001	0.16	0.07– 0.40	< 0.001

Odds ratios (OR) in univariable analysis of key factors associated with survival to hospital admission, survival to hospital discharge and 1 year survival in out-of-hospital cardiac arrest (OHCA) (n = 1138). *CI* confidence interval, *CPR* cardiopulmonary resuscitation, *EMS* emergency medical services, *OR* odds ratio

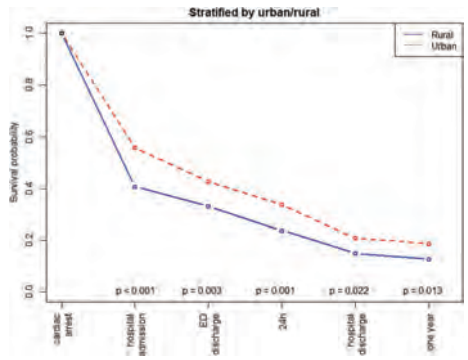

Fig. 2 Kaplan Meier type survival curves for out-of-hospital cardiac arrest patients in rural versus urban areas. *ED* emergency department

1 year. In all tests, p values of < 0.05 were considered statistically significant.

Results

The overall patient survival to hospital discharge was 18.8% and the unadjusted survival was higher in urban than in rural areas (Table 1). This was also reflected in the crude analysis with a significantly higher probability of survival to hospital admission (OR: 1.84, 95% CI 1.43–2.36, $p = < 0.001$), to hospital discharge (OR: 1.51, 95% CI 1.08–2.11, $p = 0.017$), and at 1 year (OR: 1.58, 95% CI 1.11–2.26, $p = 0.012$) in the urban group compared with the rural group (Table 2, Fig. 2). Bystander CPR was associated with improved survival to discharge only in urban areas (Fig. 3, $p < 0.001$). EMS response times > 10 min was associated with decreased survival to discharge only in urban areas (Fig. 4, $p < 0.001$). The attendance by an EMS physician was associated with improved survival to hospital discharge only in rural areas (Fig. 5). When adjusted for the modifiable factors listed above, the difference in survival to hospital admission, hospital discharge, and at 1 year between rural and urban areas remained (Table 3). There was a significant higher prehospital hazard of death in OHCA victims in rural areas. However, if they survived to hospital admission, this hazard difference disappeared (Fig. 6).

Discussion

We conducted this retrospective analysis of registry data including 1138 OHCA patients with attempted resuscitation in a region where a high survival rate has previously been reported [14]. We found a significantly higher probability of survival to hospital admission, to hospital discharge, and at 1 year in the urban group compared with the rural group of patients. While bystander CPR and EMS response time < 10 min were associated with a favorable outcome in urban patients at all stages of care, the attendance of an EMS physician was not. When adjusted for the modifiable factors; bystander CPR, attendance of EMS physician and EMS response time, the significant difference in survival to hospital admission, to hospital discharge, and at 1 year between rural and urban OHCA patients remained.

The present study shows a strong association between bystander CPR and survival, a finding that has been confirmed in several previous studies [5, 21]. However, the current study also indicates that bystander CPR had a significant impact on survival in urban areas only. This major finding cannot be explained by differences in initial cardiac rhythm, gender, OHCA location, witnessed cardiac arrest, or bystander CPR rate between rural and urban areas. One reason could be lack of statistical power to detect a significant effect of bystander CPR in the rural group as there are few patients alive to hospital discharge. However, when assessing this finding, context characteristics must be considered. The social structure of rural communities means that there are fewer potential CPR bystanders compared with more densely populated areas. In urban areas, a greater number of potential bystanders are present, or in proximity, to initiate

