Contributions to effective risk management

On the use of safety principles, economic tools and safety climate instruments

by

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“*A prudent person foresees danger and takes precautions.*
The simpleton goes blindly on and suffers the consequences.”

Proverbs 22:3, NLT

Preface

This PhD thesis is funded by the Norwegian Ministry of Education and Research. The financial support is gratefully acknowledged.

My interest in the field of risk analysis started in 2012 during my master's study in Industrial Economics with a specialization in risk management. I soon realized that I wanted more and started working as a risk consultant afterwards to gain more experience. One year later, in 2015, I received an invitation from Professor Eirik B. Abrahamsen to apply for a PhD degree in Risk Management. Or, to be more exact, his wording in the e-mail was "we should have a chat :)".

I owe you a tremendous lot of thanks, Professor Eirik B. Abrahamsen. As my supervisor, you have provided invaluable guidance and critique, as well as endless support and patience. I appreciate your positive attitude, your motivating skills, and all the inspirational and cheerful conversations we have had. I will be forever thankful for your invitation to this opportunity and for guiding me throughout this journey.

I wish to thank my co-supervisor and co-author, Associate Professor II Håkon B. Abrahamsen. The encouragement and inspiration you have given is well appreciated. Thank you for your guidance in the world of prehospital patient safety. I would also like to thank co-supervisor, Professor Frank Asche, for your comments to part of the work.

My gratitude also goes to other co-authors for your contribution to the papers. Dr Espen Olsen, thank you for your invaluable guidance and for the good and motivational conversations. Associate Professor Jon T. Selvik, thank you for fruitful discussion and suggestions, and for your sense of humor! Associate Professor Stephen J. M. Sollid, thank you for your support and comments.

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I would also like to give thanks to my fellow PhD students and colleagues at SEROS (Centre for Risk Management and Societal Safety) at the University of Stavanger for all the good moments we have had together, from lunch breaks to international conferences. A special thanks to you, Christian H. A. Kuran, whom I have shared an office with, for all the good, interesting and sometimes nerdy conversations.

Special thanks also to Linda March at The Good English Company for excellent proofreading.

Through my voluntary work in Normisjon I have experienced tremendous support from other volunteers and leaders, and for that I am very grateful. I also want to thank friends and neighbors for cheering me on!

Finally, I want to thank my family for your encouragement, patience and much needed distraction throughout these years. My wife, Bente, and our lovely children, Rebekka, Timothy, Miriam and Joanna—you are the best—and I love you so much!

Stavanger, September 2018

Leif Inge Kjærvoll Sørskår

"*Whatever I have, wherever I am, I can make it through anything in the One who makes me who I am. I don't mean that your help didn't mean a lot to me—it did. It was a beautiful thing that you came alongside me in my troubles.*"

Philippians 4:13-14, MSG

Summary

For an organization, effective risk management involves supporting informed decision-making for improved allocation of resources, as well as playing an active part in how the organization is governed and, ultimately, performs. The aim of this thesis is to contribute to effective risk management and, in particular, to two research areas. The first is a focus on approaches that are utilized to either achieve or conflict with the main purpose of risk management: a balance between value creation and protection. The second is to contribute to improved patient safety in the prehospital domain, particularly through the development of safety-climate theories and -instruments.

The scientific contribution of this thesis consists of five papers, of which Papers I-III belong to the first research area and Papers IV and V to the second. The content of the papers is summarized briefly in the following.

Paper I concerns regulatory HSE (health, safety and environment) interventions in the oil and gas industry. The background is a methodology for the evaluation of regulatory interventions, developed by two consulting agencies, in which the preferred method is to address uncertainties, mainly by the use of expected values. This approach is discussed in Paper I, as expected values may be very misleading when used in a context prone to potential major accidents. Paper I suggests another approach, which more adequately addresses risk, to obtain a balance between value creation and protection. A simple example is provided to highlight the difference between the approaches.

The background for Paper II is a conflict related to the use of Vision Zero (VZ) as a guiding principle for managing production assurance risk in the oil and gas industry. Paper II addresses this conflict and discusses the rationality of complementing VZ with another principle: the 'As Low As Reasonably Practicable' (ALARP) principle. Paper II argues that the ALARP principle may serve as a practical tool to evaluate risk of production loss, including balancing different concerns. The intention of the proposed combined principle is to continually (over time) draw closer to the state of zero risk.

Paper III focuses on the difficulty of performing economic evaluation as part of health technology appraisal for the helicopter emergency medical services (HEMS). The issue is that HEMS is a complex sociotechnical system; to address this, Paper III proposes a framework, using a systems model approach for evaluating the system as part of the economic evaluation. The purpose of the framework is to determine and highlight critical system elements. Paper III includes an example, to demonstrate how 'missing' crucial information may lead to unintended economic consequences.

The research in Papers IV and V is based on data retrieved from a patient safety survey conducted in 2016 among workers in the emergency medical services (EMS) in Norway. In addition, Paper V is based on data retrieved from an equal survey in the Norwegian HEMS in 2012.

Paper IV utilized the Norwegian version of the Hospital Survey on Patient Safety Culture (HSOPSC), to perform a safety climate study in the prehospital domain. In general, participants were asked to provide their view on different statements related to patient safety. Overall, acceptable psychometric properties were observed, and the outcome of Paper IV is a validated safety climate instrument for use in the EMS setting: the Prehospital Survey on Patient Safety Culture (PreHSOPSC).

Building on Paper IV, Paper V utilized three different sets of data in a similar study. The study provided two major findings. First, a modified short version, PreHSOPSC-S, was validated for use in the EMS and HEMS settings. Second, new theories was developed: Based on a structural model, positive safety climate relations were demonstrated between organizational levels (from top and unit management, to the unit and individual levels), and finally on what may be considered as the outcome "product" of the prehospital domain; transitions and handoffs.

Contents

List of papers

I. Sørskår, L.I.K. & Abrahamsen, E.B. On how to manage uncertainty when considering regulatory HSE interventions. *EURO Journal on Decision Processes*, *5*(1-4), 97-116, 2017.

II. Sørskår, L.I.K., Selvik, J.T. & Abrahamsen, E.B. On the use of Vision Zero and the ALARP principle for production loss in the oil and gas industry. Revised and resubmitted for possible publication.

III. Sørskår, L.I.K., Abrahamsen, E.B. & Abrahamsen, H.B. On the use of economic evaluation of new technology in helicopter emergency medical services. *International Journal of Business Continuity and Risk Management, 9*(1), 1-23, 2019.

IV. Sørskår, L.I.K., Abrahamsen, E.B., Olsen E., Sollid, S.J.M. & Abrahamsen, H.B. Psychometric properties of the Norwegian version of the Hospital Survey on Patient Safety Culture in a prehospital environment. *BMC Health Services Research, 18*(1), 784, 2018.

V. Sørskår, L.I.K., Olsen, E., Abrahamsen, E.B. & Abrahamsen, H.B. Assessing safety climate in prehospital settings: testing psychometric properties of a common structural model in a cross-sectional and prospective study. Submitted for possible publication.

Part I

1 Introduction

1.1 Background

The main purpose of risk management is to ensure adequate measures are taken to obtain a balance between protecting something of value from harmful consequences, on one side, and creating values, on the other (Aven & Vinnem, 2007; ISO 31000, 2018). Which measures to take involves making decisions, and the starting point for a decision-making process is to define a decision problem and decision alternatives, and then to perform analyses and evaluations of the alternatives (Keeney, 1982; Aven & Kørte, 2003). A great number and variety of approaches may be applied to ensure that decisions have the appropriate balance between creating and protecting values.

In decision-making processes, we often find defined visions and goals, which reflect important concerns and values for both the decision-makers and the stakeholders (Hoegberg, 1998; Mearns et al., 2003; Aven & Kørte, 2003; Johansson, 2009; Baard, 2016). Visions and goals provide a basis for the choice of principles, concerns, strategies and alternatives to be used in the decision process, further influencing the choice of analysis and evaluation tools (Klinke & Renn, 2002; Aven et al., 2007).

Different disciplines have a tendency to take different approaches to achieve a balance between value creation and protection. Economists constitute a discipline that tends to use tools that rely on the use of expected values. Expected values are used in a wide range of tools, with the purpose of highlighting a decision's alternative advantages and disadvantages, often expressed with the help of monetary values or other specified effects such as averted fatalities (Robinson, 1993; Drummond et al., 2015). Approaches using expected values, where little weight is given to uncertainties, may be characterized as "risk neutral" (Varian, 2014).

On the other side, safety analysts represent another discipline that is more "risk averse" and tends to choose principles and methods giving more weight to risk and uncertainty. An example is the application of the cautionary principle, which states that, in a context characterized by risk and uncertainty, caution should be the ruling principle, for example the use of minimum demands in the form of implementation of risk-controlling measures (HSE, 2001; Aven & Abrahamsen, 2007; Möller & Hansson, 2008).

However, an issue arises if the chosen approach does not obtain sufficient balance. Simply put, the selected tool does not fit the task to be performed. An example is found in an article by Hopkins (2015), in which he discusses the issue of using cost-benefit analysis as part of US regulations, in the context of offshore oil and gas production. He states: “The problem is that it is virtually impossible to quantify the benefits of preventing rare but catastrophic events.” Similar cases are discussed in Abrahamsen et al. (2004) and Abrahamsen et al. (2018).

This relates to the fact that all analyses and evaluations are based on some background knowledge, such as historical data and knowledge of the relevant situation. The issue is that the background knowledge may be of poor quality or not sufficiently comprehensive, which may induce poor decisions if the chosen approach does not reflect this issue (Abrahamsen et al., 2004; Kletz, 2005).

A solution to the issues above is to customize the approach, to adequately address the characteristics of the context (Renn, 1992; Amendola, 2002; Abrahamsen et al., 2018). In combination with the purpose of risk management – to achieve a balance between value creation and protection – the solution has two implications for informed decision-making. First, a broader understanding of the decision-making context is necessary, and, second, there is a continual need to develop appropriate tools for different decision-making contexts.