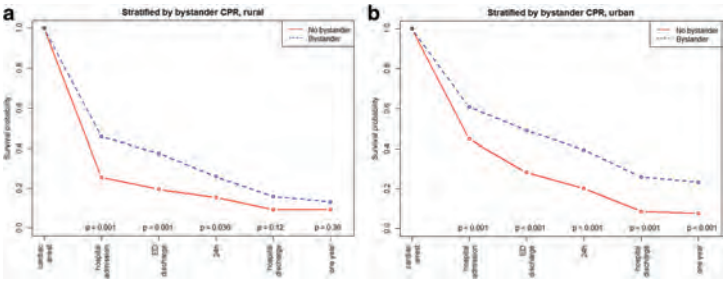

Fig. 3 Kaplan Meier type survival curves for out-of-hospital cardiac arrest patients stratified by bystander cardiopulmonary resuscitation in rural versus urban areas. CPR cardiopulmonary resuscitation, *ED* emergency department

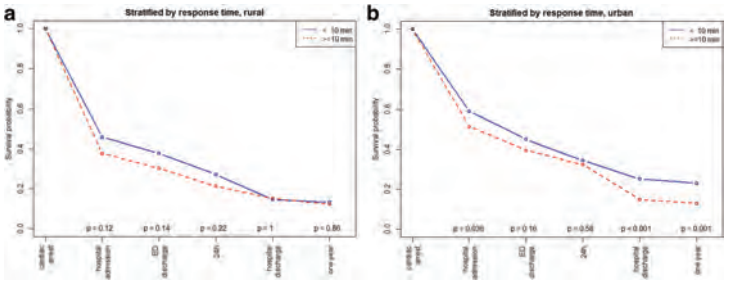

Fig. 4 Kaplan-Meier type survival curves for out-of-hospital cardiac arrest patients stratified by emergency medical services response time in rural versus urban areas. *ED* emergency department

efficient interventions, such as calling the EDC and providing CPR in OHCA incidents. This may affect the quality of the handling of the OHCA incident before the EMS' arrival.

In the present study, the median EMS response time was 2 min shorter for the urban group than for the rural group. Considering the rapidly declining effect of bystander CPR with time, the lack of statistical significance between survival and EMS response time < 10 min in rural areas was surprising (Fig. 4) [6]. However, as time to intervention is crucial for survival, longer EMS response times may still explain the lower survival rate in the rural group. Optimizations in logistics can save lives, [22, 23] and EMS response time is thus one modifiable factor in improving survival.

Attendance by an EMS physician in OHCA was associated with overall improved survival at in-hospital stages of care and at 1 year in rural areas, but only with survival to hospital admission for OHCA in the urban group. Potential selection bias for EMS physician attendance at OHCA incidents may partially explain its association with short-term survival. Also, the high OR for survival to hospital discharge in rural areas may indicate a selection bias where EMS physician is called to certain types of OHCA. Some studies have been inconclusive or not shown a survival benefit of EMS physician attendance in OHCA [24, 25],. Hamilton et al. found an association between EMS physician attendance and both ROSC at the scene and 30-day survival [7]. The attendance by EMS physicians might have the greatest impact after ROSC has been achieved [26], and for the introduction of new treatment modalities, for example extracorporeal membrane oxygenation [27].

The higher OHCA survival in urban compared to rural areas found in the present study corresponds with the results of previous reports [9–11]. Still, among patients admitted alive, our results indicate no significant difference in later mortality, whether in the emergency department, 24 h after hospital admission, mortality at hospital discharge, or at 1 year. This is an important finding, and to our knowledge not reported before. It implies that further overall improvement in survival in rural areas must be based on community-based interventions [28]. Survival following rural OHCA could be improved by strengthening rural communities' CPR training [29], increase the use of dispatcher-assisted CPR [30], implement first-responder programs [31], provision of public access defibrillators [32], and optimize the

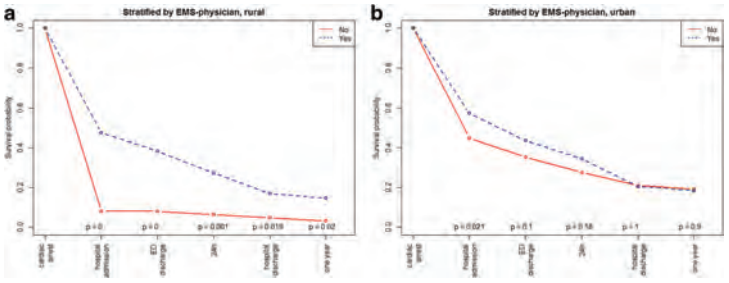

Fig. 5 Kaplan-Meier type survival curves for out-of-hospital cardiac arrest patients, stratified by emergency medical services physician attendance in rural versus urban areas. *ED* emergency department, *EMS* emergency medical services