Another purpose of risk management is to assist organizations in achieving their objectives (ISO 31000, 2018). Organizations face external and internal factors that make it uncertain whether the objectives have been achieved. Historically, risk management has mainly focused on technical issues, but much effort has also been invested in understanding human, organizational and managerial factors (see e.g. Davoudian et al., 1994; Reason, 1997; Mearns et al., 2001; Milazzo, 2016). To perform effective risk management in an organization, there must be adequate consideration of the external and internal contexts, including human behavior and cultural factors (ISO 31000, 2018).

The concept ‘safety culture’ is an inherent part of the organizational culture (Cooper, 2000), the term having been first used in a report from the International Atomic Energy Agency in the aftermath of the Chernobyl disaster in 1986 (INSAG, 1991). Research followed, and, in the late 1990s, safety culture was considered an important notion in organizations (Knegtering & Pasman, 2009). There are several definitions of safety culture (Cooper, 2000; Guldenmund, 2000; Halligan & Zecevic, 2011; Edwards et al., 2013), but in general one might say that a safety culture reflects individual, group and organizational attitudes, values and behaviors concerning safety (Ek et al., 2014).

While risk management often refers to formal practices and responsibilities, a well-developed safety culture is considered an enabler for maintaining and improving safety performance through safety work and improvement processes (Reason, 1997). Similarly, the concept of safety culture is frequently evoked as a prerequisite for good risk management (Grote, 2012).

Although interchangeably used, ‘culture’ differs from the related concept of ‘climate’ (Schneider et al., 2013). Climate is a less complex concept, and climate research is considered a “snapshot” of the present state of the culture (Flin et al., 2000). ‘Safety climate’ may be defined as “surface features of the safety culture from attitudes and perceptions of individuals at a given point in time” (Halligan & Zecevic, 2011).

Important early work on safety climate includes a study by Zohar (1980), in which he summarizes his research into safety climate as an inherent characteristic of (industrial) organizations related to the overall safety in these organizations. The research on safety climate was relatively dormant until the late 1990s, but, over the last two decades, a large number of studies have reported the value of performing safety climate assessments and, in particular, the relationship between safety climate and safety performance (Zohar, 2010; Mearns et al., 2003; Neal & Griffin, 2006; Grabowski et al., 2010; Morrow et al., 2014).

Developing concepts, tools, and method are necessary for improved risk management. This constitutes the basis for future research avenues on safety climate in response to potential disasters in high-risk industries, such as aviation, railways, oil and gas, nuclear power generation and healthcare (Griffin & Curcuruto, 2016). Within healthcare, since the famous report, “To Err is Human”, was published in 1999 (Donaldson et al., 2000), the literature on understanding patient safety has grown. A large number of studies has demonstrated the value of safety climate studies in healthcare (see e.g. Naveh et al., 2005; Hofmann & Mark 2006, Hellings et al., 2007; Vogus & Sutcliffe, 2007; Singer, et al., 2009; Mardon et al., 2010).

To further improve the safety of patients, safety climate assessments may actively be used to, for example, evaluate safety initiatives and trends, and to identify, monitor and proactively manage risk-related issues (Nieva & Sorra, 2003; Flin, 2007; McFadden et al., 2015). However, within healthcare, a domain where there is little research on patient safety, is the emergency medical services (EMS) (Atack & Maher, 2010; Patterson et al., 2010; Bost et al., 2010). Several knowledge gaps have been pointed out (Bigham et al., 2012), for example research into safety culture and safety climate. Overall, this indicates that the development of assessment instruments for patient safety climate in the EMS environment is beneficial for continual patient safety improvements.

1.2 Objectives

The aim of this thesis is to contribute to new knowledge in the following research areas:

1) The development of approaches to obtain the appropriate balance between value creation and protection.
2) The use of safety climate instruments to improve patient safety in the prehospital domain.

1.3 Scientific approach

In Norway, the Norwegian Association of Higher Education Institutions has developed recommended guidelines for the PhD degree, in which some general requirements for a PhD thesis are stated: "A doctoral thesis must be an independent piece of scientific research that meets international standards with regard to ethical requirements, academic level and methodology used in the research field. The thesis must contribute to the development of new knowledge and achieve a level meriting publication in the literature in the field" (Universities Norway, 2011, cited by Thune et al., 2012).

Scientific research has, as in other disciplines, ethical norms to guide their actions and activities and to establish the public's trust in the discipline (Resnik, 2011). The scientific contributions of this thesis are, to the best of the author's ability, conducted in adherence with the following compilation of relevant ethical principles (see e.g. Resnik, 2011; REC, 2018):

- Striving for new knowledge with a critical and objective approach, to avoid errors and biases. This includes good reference practices and documentation for verifiability, as well as the use of peer review as part of the publishing process in scientific journals.
- Sharing of results, obtained through publishing and sharing of data. This is based on an overall responsibility to let the scientific contributions serve to benefit the society and not be a cause of harm.
- Respect for individuals participating in the research. In particular, obtaining informed consent from the participants and the confidential management of retrieved data.
- Respect for colleagues. In particular, to clarify and follow best practice for sharing, authorship, publishing and cooperation in general.

According to Badley (2009), the most important criteria for scientific quality are: originality, rigor and significance. The work in this thesis is original, as it provides knowledge and methods to understand, identify, evaluate and manage risk. The rigor criterion is met, firstly, by the fact that the scientific contributions of this paper are based on scientific methods and principles (Aven, 2018) and, secondly, through the peer-review publication process in scientific journals. It meets the criterion of significance, as the work relates to real-world issues and provides knowledge and approaches to manage these issues.

This thesis is aligned to a model known as "PhD by Publication" (Park, 2007) and consists of two parts, a scientific contribution, consisting of individually published papers, and an introduction that frames the papers in a broader context. All papers were developed by the means of literature studies, data collection and analysis tools, guidance from supervisors, discussions with co-authors and professional practitioners, presentation of research at national and international conferences, and publication in peer-reviewed international scientific journals.

1.4 Thesis structure

The PhD thesis is divided into two parts.

Part I contains an introduction to the background and focus areas for the research, a brief presentation of relevant scientific theory, a summary of the scientific contributions as a result of the project, and some suggestions for further work.

Part II comprises the main scientific contributions of this work, in the form of five scientific papers written for publication in international scientific journals during the PhD period.

Papers I, III and IV have already been published, Paper II has been revised and resubmitted for possible publication, and Paper V has been submitted for possible publication.

2 Theoretical foundations

While the history of risk stretches over millennia, the scientific field of risk analysis is quite young, and over the last 40 years there have been a number of suggestions on how to define and understand the concept of risk. The perspectives on risk developed in the industry in the 1970s and 80s remain, to a large extent, the basis for the field today (Aven, 2016). However, an answer to how risk should be conceptualized, assessed and managed is still both contentious and multifaceted. The scientific field has yet to reach full consensus on how to define and understand risk. This is challenging because a risk perspective held by, for example, a risk analyst or a decision-maker influences how to describe, analyze, communicate and manage risk (Renn, 1992; 2008; Veland & Aven, 2013). The purpose of this chapter is to present some fundamental issues about risk, particularly how to define, describe and manage risk.

2.1 The concept of risk

Credited for the first formal definition of risk, Abraham de Moivre defined in 1711 the risk of losing any sum to be the sum adventured multiplied by the probability of the loss; i.e. risk is defined as the expected loss. From this first definition, Aven (2012b) has extrapolated six overall paths of development of the concept of risk. To some extent, these paths may be traced back to different disciplines, which often operate with their own tailor-made definitions, such as economics, business, healthcare, decision analysis, engineering, etc. One interpretation of risk developed from expected loss is: a combination of probability and scenarios and their consequences (Aven, 2012b).

Typical examples of probability-focused risk definitions are:

- Risk is a set of scenarios s_i, each of which has a probability p_i and a consequence c_i (Kaplan & Garrick, 1981).
- Risk is the combination of the probability of an event and its consequences (IRM, 2002).

During the last two decades, the scientific field has shifted from defining risk in terms of probabilities to defining it in terms of uncertainties (Rosa, 1998; Renn, 2008). A recent contribution from the Society of Risk Analysis (SRA) is an authoritative glossary, listing various risk-related terms and the relationships between these, bringing the scientific field one step closer to a much-needed consensus. The Glossary provides seven qualitative definitions of risk, which may be justified for different contexts (SRA, 2015).

a) Risk is the possibility of an unfortunate occurrence.
b) Risk is the potential for realization of unwanted, negative consequences of an event.
c) Risk is exposure to a proposition (e.g. the occurrence of a loss) of which one is uncertain.
d) Risk is the consequences of the activity and associated uncertainties.
e) Risk is uncertainty about and severity of the consequences of an activity with respect to something that humans value.
f) Risk is the occurrence of some specified consequences of the activity and associated uncertainties.
g) Risk is the deviation from a reference value and associated uncertainties.

In addition to risk being defined by uncertainty or related terms, the common factors are that a future activity is considered, and risk is defined in relation to the consequences of this activity in light of something that humans value. The ISO 31000 standard on risk management launched in 2009 also adopted a focus on uncertainty, with the definition of risk understood as "the effect of uncertainty on objectives" (ISO 31000, 2009). The recently updated standard has retained this definition (ISO 31000, 2018). One may interpret this as a special case of the definitions listed above, with consequences seen in relation to the objectives (SRA, 2015). However, the ISO 31000 definition on risk has been criticized for being unclear and lacking scientific justification, and it is recommended that the SRA Glossary be applied for authoritative guidance on how to define and understand risk (Aven, 2017).

In this thesis, the concept of risk has a focus on consequences and associated uncertainties, as in the definitions stated in d) and f) above. Risk is equal to the two-dimensional combination of events/consequences (of an activity) and associated uncertainties (Aven, 2007; 2012a).