Table 3 Adjusted odds ratios for survival to different stages of care using geographical area and modifiable factors in the adjustments

	Survival to hospital admission			Survival to hospital discharge			1-year survival		
	OR	95% CI	*p*	OR	95% CI	*p*	OR	95% CI	*p*
OHCA in urban area vs. rural area	9.28	3.42– 25.21	< 0.001	5.11	1.45– 18.05	0.011	6.81	1.52– 30.49	0.012
Bystander CPR vs. no bystander CPR	2.02	1.54– 2.65	< 0.001	2.98	1.95– 4.56	< 0.001	2.76	1.77– 4.29	< 0.001
EMS response time ≥ 10 min vs. ≤ 10 min.	0.69	0.54– 0.88	0.003	0.61	0.44– 0.84	0.002	0.57	0.41– 0.80	< 0.001
EMS physician attendance in rural area vs. no EMS physician attendance in rural area	10.7	3.94– 26.25	< 0.001	3.58	1.07– 12.01	0.039	4.71	1.10– 20.15	0.037
EMS physician attendance in urban area vs. no EMS physician attendance in urban area	1.62	1.06– 2.48	0.025	0.91	0.54– 1.45	0.736	0.91	0.53– 1.56	0.730

Adjusted odds ratios (multivariable analysis) of modifiable factors associated with survival to different stages of care in rural and urban out-of-hospital cardiac arrest (OHCA) (n = 1138). Due to significant interaction with area EMS-physician are reported separately for urban and rural area
CI confidence interval, *CPR* cardiopulmonary resuscitation, *EMS* emergency medical services, *OR* odds ratio

localization of EMS units [23]. With implementation of best practice, survival following OHCA could also be improved [33].

In the present study, bystander-witnessed OHCA with shockable first rhythm was 48.3% survival. Compared to a previous study conducted in the Stavanger region, in which a 52% survival to hospital discharge rate was found, the survival rate in the present study remains very good (Table 1) [14]. However, unlike the previous study, the results in the current study are based on non-EMS witnessed OHCA patients with a presumed medical cause (including a cardiac cause) for OHCA. Although the patient populations of the two studies are not entirely comparable, the results in the current study imply that the survival rate in the Stavanger region has not improved during the last decade, which contrasts with what has been found in several other regions [34, 35]. Opportunities for improvements include shortening of EMS response times, and strengthening community preparedness by e.g. additional lay person first responders via short message service alert or mobile app-based alert system. [36] To save more lives following OHCA, continuous endeavors to optimize modifiable factors are required to improve every link in the chain of survival.

Limitations

The data in this study did not allow us to assess patient neurological status and recovery in the surviving patients. However, previous studies from the Stavanger region have shown a good neurological status for the surviving patients [14], and there have been no major changes in OHCA patient treatment to indicate that this has changed over time. We chose the population and EMS response time categories that were appropriate for our region, so this choice may not be generalizable to other regions and countries. Further, we did not record the presence or absence of dispatcher-assisted CPR, which has been shown to affect survival in OHCA [37]. The calculated incidence of 47 OHCA per 100,000 per year in our region