2.2 Risk description

Establishing a concept of risk is not the same as providing the means to evaluate and manage risk. In line with the definition above, a description of risk is obtained by specifying the consequences and using a description (measure) of uncertainty. When performing risk analysis, the specified consequences (e.g. economic loss, averted fatalities, number of incidents, etc.) are normally predicted in the form of a single value or an interval, and the expressed uncertainty is assessed based on a set of background knowledge (Aven, 2012a).

The most common approach to describe the uncertainties is by the means of probabilities. There are in general two interpretations of probability: as a relative frequency and as a subjective (knowledge-based) measure of uncertainty (Bedford & Cooke, 2001; Aven, 2011a; Fenton & Neil, 2013). Relative frequency-interpreted probabilities represent the relative fraction of times the event occurs if the situation analyzed were hypothetically "repeated" an infinite number of times. Subjective probabilities mean that uncertainty is expressed, based on the analyst's degree of belief, based, in turn, on the background knowledge (Aven, 2011a).

It has been shown that traditional risk perspectives based on probabilistic approaches are too narrow to adequately reflect all relevant aspects of risk and uncertainties (Hoegberg, 1998; Aven & Heide, 2009). The issue is that probabilities may provide poor predictions of the quantities of interest (Aven, 2012a) and that they do not deal adequately with potential surprises concealed in the background knowledge (Aven, 2014).

To better address risk, a broader approach and framework for understanding background knowledge and uncertainty has been developed: uncertainty-based approaches (Aven, 2012a; Aven & Zio, 2011; Flage et al., 2014; Haugen & Vinnem, 2015; Montewka et al., 2014). The goal for uncertainty-based approaches is not accurate estimation but a broad characterization of the available knowledge and uncertainties about the unknown quantities of interest (Aven, 2011b; Goerlandt & Reniers, 2016). The characterization is related to, for example, understanding the phenomena, choice of models, quality and strength of data and assumptions, and the degree of consensus among expert opinion (Abrahamsen et al., 2013).

As an example of an uncertainty-based approach, Aven (2008a) has suggested a semi-quantitative approach, in which the background knowledge used as basis for the subjective probabilities is qualitatively evaluated for any 'hidden' uncertainty factors. Identification of these factors is performed by using simple rules and procedures to categorize the strength-of-knowledge. See examples of such classification in Flage & Aven (2009) and in Goerlandt & Reniers (2016).

2.3 Risk management

When exploring future opportunities or threats/hazards, it is widely accepted that risk cannot be eliminated, but must be managed. The purpose of this chapter is to highlight some characteristics of risk management and its main components. Risk management has several definitions, some examples are:

- Risk management helps ensure that adequate measures are taken to protect people, the environment and assets from harmful consequences of the activities being undertaken, as well as balancing different concerns, in particular HSE (health, safety and environment) and costs (Aven & Vinnem, 2007).
- Activities to handle risk, such as prevention, mitigation, adaptation or sharing. It often includes trade-offs between costs and benefits of risk reduction and choice of a level of tolerable risk (SRA, 2015).
- Risk management is a matter of assessing, prioritizing and allocating resources to the areas which provide the best safety gain (PSA, 2016).
- The culture, capabilities, and practices, integrated with strategy-setting and performance, that organizations rely on to manage risk in creating, preserving, and realizing value (COSO, 2017).
- Coordinated activities to direct and control an organization with regard to risk (ISO 31000, 2018).
- The act of managing processes and resources to address risk, while pursuing reward (OCEG, 2018).

A common factor for several of the risk management definitions is that different concerns must be considered when evaluating and managing risk in an environment of uncertainty, and, particularly, to obtain a balance between economic aspects, on one hand, and safety aspects, on the other.

Decision-making under uncertainty

An objective of risk management is to support the decision-makers in addressing risk when making decisions under uncertainty, leading to better allocation of resources and, ultimately, improving the organization's performance. A great number of different approaches may be applied to ensure that decisions achieve a balance between different concerns, such as economic and safety aspects. The challenge is to determine what approaches should be chosen when evaluating risk and, in particular, how much weight should be given to uncertainty. Overall, three categories of different approaches may be taken (Abrahamsen & Abrahamsen, 2015; Sørskår & Abrahamsen, 2017), as illustrated in Figure 1.

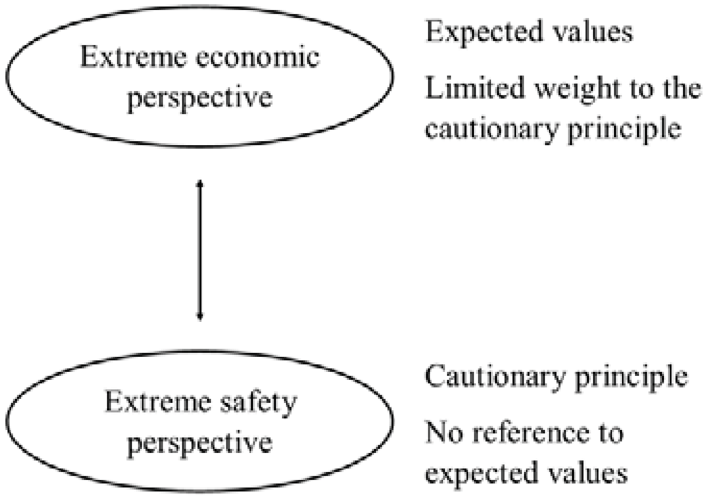

Figure 1 – Dynamic approach (Abrahamsen & Abrahamsen, 2015; Sørskår & Abrahamsen, 2017)

One common approach is to apply a traditional cost-benefit analysis (CBA); see, for example, Ale et al. (2015) and Watkiss et al. (2015). The decision alternatives are then assessed and compared, often based on expected values (see e.g. Watkiss et al., 2015). Approaches heavily based on expected values are referred to as an extreme economic perspective, as limited weight is given to uncertainty. In general, several researchers criticize the use of expected values when managing risk, as uncertainties are not fully addressed; see, for example, Hoegberg (1998), Abrahamsen et al. (2004), Aven & Renn (2010), Ale et al. (2015) and Watkiss et al. (2015).

Another approach is to apply the cautionary principle when evaluating risk. The cautionary principle is a fundamental principle in safety management, often applied as part of safety regulation requirements. It states that caution should be the ruling principle in a context of uncertainty and risk, such as implementing risk-reducing measures, minimum requirements to protect people and the environment, or not starting an activity (Aven & Vinnem, 2007; HSE, 2001). More examples of approaches for implementing the cautionary principle are found in Aven & Abrahamsen (2007). Cautionary approaches not taking economic aspects into consideration are referred to as an extreme safety perspective. Adopting an extreme safety perspective is not considered appropriate in general, due to the absence of economic considerations (Abrahamsen et al., 2018).

A third perspective lies between the two extremes: i.e. economic considerations are included, while uncertainties are weighted more heavily than in the case of expected values (Abrahamsen et al., 2018). The question is: which perspective should the decision-makers choose to obtain balance between different concerns in risk management?

As no single perspective is appropriate for all decision-making contexts, Abrahamsen et al. (2018) argue for a dynamic approach in the choice of perspective, such that the approach taken is customized and appropriate for its context. For example, a context may be characterized by a great amount of available historical data, the cause-consequence relations are well-known and widely accepted, consequences are known and of little impact, there is little uncertainty, and strength-of-knowledge is strong. Such a context requires a substantially different approach than that of a context characterized by poor data, a great amount of uncertainty, weak strength-of-knowledge, and severe consequences.

Framework for risk management

Risk assessment approaches constitute the basis for risk management, but risk management also involves activities such as establishing roles and responsibilities, communication, training and developing a good culture (Aven, 2014). As an aid to implementing risk management in an organization, the decision-makers may choose to adopt comprehensive tools such as guides, frameworks and standards (see e.g. COSO, 2017; OCEG, 2015; IRM, 2002). One such comprehensive tool is the ISO 31000 standard (2018), which offers guidance on how organizations can integrate risk-informed decision-making into the organization's activities.

ISO 31000 aligns with the main purpose of risk management: to obtain a balance between value creation and protection. It also provides a holistic and dynamic approach to risk management. 'Holistic' means that it applies to all types of organizations and to all types of risk in an organization, for example, hazard, financial, operational, strategic risk. 'Dynamic' refers to the fact that the risk management may be customized to the organization's internal and external contexts.

Characteristics of the internal context are related to, for example, the organization's vision and goals, structure and culture, capabilities in terms of knowledge and resources, available data and information, and the internal relationships, networks and interconnections. Characteristics of the external context are related to, for example, societal factors such as regulations and the economic situation, trends influencing the objectives, external stakeholders' influence, external networks and dependencies (ISO 31000, 2018).

To obtain the balance between value creation and protection, ISO 31000 adopts a principle-based system, with a set of principles for effective risk management. The principles, as a basis for the other elements of the ISO 31000 risk management model, are illustrated in Figure 2, followed by a short presentation of these main elements: the risk management process, framework and principles.

The ISO 31000 principles influence how risk is managed by the leadership and how risk is assessed and treated. The standard provides a strong focus on the crucial leadership role in integrating risk management into the organization. It also provides a process to help identify and evaluate risk and its associated activities such as communication and monitoring. Fischhoff (2015) argues that stakeholders and analysts should have ongoing communication, to obtain effective risk management. ISO 31000 adopts a similar view, as part of the risk management process. In addition, it emphasizes that leadership influences how to assess and evaluate risk, and that the risk assessment process influences how risk management is integrated into the organization.

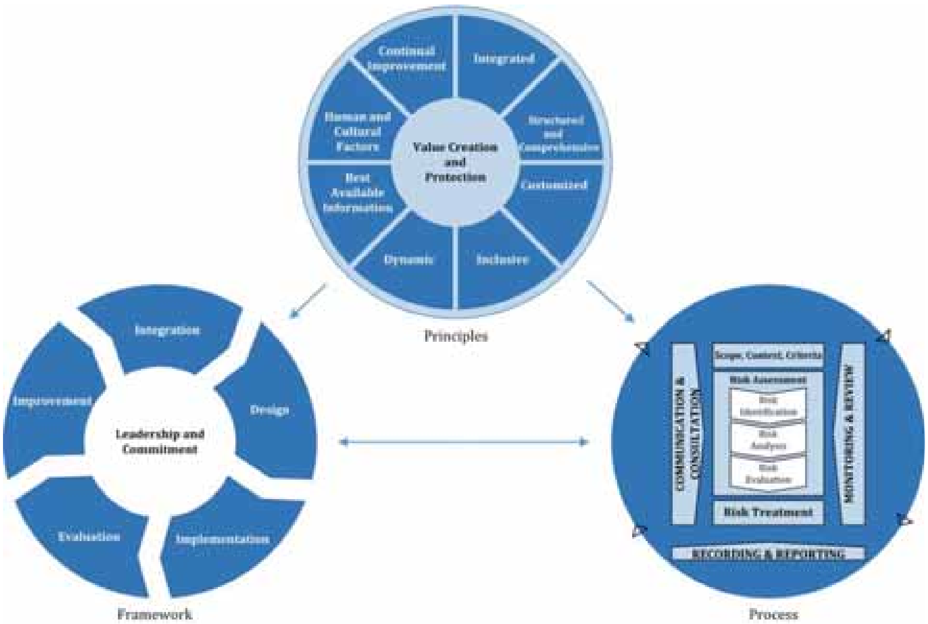

Figure 2 – The ISO 31000 model (Source: ISO 31000, 2018)

The ISO 31000 risk management process

The purpose of the risk management process is the systematic application of policies, procedures and practices to the activities of communicating and consulting, establishing the context, and assessing, treating, monitoring, reviewing, recording and reporting risk (ISO 31000, 2018). The process starts by understanding the context and establishing the scope and objectives. It also involves activities such as problem definition, information gathering, organization of work and the selection of the analysis method (Aven, 2008b). Understanding the context is important, as it reduces the overall risk by preventing the decision-makers from neglecting concerns that may lead to undesirable surprises (Aven & Renn, 2010).

The main core of the risk management process is the risk assessment, which is defined as a "systematic process to comprehend the nature of risk, express and evaluate the risk", based on the available knowledge (SRA, 2015). The common approach is to first identify risks that may have an impact on the organization's objectives (ISO 31000, 2018). The risk assessment might also reveal emerging risks, which involve rather weak background knowledge but still indicate some sort of a new type of event with potential severe consequences that might occur. This is distinctive from hazards/threats/opportunities, which are considered well-known events (Aven & Flage, 2018).

Identified risk is then analyzed with the help of cause and consequence analysis tools, that is to highlight and evaluate what is needed for the initiating events to occur and the possible consequences (Aven, 2008b). Causes and consequences are evaluated and presented with the help of, for example, probabilities, expected values, prediction intervals, uncertainty factors, evaluation of strength-of-knowledge, etc. (Aven, 2008b). Finally, the risk is evaluated, and risk-treatment recommendations to the decision-makers may be to maintain the current risk-controlling measures, to consider risk-treatment options, to perform further analysis for improved understanding of the risk, to reconsider the organization's objectives, or to do nothing (ISO 31000, 2018).

The ISO 31000 risk management framework

The effectiveness of risk management is dependent on its integration into the organization and the decision-making. The purpose of the risk-management framework is to function as a tool for the decision-makers to integrate risk management into the organization's activities and purposes (ISO 31000, 2018). The center for the framework is leadership and its commitment to risk management. While the purpose of risk management is to obtain a balance between different concerns, it is the decision-makers' role to state which concerns to consider and how much weight should be given to the different concerns. The framework interacts with the risk management process, meaning that the decision-makers' objectives and leadership influence the approach taken to evaluate and manage risk.

The ISO 31000 risk management principles

To achieve the balance between value creation and protection, principles may be expressed that relate to the foundational properties of effective and efficient risk management. According to ISO 31000 (2018), risk management should be:

1) Customized: Framework and processes are proportionally aligned to the organization's external and internal contexts in relation to its objectives.
2) Inclusive: Appropriate and timely involvement of stakeholders, such that their knowledge, views and perceptions are considered.
3) Structured and comprehensive: A structured and comprehensive approach is required and contributes to consistent and comparable results.
4) Integrated: Integral part of all organizational activities.
5) Dynamic: Adequately anticipate, detect, acknowledge and respond to changes and events.
6) Best available information: Explicitly consider any limitations and uncertainties of the available knowledge, which is based on historic and current information and future expectations.
7) Human and cultural factors: Significant influence on all aspects of risk management at every level and stage.
8) Continual improvement: Continuous improvement through learning and experience.

The principles provided in ISO 31000 should not be seen as strictly compartmentalized, as they both influence and depend on each other. One example of this is that stakeholders are important when integrating risk management initiatives into organizational activities; in other words, the principles, 'inclusive' and 'human and cultural factors', influence the 'integrated' principle. An aspect of ISO 31000 is that the model should be adapted or improved to obtain effective risk management. This means that, for different contexts, different weight should be given to the different principles.

The principles, 'customized', 'inclusive', 'structured and comprehensive', 'integrated' and 'dynamic', are primarily related to the design and planning of risk-management initiatives, while 'best available information', 'human and cultural factors', and 'continual improvement' relate principally to the operation of risk-management initiatives (IRM, 2018). Some of the principles are further discussed in Section 3.

3 Research areas and problems

The scientific contribution consists of five papers, presented in Part II of this thesis. The focus is twofold, and the papers are linked to the research areas stated in Section 1.2, as listed below.

Research area 1: The development of approaches to obtain the appropriate balance between value creation and protection.

Paper I:	On how to manage uncertainty when considering regulatory HSE interventions
Paper II:	On the use of Vision Zero and the ALARP principle for production loss in the oil and gas industry
Paper III:	On the use of economic evaluation of new technology in helicopter emergency medical services

Research area 2: The use of safety climate instruments to improve patient safety in the prehospital domain.

Paper IV:	Psychometric properties of the Norwegian version of the Hospital Survey on Patient Safety Culture in a prehospital environment
Paper V:	Assessing safety climate in prehospital settings: testing psychometric properties of a common structural model in a cross-sectional and prospective study

The two research areas and the five papers are associated with the principles for effective risk management in ISO 31000. A similarity is that they relate to underlying aspects that have an impact on the potential effect and outcome of risk management.

The first research area concerns issues and possibilities of different approaches to obtain an appropriate balance between value creation and protection. Simplified, in Paper I, the focus is on a methodological approach, in Paper II the focus is on the use of approaches based on goals and principles, and Paper III focuses on a systems model approach. The discussions and suggested approaches in Papers I and II are primarily related to the 'customized' principle in ISO 31000. The suggested conceptual method developed in Paper III is primarily related to the 'structured and comprehensive' principle.

The second research area focuses on the use of safety climate instruments as tools to improve the prehospital patient safety. The instruments developed and validated in Papers IV and V are intended for application in the operation of risk-management initiatives, such as retrieving knowledge on the relationship between safety climate and safety performance or monitoring the effect of risk-management interventions. The topic is primarily related to the principle 'cultural and human factors' in ISO 31000.

The link between research areas and papers, and their designated principle, is illustrated in Figure 3. Although the different papers are linked to specific principles, they also relate directly or indirectly to the other principles, as well as to the risk-management framework and -process. However, the main point is that the papers help to highlight why these principles are necessary for effective and appropriate risk management.

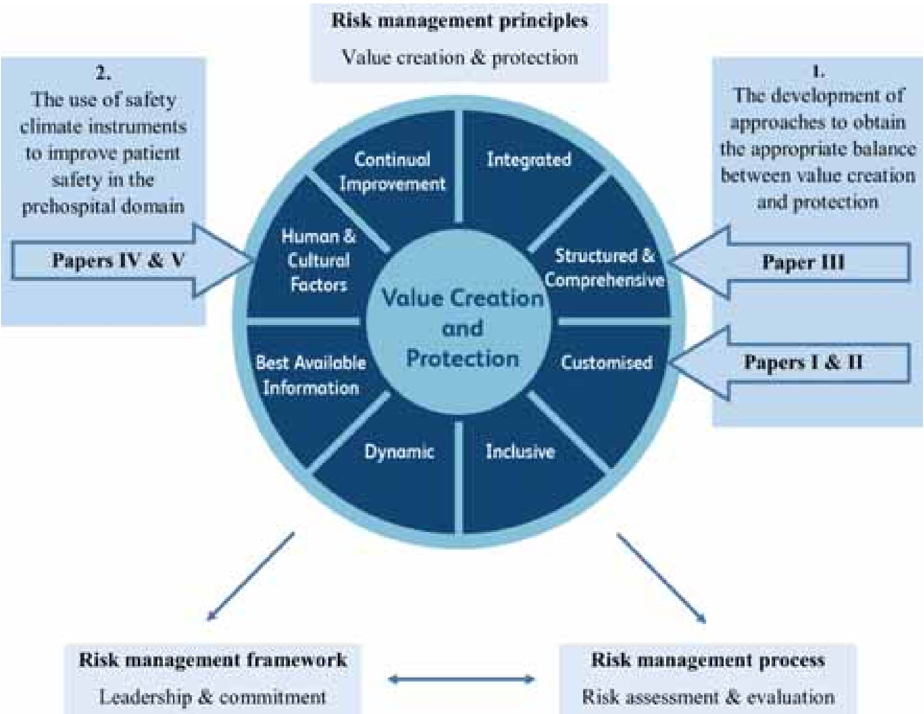

Figure 3 – Illustration of the link between the research areas set out in Section 1.2, papers in Part II of this thesis and the ISO 31000 model.