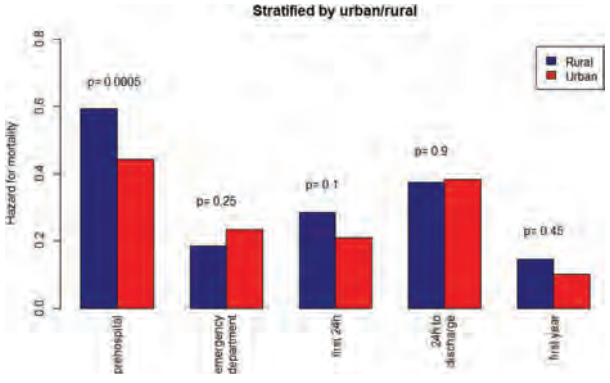

Fig. 6 Bar graphs illustrating the hazard for mortality in out-of-hospital cardiac arrest patients in rural versus urban areas. The hazard is the probability of dying between two consecutive stages of care, given that the patient is alive at the first stage

is low compared to other reports [38], but the adjusted rate of 54 OHCA per 100,000 per year is according to OHCA in the general Norwegian population [39]. Also, for quality assurance, a designated nurse cross-checked data before entering into the OHCA database. Thus, we do not suspect selective reporting. The study region was that encompassed by the Stavanger Hospital Trust and the current findings may therefore not be generalizable to other different systems. Several hypothesis tests are conducted without any explicit adjustment for multiple testing. We acknowledge that some small p values might have been obtained by chance, and in particular should p values close to 0.05 be interpreted with care.

Conclusions

We found that OHCA survival was higher in urban compared to rural areas, and that the impact of the prehospital modifiable factors bystander CPR, EMS response time, and EMS physician attendance differed in urban and rural areas. The main difference is due to a lower ROSC rate and hospital admission rate of OHCA patients in rural areas. Importantly, in patients admitted alive to the hospital, survival rate did not differ between rural versus urban areas. Further improvements in survival in rural areas can be built on community-based interventions such as CPR training, first-responder programs, and public access defibrillation.

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Availability of data and materials
The data and materials used in the present study are available on request from the corresponding author.

Authors' contributions
WTM contributed to the creation of the study material, participated in the design of the study, drafted and helped to revise the manuscript. CAB participated in the design of the study and helped to revise the manuscript. JTK participated in the design of the study, performed the statistical analyses and helped to revise the manuscript. ES contributed to the creation of the study material and helped to revise the manuscript. All authors read and approved the final manuscript and take full responsibility for all aspects of the study.

Ethics approval and consent to participate
The Utstein template database was nationally and locally approved for scientific purposes by the Regional committee for Research Ethics and the Institutional Review Board at Stavanger Hospital Trust, Norway, respectively. Patient's informed consent was not considered necessary for this study to be approved as the purpose for the analysis of the data collection was for quality management.

Consent for publication
Not applicable.

Competing interests
WTM is employed with financial support by The Norwegian Air Ambulance Foundation.
CAB is employed by the Regional Competence Center for Acute Medicine in western Norway (RAKOS) with financial support from the Norwegian Directorate of Health. He has participated in Global Resuscitation Alliance meetings sponsored by the Laerdal Foundation for Acute Medicine, TrygFonden and EMS2017.
The authors declare that they have no competing interests.

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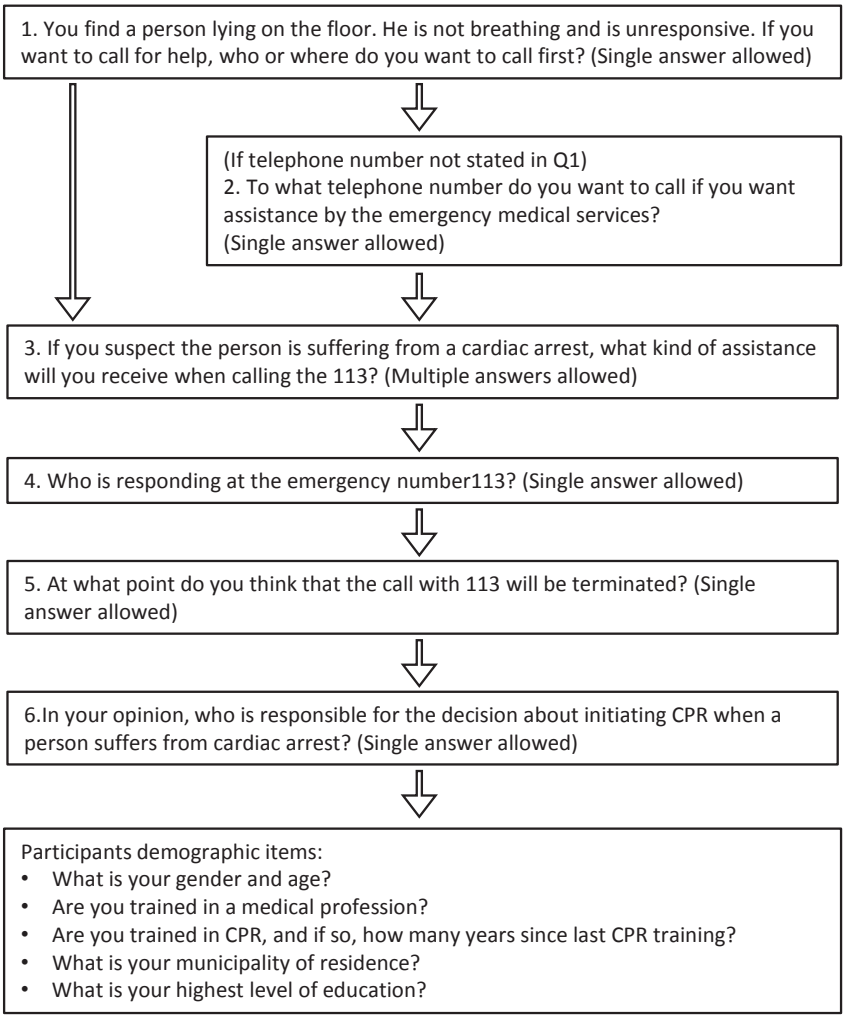
Appendices

Appendix A

Questionnaire used in Paper I



Appendix B

Interview guide used in Paper II

Interview guide

(Subjects with optional additional areas for elaboration)

Introduction and information provided by the interviewers

- The aim of the study
- The official rights and protections due to participation in the study
- Participant consent form
- Bystander resident in a municipality in Southern Rogaland
- Duration of residence in the area
- Avoid unnecessary information about the patient, place emphasis on the participant's experiences
- Participant age
- Participant gender
- OHCA victim's approximate age
- Relation to the cardiac arrest victim (relative, acquaintance, unknown)
- Time from last CPR training to cardiac arrest incident
- In what context did the cardiac arrest incident happen (home/at work/in public)
- Time between the OHCA incident and interview

Question 1: You were present at a cardiac arrest incident. Could you please tell us in detail what happened.

Question 2: Communication with the dispatcher

- What led you to interpret this situation as a cardiac arrest incident, or did you interpret it to be something else?

- How do you think you would have interpreted the incident if you had been in a foreign place or country?

- What expectations did you have of the dispatcher operating the emergency telephone number113?

- How was your experience in talking to the dispatcher at the emergency telephone number 113.

- How do you think you would manage talking to a dispatcher at the emergency telephone number in a foreign place or country?

Question 3: Expectations after having provided CPR

- What were your expectations of others present during the OHCA incident to help/assist?
- What reactions did you expect from others after you had provided CPR?
- Please imagine that you did **not** provide CPR. How do you think your family and friends would have reacted?
- What reactions would you have expected from strangers if you had provided CPR in a foreign place or country?
- Can you imagine circumstances that would have hindered you from providing CPR?

Question 4: Previous experiences

- Did the OHCA incident resemble any other previous experiences you have had?
- How did you acquire your CPR knowledge (school, CPR course, family, work, mass media)?
- After learning CPR, how often have you re-trained?
- Have you read articles in mass media about successfully reported CPR, and what do you think this means for the general willingness in the general public to provide CPR?

Question 5: Fear

- Did you at any time during the OHCA incident experience a fear of hurting or injuring the OHCA victim?
- Can you explain why you dared to start CPR?
- What impact did other people present during the OHCA incident have on your initiation of CPR?
- During the OHCA incident, did you ever think that a public automated external defibrillator (AED) at hand would make the task easier for you?

Question 6: Public willingness

- What do you think would have happened if you had had a cardiac arrest in a public place, for instance, in a shopping center?