3.1 Approaches to obtain balance between value creation and protection

Papers I and II are primarily related to the 'customized' principle, which, simplified, states that risk management should be aligned to the organization's external and internal context. When performing decision-making processes, contextual factors influence the approach chosen to ensure that decisions obtain the appropriate balance between different attributes, and how much weight is given to different attributes, such as costs, benefits, risks and uncertainty. In essence, the 'customized' principle may be interpreted to mean that the approach taken should be appropriate for its context. This is similar to the dynamic approach (Abrahamsen et al., 2018), as discussed in Section 2.3. The main issue discussed in Papers I and II relates to the conflict that appears when the chosen approach for managing risk is not appropriate for its context.

Paper I

Paper I's main topic is the use of an approach that applies expected values to evaluate regulatory HSE requirements in the oil and gas industry. Regulatory HSE requirements change occasionally, due to new knowledge or a change in governmental objectives. The purpose is often to improve HSE matters but may involve great economic consequences. One approach for evaluating the HSE regulatory requirements is to apply a CBA to justify an implementation (Hayes, 2014). The issue addressed in Paper I is that the oil and gas industry represents a context characterized by complexity and deep uncertainties, prone to potential major accidents. A CBA approach in such a context is considered both difficult and controversial (Hopkins, 2015).

Based on a government-assigned project in 2015, the consulting companies, DNV GL and Menon Business Economics, presented a new methodology for evaluating whether instruments in HSE regulations were socioeconomically beneficial (DNV GL and Menon, 2015). Although listing several approaches for evaluation, their preferred approach to account for uncertainties is to modify a traditional CBA.

In a traditional CBA, the expected net present value (E[NPV]) is calculated from point estimates of costs and benefits. The modified CBA approach in the aforementioned methodology is to present two alternative calculations of E[NPV], in addition to the calculated value from the traditional CBA. The first is the 'maximum expected profitability', found by subtracting the lowest estimate for costs from the highest estimate for benefits. The second is the 'minimum expected profitability', found by subtracting the highest estimate for costs from the lowest estimate for benefits (DNV GL and Menon, 2015). Their approach is only one of several that could be chosen when modifying CBA (see e.g. HSE, 2001; Binder, 2002; EAI, 2006; Hallegatte, 2006; Helle et al., 2015; Talarico & Reniers, 2016).

The main point in Paper I is that the modified CBA still relies heavily on the use of expected values, and, in a context prone to potential major accidents, the calculated values may still provide poor predictions of the actual net present value (NPV). Conclusively, the use of a modified CBA, with a basis in expected values, may be very misleading when having a portfolio of projects with the potential for extreme consequences. The average value of many such projects (n) could deviate significantly from the expected value, even if n is relatively large, due to:

1) the extreme outcomes that greatly influence the average, and/or
2) the fact that the expected values express the analysts' judgement based on background knowledge: knowledge which could be more or less incomplete (Aven & Abrahamsen, 2007)

Based on the work of Aven and Vinnem (2007) and Aven (2011b), the suggested solution in Paper I is a customized flexible approach, in which the appropriate balance between economic and risk considerations is obtained (Sørskår & Abrahamsen, 2017). The developed approach for the evaluation of regulatory HSE interventions is presented in Figure 4.

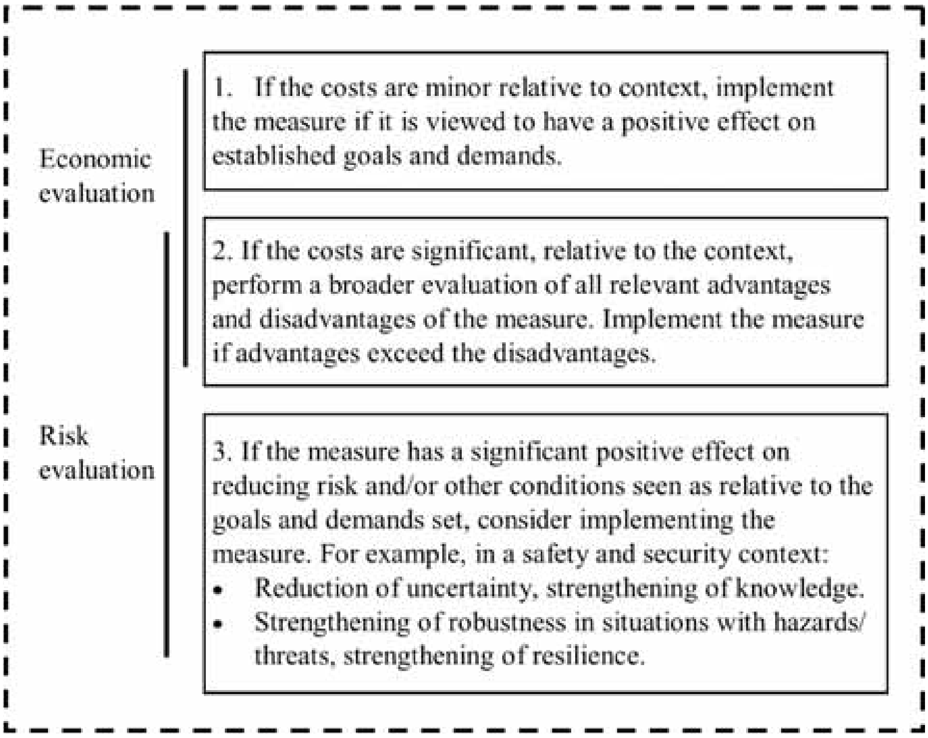

Figure 4 – Approach for evaluation of regulatory HSE interventions (Sørskår & Abrahamsen, 2017)

The approach represents a dynamic approach (Abrahamsen et al., 2018), which means that the outcome of evaluating HSE requirements may vary, depending on the context.

Paper II

The main topic for Paper II is the use of governing principles, in particular the use of Vision Zero and the As Low As Reasonably Practicable (ALARP) principle, for managing the risk of production loss in the oil and gas industry. The issue addressed in Paper II is that the operators' overall objectives, especially their economic objectives, are not necessarily reflected by the use of principles that primarily have a strong focus on risk reduction.

Vision Zero (VZ) represents an approach that may be adopted as a guiding principle. Simplified: for an activity or organization, the goal of VZ is to reduce a measurable undesired outcome to zero. An example is traffic safety, which has been in the spotlight for over a century and, in the last two decades, has been influenced by Vision Zero, stating that traffic safety should reach a state where there are no fatalities and no severe injuries from traffic accidents (Johansson, 2009). Whether VZ constitutes a rational goal in an HSE context has been discussed in the literature (see e.g. Ivensky, 2016), and it has been argued that VZ is a rational approach to traffic safety (Rosencrantz et al., 2007).

The background for Paper II is the use of VZ as a governing principle when managing the risk of production loss in the oil and gas industry (Grinrød et al., 2004; Andersen et al., 2006). Selvik and Aven (2012) have argued that, in this context, VZ does not sufficiently recognize the relevance of other concerns, in particular economic concerns, and should be avoided, as it is in conflict with the primary objectives of the industry: optimization of values. The decision-makers should be able to give weight to both economic and other concerns, aligned with other stated management objectives. Overall, the decision-makers should be able to take a dynamic approach, i.e. the choice of perspective should be appropriate for the decision-making context (Abrahamsen et al., 2018).

Another guiding principle which may be adopted to manage risk is one stating that risk should be reduced to a level that is As Low As Reasonably Practicable: the ALARP principle. A common interpretation of this principle is that risk-reducing measures should be implemented, unless there is a gross disproportion between costs and benefits. Another interpretation is to implement a "layered approach", developed by Aven & Vinnem (2007) and Aven (2011b). Abrahamsen et al. (2018) argue that this interpretation of the ALARP principle represents a dynamic approach.

Paper II examines whether a combination of VZ and the ALARP principle may be appropriate for managing the risk of production loss. Other attributes of VZ may serve objectives related to a long-term perspective, for example stimulating development and creative thinking or inducing new technologies (Selvik & Aven, 2012). From a short-term perspective, the ALARP process may help prioritize between different concerns such as economic objectives and risk-reduction. Paper II found that complementing VZ with the ALARP principle may serve a long-term perspective, in the pursuit of reducing the risk of production loss closer to zero, while, at the same time, providing a pragmatic tool to (over time) continually draw closer to this goal. Hence, the VZ would act as the governing principle, and the ALARP principle would serve as the tool for implementing risk-reducing measures in practice and as a benchmarking tool for VZ.

An important point in Paper II is that, in other decision-making contexts, it might be more appropriate to use other principles or a mix of principles, for example to use only ALARP as a governing principle or to find other tools to complement VZ. However, for the context of production assurance, Paper II concluded that complementing VZ with the ALARP principle would serve to meet decision-makers' overall objectives. In essence, the combined principle is adequately customized for its context.

Paper III

In Paper III, the main topic is how to assess a complex sociotechnical systems' context when performing economic evaluations as part of health technology appraisals. The issue discussed is that incomplete understanding of the context leads to poor background knowledge used as a basis for the assessment, which again may induce poor decisions. The approach suggested in Paper III is to use a systems model to identify, structure and evaluate contextual elements and their interconnectedness. The output of such an assessment would aid analysts and decision-makers in understanding the context and avoid the risk of "missing" crucial knowledge.

Simplified, sociotechnical systems have their basis in the interconnectedness and complexity of social and technical systems (Kleiner et al., 2015; Pierre et al., 2016) and include interconnection between persons, technology, internal and external environment, and organizational design and management systems (see e.g. Carayon & Smith, 2000). The focus for Paper III is the sociotechnical system in the acute care setting of helicopter emergency medical services (HEMS).

To maintain medical emergency preparedness within the prehospital domain, the HEMS is seen as vital for providing patients with time-critical medical treatment. The highly competent HEMS team consists of an anesthesiologist, a HEMS crewmember (HCM) and a pilot, each performing complex and interacting tasks of a medical, technical, flight-operative, rescue and multidisciplinary character (Abrahamsen et al., 2015). The context for performing the tasks is complex, characterized by time pressure and high stakes, uncertain situations and shifting environment, and demanding for the providers.