- What do you think would have happened if you had had a cardiac arrest in your own home?
- What do you think about other people who do not provide CPR in an OCHA incident like the one you experienced?
- What or who has influenced your decision about providing CPR?
- In what way do you think we have a responsibility to each other in society?
- Did you at any point hesitate that it was you who should start or provide CPR?
- Is there anything I have not asked you about contributing factors to your decision about providing CPR?

Question 7: Contact

- If I need elaboration on some responses, can I contact you?

Appendix C

Interview guide used in Paper III

Interview guide

(Subjects with optional additional areas for elaboration)

Introduction and information by the interviewers

- The official rights and protections due to participating in the study
- Participant consent form
- Avoid gathering unnecessary information about the patient; emphasise to the participant that it is his/her experiences the interview will be focused on.
- Participant's age
- Participant's gender
- Health educated (yes/no)
- Relation to the cardiac arrest victim (relative, colleague, acquaintance, unknown)?
- Time from last cardiopulmonary resuscitation-training to cardiac arrest incident?
- In what context did the cardiac arrest incident happen (home/at work/in public)?

Question 1: You were present during a cardiac arrest incident. Please tell us in detail what happened.

Question 2: What were the reasons for calling the medical emergency telephone number?

- How was the patient's appearance (colour in face, notable/abnormal looks)?
- Where was the patient located?
- How was the patient breathing?
- What signs made you call the medical emergency number?
- How many individuals participated in the incident and how did they act (alerting/ calling and CPR)?
- Who alerted and received CPR instructions from the medical emergency number?
- Where was the caller located? By the patient? Was the telephone close to the patient?

- Was a portable or non-portable telephone used? Was the speaker on the phone activated?
- How did you experience, and indicate how long, the time was from the patient losing consciousness until you started CPR?

Question 3: Please tell us about your experience of the incident and the experience of providing CPR?

- What kind of first-aid was provided (mouth-to-mouth ventilation, chest compressions, recovery position)?
- Did you take pauses during the compressions?
- How did you experience giving mouth-to-mouth ventilation? Was it easy?
- How did you experience providing CPR until the ambulance arrived on scene?
- Did you get exhausted? Did others provide chest-compressions?
- How do you recognise adequate CPR?
- Prior to ambulance arrival on scene, what is your opinion about your own effort in the incident?

Question 4: What made you choose to start CPR?

- What was the motivation behind providing CPR?
- Was it the instructions from the emergency dispatcher?
- Were other individuals present on scene?

Question 5: How did you experience talking to the medical dispatcher?

- How could the dispatchers help you?
- Did you receive continuous support from the medical dispatchers?
- Did you experience any challenges the medical dispatchers could have improved?

Question 6: How did you experience the ambulance arrival on scene?

- What happened?
- How were you taken care of by the emergency medical personnel on scene?
- How did you communicate with the emergency medical personnel (Verbally/nonverbally)?

Question 7: How did you experience the situation after the emergency medical personnel had left the scene?

- What was your experience following/after the out-of-hospital cardiac arrest incident?
- What is your opinion of your own effort in the incident?
- What is your opinion about the provided work by the emergency medical personnel?
- What are your expectations of emergency medical services?

Question 8: Do you believe there are any previous experiences in your life that may have influenced you in your handling of the cardiac arrest incident?

- CPR-course
- Previous acute incidents
- Media focusing on successful resuscitations

Question 9: Follow-up after the study

- If we are in need of a new interview or telephone call, is it OK if we contact you?
- If you have further comments or questions regarding the study, you are most welcome to contact us.

Additional questions emerging during the study:

- If you were to choose: What kind of follow-up would you have chosen and from whom?
- Have you had any form of follow-up after the cardiac arrest incident?
- What did you expect of follow-up after the cardiac arrest incident?
- After the cardiac arrest incident: Did you sleep well? Did you have nightmares? Who did you talk to/confide in?
- How was your social and work life after the incident?
- Can you describe your thoughts and, if any, concerns about the patient after the incident?
- Has this incident altered your view of the world and how things are interrelated?
- Have you experienced any feelings of guilt related to the provided CPR or patient outcome?