HEMS is ever developing, and the introduction of new technology into this context is common, with the purpose of improving the patient-safety and the healthcare outcomes. As part of the health technology assessment, a common approach is to perform an economic evaluation, to highlight any advantages and disadvantages of the new technology (Lerner et al., 2006). Several economic evaluation tools may be utilized for this purpose, but an aspect they all have in common is the dependency on background knowledge, that is, the contextual elements and their interconnectedness.

In a complex sociotechnical system such as HEMS, it is challenging to obtain sufficient and good quality background knowledge. This is mainly due to the fact that, when a change in the system occurs, the effect on the whole system has to be considered (Carayon et al., 2016). New technology in HEMS may have an impact on several system elements and on the interaction between system elements. A key issue discussed in Paper III is that, although several crucial factors are likely to be included in the economic evaluation, if there is a lack of a systems approach for managing the background knowledge, it may be arbitrary what is considered.

The suggested solution in Paper III is related to the contention of the ISO 31000 principle that risk management should be 'structured and comprehensive'. The 'structured' part is to take a systems approach by utilizing the Systems Engineering Initiative for Patient Safety (SEIPS) model to perform a 'comprehensive' assessment of the system elements, i.e. to identify, structure and evaluate the background knowledge. The SEIPS model is one of many models developed for describing sociotechnical systems and is applied for a wide range of healthcare quality and safety issues (Carayon et al., 2006; 2014; Holden et al., 2013). The model is illustrated in Figure 5.

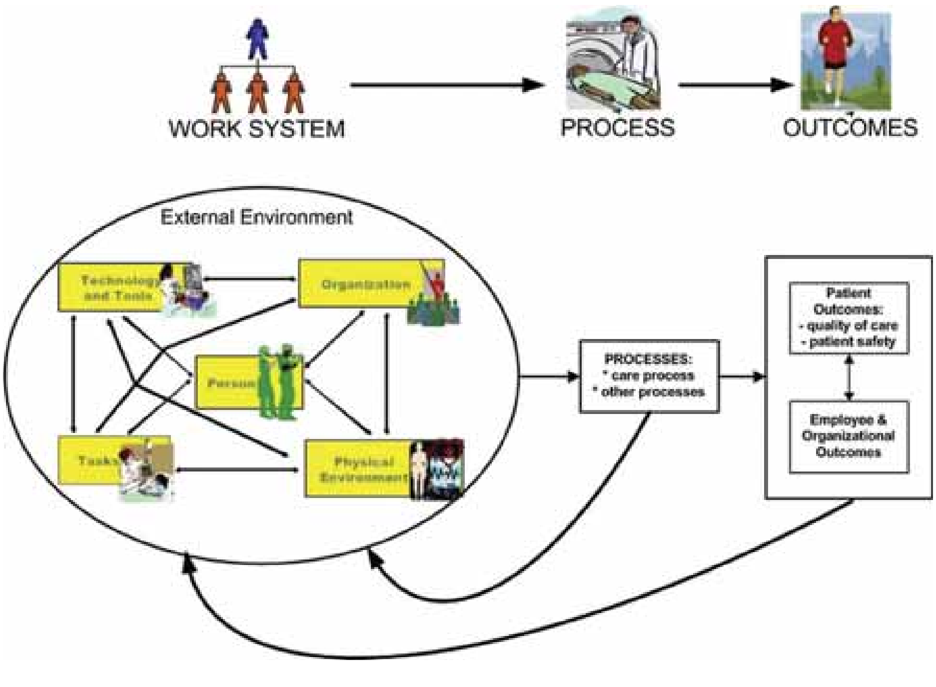

Figure 5 – The SEIPS model (Source: Carayon et al., 2006;2014)

Overall, the suggested methodical approach in Paper III consists of three main steps:

1. Use the SEIPS model to identify relevant background knowledge, the systems elements and interactions related to the new technology, which also have a potential effect on the economic evaluation.
2. Assess the strength-of-knowledge of the identified elements to reveal any weak or insufficient background knowledge.
3. Evaluate identified elements with relatively poor strength-of-knowledge for their impact on the economic evaluation. Elements with relatively high impact should be referred to as critical.

The purpose is to reduce the risk of missing crucial input when performing the economic evaluation. In addition, it is valuable to highlight any critical elements that the decision-makers should pay closer attention to. This is a similar objective to that in risk management: to provide the decision-makers with an informative risk picture (Aven, 2014). Overall, the intentional outcome of the structured and comprehensive approach suggested in Paper III is to obtain improved health technology assessments for HEMS and, ultimately, to obtain improved healthcare quality and patient safety.

3.2 Safety climate instruments in the prehospital domain

The main topic of Papers IV and V is closely associated with the ISO 31000 principle, 'human and cultural factors'. 'Human factors' is a generic term with several meanings (Pierre et al., 2016); simplified, it relates to anatomical, physiological, psychological and social aspects of individuals in a specific environment, such as workers in their working environment. This includes environmental, organizational and job factors that align with their behavior and influence their health and safety.

'Cultural factors' is a wider term, but, simplified, the basis for culture is the shared assumptions and beliefs for a group, obtained through collective learning, and how these are manifested in expressed attitudes, emotions and behavior. For an organization, the culture may be summarized as "the way we do what we do, how we think about it and how we feel about it" (Pierre et al., 2016).

The concepts of safety culture and safety climate are among several other cultural factors. The distinction between culture and climate may be linked to the three-level framework on organizational culture (basic assumptions, espoused values and artefacts), developed by Edgar H. Schein in the 1980s (Schein, 2017). The core of the culture is on a level with basic assumptions, and climate is on a level with artifacts and espoused values (Guldenmund, 2000; Schein, 2017).

Healthcare is one of several high-risk industries where a number of different methods exist to measure safety culture and safety climate (Halligan & Zecevic, 2011; Pierre et al., 2016), of which a common method is the use of questionnaires. Whether safety culture may be assessed by the help of questionnaires is disputed (Guldenmund, 2007; Haukelid, 2008). While quantitative methods such as questionnaires are suitable for measuring safety climate, qualitative methods are more suitable for capturing the underlying safety culture (Denison, 1996). Table 1 shows the different levels of organizational culture, with examples of safety culture, and suitable instruments for measuring patient safety.

Table 1 – Organizational culture levels, safety culture examples and suitable measuring instruments (based on Pierre et al., 2016)

Cultural levels	**Meaning in general**	**Safety culture examples**	**Suitable measuring instruments for patient safety**
Artifacts; visible characteristics	Observable behavior and demeanor of an organization	Hand disinfection Technical condition of medical equipment Safety checklists Reporting system available	Inspections and audits Document analysis Observational study
Espoused values; publicly known values and opinions	Provide basis for action justification May be expressed and often communicated to the workers	Mission and vision statements Top management behavior and attitudes towards safety Safety precautions Plan for managing incidents	Safety climate questionnaires Qualitative interviews
Basic underlying assumptions	Core of the culture and the basic assumptions on human activity and relationships	Human nature Work ethics Attitudes toward learning and change	Not (immediately) apparent, but may be derived from expressed values and artifacts Qualitative interview (partial approximation) is a possibility

A practical benefit of safety climate studies is that safety climate may be more directly measured and is more manageable when using deliberate and directed efforts (Lee et al., 2018). Papers IV and V are within the category of safety climate research and apply a questionnaire to measure the safety climate in a prehospital environment. This is a domain within healthcare where few safety climate studies have been undertaken.

Both papers are based on data retrieved from a safety-climate survey conducted in 2016 among Norwegian EMS workers. The population mainly consisted of ground ambulance (car- and boat ambulance; GEMS) workers: emergency medical technicians (EMT), nurses and paramedics, and HEMS workers: physicians, HEMS crew members and pilots. In Norway, regional health trusts are responsible for the EMS activities, and their main task is to maintain prehospital medical emergency preparedness and to provide transport for patients in need of acute medical treatment or where monitoring is necessary. In addition to the data collected in 2016, Paper V also utilized data collected within HEMS in 2012. In this paper, the data was split into three samples: HEMS 2012, HEMS 2016 and GEMS 2016.

Paper IV

In Paper IV, the Norwegian version of the questionnaire, Hospital Survey on Patient Safety Culture (HSOPSC), was applied to perform the patient safety climate assessment. HSOPSC is one of several instruments developed to measure patient safety climate (Halligan & Zecevic, 2011) and has previously been validated for use in settings within Norwegian hospitals (Olsen, 2008; 2010; Haugen et al., 2010, Ballangrud et al., 2012; Olsen & Aase, 2012). The original HSOPSC was developed based on a literature review, with a focus on safety, errors and misconduct, and on other existing instruments for measuring patient safety (Sorra & Nieva, 2004).

As the instrument was primarily developed for use within hospitals, using it outside the hospitals may interfere with the contextual meaning of the content. The prehospital environment differs from hospitals in, for example, organizational levels, team organization, tasks, and situation characteristics. A major purpose of Paper IV was to perform a new test and validation of the psychometric properties of the HSOPSC in a prehospital context. This is necessary before using it as a basis for safety-management interventions (Pfeiffer & Manser, 2010). At the front of the survey, the wording of the Norwegian HSOPSC was contextually adjusted to fit the prehospital environment, but the conceptual meaning was not changed.

Paper IV provides two major findings. First, the instrument was validated for use in a prehospital context, but it was also revealed that some further modifications of the instrument would be beneficial for improved application. Second, the explanatory power of some of the outcome variables was relatively high, meaning stronger relations regarding which safety climate dimensions affect which outcome variable. A significant contribution from Paper IV is to provide the prehospital environment with a validated safety climate measuring tool: the PreHSOPSC.

Paper V

Paper IV is the starting point for Paper V, and the suggested modifications in Paper IV are evaluated further. Another focus adopted in Paper V was to consider the cultural relationships in the prehospital chain. For the prehospital context, there is little research on the relations between organizational factors which may create barriers and increase patient safety (Wood et al., 2015); patient safety is such a broad endeavor that characteristics of the whole system should be considered (Vincent, 2010).

The study in Paper V utilized a short version of HSOPSC, the HSOPSC-S, which is based on a multilevel theoretical framework (Olsen, 2010). As the prehospital setting is different from the hospital setting, it was necessary to test the validity of the psychometric properties of the instrument.

Paper V focuses on the prehospital chain as a multilevel system, which is beneficial, as taking a multilevel perspective is recommended when performing safety-climate research (Flin, 2007; Zohar, 2014). In general, a multilevel perspective emphasizes that different levels in an organization influence each other, for example that the management level ultimately influences the individual level, directly or indirectly.

Similar to the original HSOPSC-S research (Olsen, 2010), a theoretical framework for the prehospital chain was hypothesized, as shown as a simple illustration in Figure 6. Simplified, it was hypothesized that the prehospital safety climate is aligned with a multilevel perspective, and that the management levels influence the lower levels: the unit and individual levels and, ultimately, the outcome.

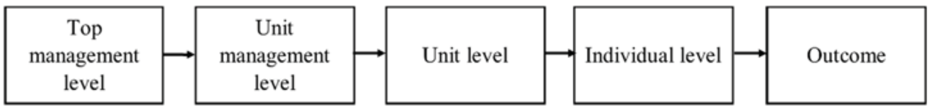

Figure 6 – Simplified theoretical framework for the prehospital chain

The outcome hypothesized in Paper V is associated with patient transitions and handoffs in the prehospital domain, that is that patient safety in handovers is considered the final ‘product’ of the prehospital chain. Recently, patient transitions and handoffs have obtained more attention in the prehospital environment (Owen et al., 2009; Jensen et al., 2013; Wood et al., 2015; Meisel et al., 2015; Shelton & Sinclair, 2016; Cuk et al., 2017). Good transitions and handoffs are related to improved patient safety, continuity of patient care and better decision-making (Thakore & Morrison, 2001; Berkenstadt et al., 2008; Smith et al., 2008; Owen et al., 2009).

Patient handovers to the hospital are viewed as critical in EMS providers' view, as this brief moment of transitions and handoffs provides an opportunity to influence the further course of patients' care (Meisel et al., 2015). To make improvements in this area, the first step is for the policy decision-makers to understand how the organization's patient safety climate is perceived by its workers (Lee et al., 2016).

Paper V provided three major findings. First, the pre-modified version of the measurement model of HSOPSC-S was validated for distribution in GEMS but not validated for HEMS. Second, a post-modified version of the measurement model was validated for both GEMS and HEMS. Third, testing of the theoretical structured framework provided an observed relationship between levels, culminating in a significant influence on the outcome. In summary, the post-modified version, the PreHSOPSC-S, is validated and suitable for application in the EMS environment. The final structure is displayed in Figure 7.

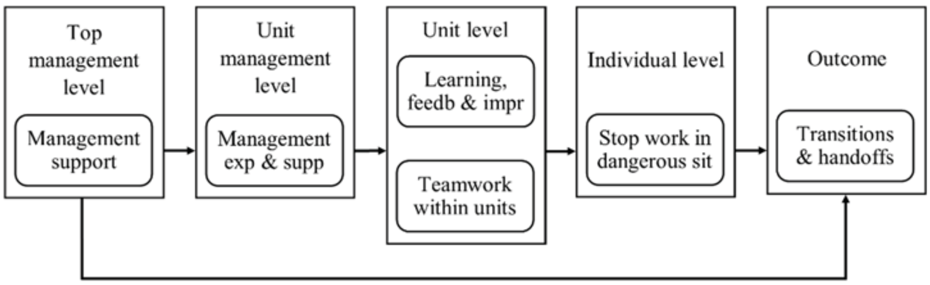

Figure 7 – Structured framework for the prehospital environment. Note: Management support = "*Management support for patient safety*", Management exp & supp = "*Manager expectations & actions promoting patient safety*", Learning, feedb & impr = "*Learning, feedback & improvement within units*", Stop work in dangerous sit = "*Stop working in dangerous situations*".

The study in Paper V demonstrates that the multilevel patient-safety climate is positively related to the outcome related to transitions and handoffs. Based on the new theory on the final structured framework developed in Paper V, several strategies to improve patient safety may be chosen. An example is to define and implement a multilevel safety program, with the purpose of improving the safety culture and safety behavior (Olsen et al., 2009). Normally, improved safety climate is obtained by implementing interventions targeting a few areas at a time (Halligan & Zecevic, 2011), but a multilevel safety program could address several levels and areas simultaneously.

The validated PreHSOPSC-S may then be used to monitor and determine the effects of interventions on the prehospital patient-safety climate.

Another benefit of a short safety climate instrument (fewer statements in the questionnaire) is that its application is beneficial for use in fast-pace work environments, such as the prehospital domain, as it may be challenging to perform frequent assessments of the patient safety climate with a relatively longer instrument. However, which instrument to choose depends on what elements of the contexts should be measured, and how comprehensive an approach the decision-makers find necessary. The contributions given by Papers IV and V provide two measuring tools with different properties, which may be used for different purposes and different prehospital contexts.

Supplemental reading: Psychometric theory

The scientific contributions in Section 3.2 are based on collected data, retrieved from a digitally distributed questionnaire. In particular, the participants were asked to provide their view on different statements related to patient safety, adverse events and the reporting of such.

Measurement is a fundamental activity in science, where knowledge is gained through observation. It is common for each area of science to develop its own set of measurement tools and procedures. Within behavioral and social sciences, 'psychometrics' is the term used when quantitatively measuring psychological and social phenomena (DeVellis, 2017). While measurements in some settings are obvious, such as measuring weight in kilograms, psychometrics is more challenging (Netemeyer et al., 2003). It is not obvious how to measure phenomena such as a no-blame culture, social dependencies in a team, or life quality.

The phenomenon in question is often derived from theory, and similar to other sciences, a theoretical variable is confirmed by measurement. In behavioral and social sciences, the theoretical variables are not directly observable and are measured by what is referred to as scales or dimensions (DeVellis, 2017; Netemeyer et al., 2003). A scale often consists of multiple items, for example statements in a questionnaire, which are combined into a score for a hypothesized dimension (Netemeyer et al., 2003). The underlying phenomenon that a scale is intended to reflect is often called the latent variable (DeVellis, 2017).

It is common to apply a questionnaire as the measuring instrument, in which the variables of interest are part of a broader theoretical framework (DeVellis, 2017; Netemeyer et al., 2003). Several criteria (psychometric properties) exist for evaluating the dimensionality and the ‘goodness’ of instruments. Which criterion is relevant depends on the assessment’s objectives and the scientific endeavor undertaken (Netemeyer et al., 2003), meaning that the criterion used should be aligned to what is accepted in the scientific community. In general, the criterion is that instruments should have sufficient reliability and validity.

As the term ‘reliability’ implies, a reliable instrument is one that performs in consistent and predictable ways. A common approach is to measure the internal consistency among items on a scale, and that the items share a common latent variable. High inter-item correlations suggest that the items are all measuring the same thing (Netemeyer et al., 2003; DeVellis, 2017). This is typically measured with Cronbach’s (1951) coefficient alpha.

Validity often refers to how well an instrument actually measures the phenomenon it is intended to measure (Netemeyer et al., 2003; DeVellis, 2017). The conventional interpretation of validity is related to the relationship between variables (construct validity), how the scale was developed (content validity) and its ability to predict specific outcomes (criterion-related validity) (DeVellis, 2017).

Construct validity is commonly assessed by other validity assessments, one of which is convergent validity, meaning that variables often correlate when ‘belonging to’ the same theoretical domain (e.g. patient safety climate); another is discriminant validity, meaning that the different variables should be sufficiently different, as they should not measure the same theoretical concept (Netemeyer et al., 2003).

Content validity is often related to the development of instruments and focuses on whether the items in an instrument adequately reflect the theoretical domain, including item wording, response formats and instructions. Criterion-related validity is assessed by other validity assessments. One is ‘internal’ which compares measured variables with a related criterion or outcome variable measured simultaneously (concurrent validity), for example a relationship between variables associated with ‘organizational learning’ and ‘overall perception of safety’. Another is ‘external’, which compares measured variables with an external criterion separated by time (predictive validity), for example a relationship between the variable related to ‘organizational learning’ and a reported number of actual incidents/accidents (Netemeyer et al., 2003).

For an instrument, support for reliability and validity is strengthened by testing for different time periods, for different settings and populations, and also by different psychometric approaches and tools. These aspects have been considered in Papers IV and V. See the methods section in these papers for more details.

4 Further work

The starting point for Papers I, II and III in Section II of this thesis were ideas described in previous conference papers, which the author of this thesis was a co-author for two of them. In extending the conference papers, the intention was to take another step in the direction of practical application, by means of an extended theoretical framework, descriptive approaches and/or more substantiated examples. Further work beyond this point is to refine and validate the suggested approaches and frameworks in Papers I, II and III, before an eventual implementation. This includes commencing testing on real-world problems and settings.

Safety-climate research provides an opportunity to identify areas to which researchers and management should pay attention. Continued work is necessary to understand the prehospital patient-safety climate. Surveys are a suggested first step to measure the current status (Pronovost et al., 2005; Huang et al., 2007). Papers IV and V pointed out several weak items and structural relationship issues that future research should take into account. Multiple tests and application over time are recommended to establish validity, which may require modification and refinement of both the theoretical framework and the instrument (Netemeyer et al., 2003).

To obtain a deeper understanding of cultural factors, a recommended approach is to triangulate data from both qualitative and quantitative methods (Haukelid, 2008). Using data from several sources is also common when performing risk assessments to establish a risk picture, for example using 'soft data' (observational studies, expert judgement, etc.) to understand 'hard data' (statistics, trials, etc.) and vice versa.

In safety-climate research, there are, in general, three approaches to establish a relationship between safety climate and safety performance. The first is a cross-sectional study, in which climate factors are correlated across subgroups within a population. The second involves longitudinal studies, in which safety-climate factors are correlated with subjective measures of safety-performance samples at a later point in time. Third, climate factors are correlated with external factors such as incident rates, reported near misses, etc. (Kongsvik et al., 2010). Papers IV and V have largely met the requirements of the first and second approaches, so a natural next step is to conduct more research related to the third approach, particularly for Paper V, as the data retrieved from HEMS in 2012 and 2016 could be compared to databases of reported incidents for the same time period.

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Part II

Paper I

On how to manage uncertainty when considering regulatory HSE interventions

Authors: Leif Inge K. Sørskår & Eirik Abrahamsen

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Paper II

On the use of Vision Zero and the ALARP principle for production loss in the oil and gas industry

Authors: Leif Inge K. Sørskår, Jon T. Selvik & Eirik B. Abrahamsen

Revised and resubmitted for possible publication

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Paper III

On the use of economic evaluation of new technology in helicopter emergency medical services

Authors: Leif Inge K. Sørskår, Eirik B. Abrahamsen &
Håkon B. Abrahamsen

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Paper IV

Psychometric properties of the Norwegian version of the Hospital Survey on Patient Safety Culture in a prehospital environment

Authors: Leif Inge K. Sørskår, Eirik B. Abrahamsen, Espen Olsen, Stephen J.M. Sollid & Håkon B. Abrahamsen

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Psychometric properties of the Norwegian version of the hospital survey on patient safety culture in a prehospital environment

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Abstract

Background: To develop a culture of patient safety in a regime that strongly focuses on saving patients from emergencies may seem counter-intuitive and challenging. Little research exists on patient safety culture in the context of Emergency Medical Services (EMS), and the use of survey tools represents an appropriate approach to improve patient safety. Research indicates that safety climate studies may predict safety behavior and safety-related outcomes. In this study we apply the Norwegian versions of Hospital Survey on Patient Safety Culture (HSOPSC) and assess the psychometric properties when tested on a national sample from the EMS.

Methods: This study adopted a web based survey design. The Norwegian HSOPSC has 13 dimensions, consisting of 46 items, in addition to two single-item outcome variables. SPSS (version 21) was used for descriptive data analysis, estimating internal consistency, and performing exploratory factor analysis. Confirmatory factor analysis (CFA) was applied to test the dimensional structure of the instruments using Amos (version 21).

Results: N = 1387 (27%) EMS employees participated in the survey. Overall, acceptable psychometric properties were observed, i.e. acceptable internal consistencies and construct validity. The patient safety climate dimensions with highest scores (number of positive answers) were "*teamwork within units*" and "*manager expectations & actions promoting patient safety*". The dimension "*hospital management support for patient safety*" had the lowest score.

Conclusions: The results provided a validated instrument, the Prehospital Survey on Patient Safety Culture (PreHSOPSC), for measuring patient safety climate in an EMS setting. In addition, the explanatory power was strong for several of the outcome dimensions; i.e., several of the safety climate dimensions have a strong predictive effect on outcome variables related to employees' perceptions on patient safety and safety-related attitude.

Keywords: Prehospital, Emergency medical services, Patient safety culture, Patient safety climate, HSOPSC, Psychometric properties

Background

Emergencies appears to constitute the most challenging situations in medicine. Prehospital emergency medical services (EMS) are sometimes called the 'extended arm of the hospital' and are characterized by high activity, time pressure, constantly changing environments, and uncertainty; a demanding mix for the providers, and prone to misconduct and errors [1].

Threats to patient safety in the prehospital setting consist of e.g. medication administration errors [2], communication problems [3], deviation from instructions [4], insufficient information [5], lack of training [6], intubation issues [7], patient condition and the related decision-making [8]. Some threats are technical, related to e.g. stretcher issues [9], crash related issues [10] or the introduction of new technology [11]. Frequent handovers between the different EMS organizations may also cause miscommunications and adverse events [12]. Near misses and adverse events appear to be common in the EMS setting, but the culture may suppress the reporting and sharing of such occurrences [1].

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Since the famous report *To Err is Human* was published by the Institute of Medicine around the millennium shift [13], the amount of literature on understanding patient safety has grown – but in the context of EMS there is little research on patient safety, and thus little is understood [14, 15]. A literature study [16] pointed to knowledge gaps in the clinical handover of patients arriving by ambulance at the emergency department; e.g. handover information, transfer of responsibility, and staff perceptions and training. Another literature study [17] revealed several gaps compared to the established literature on patient safety, e.g. research into prehospital staffing, safety culture and climate, near-miss reporting, nosocomial infections, quality improvement techniques, and human factors engineering.

For the further improvement of patient safety in health care, safety culture is seen as an important issue and premise [18–20]. A commonly used definition for safety culture is "*the product of individual and group values, attitudes, competencies and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization's health and safety programmes* (sic). *Organizations with a positive safety culture are characterized by communications founded on mutual trust, by shared perceptions of the importance of safety, and by confidence in the efficacy of preventive measures*" [21]. Safety culture is developed in response to local conditions, past events, employees' attitudes, and leadership's safety-related attitudes and actions. The latter is especially crucial in the development of a good safety culture [1]. It exists several reports on the significant relationship between patient safety culture and specific patient outcomes [22], and improved safety culture is also related to safety performance and a lower incidence of adverse events [19, 23].

Safety climate is a term often used interchangeably with safety culture. Safety climate is commonly defined as "*surface features of the safety culture from attitudes and perceptions of individuals at a given point in time*" [21]. In other words, safety climate research is a 'snapshot' of the safety culture, and hence has less depth and is more transient than safety culture. Safety climate research concerns subjective perceptions and attitudes relating to a phenomenon and should not be mistaken for an objective view of the same phenomenon [24]. Safety behavior has been found to have a strong association with safety climate [25–27]. Research indicates that safety climate studies may predict safety behavior and safety-related outcomes such as harm or accidents [28]. Safety climate assessments have become a common practice in health care organizations, and the purposes are e.g. to conduct safety benchmarks and evaluate trends, to identify, monitor and proactively manage safety issues, to evaluate initiatives and interventions, and to meet regulatory requirements [18, 25, 29]. Such assessments have been made for over two decades, and a growing number of studies report on their value [23, 30].

Several instruments have been developed to assess patient safety climate in health care services [21]. Survey methods are regarded as a good way to study attitudes, values and perceptions, and this appears to be the dominant approach for assessing safety climate [31]. One of these is the Hospital Survey on Patient Safety Culture (HSOPSC), which was originally developed by the Agency for Healthcare Research and Quality (AHRQ) for use in hospitals. The dimensions of HSOPSC were chosen based on a literature review of the research, with a focus on safety, errors and misconducts, and on the existing instruments for measuring safety climate [32]. The HSOPSC has several positive attributes; it is one of the few safety climate measuring instruments in which initial psychometric properties are reported, it is designed for both clinical and non-clinical personnel, it distinguishes between organizational- and unit-level, there is increased use in different countries and contexts, and measuring the frequency of reported unwanted events may collaborate well with an organization's wish for a better reporting climate [33].

Previous studies in Norway have examined the applicability of this instrument in a Norwegian setting, and the Norwegian translation has been validated for the hospital sector [34–36], nurses in intensive care units [37], and in an operating theatre setting [38]. However, applying the instrument in a prehospital setting would interfere with the contextual meaning of the items, affected by e.g. management style, team organization and tasks, and the implementation of reporting systems. The dimensions measured by the instrument, and the underlying model of patient safety climate may be incomplete, only partly applicable for the EMS setting. This requires a new test of the psychometric properties of the instrument in a prehospital context. There is a continued need for research into psychometric properties and the reliability and validity of replicated instruments [33, 34, 38–40]. The aim of our study was to test psychometric properties for HSOPSC performed in a prehospital context.

Method

Our testing of the HSOPSC in a prehospital context may be described as a three-stage process: (1) define the relevant population and retrieve necessary permissions and respondents' contact information, (2) pre-test and adjust the instrument, (3) perform data collection and statistical analysis.

Population characteristics

Regional health trusts are responsible for the Norwegian EMS activities. Their main task is to maintain a state of medical emergency preparedness outside the hospitals and provide transport where acute medical treatment or monitoring is required. In the case of ground EMS (GEMS; car- and boat ambulance), cars are normally staffed by two persons: either two emergency medical technicians (EMT) or one EMT and another licensed health care worker with necessary EMS competence, e.g. a paramedic, a nurse or a physician. For the boat ambulance, the requirement is at least one EMT, in addition to the skipper. Some emergency missions in GEMS may require accompanying healthcare personnel with special medical competence, such as in the transportation of critically ill patients [40]. Norwegian EMTs have a high-school based vocational education, followed by a two-year apprenticeship working as an EMT, before gaining authorization. In addition to the EMT authorization, a paramedic has 60 to 180 European Credit Transfer and Accumulation System (ECTS) points [41]. Supplementing GEMS, helicopter EMS (HEMS) represents the sharp end of the prehospital chain, offering highly competent staff, consisting of an anesthesiologist, a rescuer (HEMS crewmember; HCM), and a pilot. HEMS is vital for providing patients with time-critical medical treatment, particularly in situations involving long distances to the relevant hospital [40]. Search and Rescue Services (SAR) and fixed wing (FW) air ambulances were excluded, since their mission profile and crew concepts differ substantially from HEMS, leading to an exclusion if such personnel were found among the respondents.

Questionnaire

The Norwegian version of the HSOPSC questionnaire was applied for this study. Prior research has translated the questionnaire into Norwegian and back-translated it by two different professionals [34]. Prior HSOPSC research for Norwegian hospitals [35, 36, 38] found that the outcome variable "*number of events reported*" proved to provide poor correlation with the safety dimensions;to compensate, the outcome dimension "*stop working in dangerous situations*" was amended. This outcome dimension reflects perceived individual safety behavior. It is based on items originally included as part of a questionnaire, called the Norwegian Offshore Risk and Safety Climate Inventory (NORSCI), developed through collaboration between the petroleum industry and various research environments during 2000 [42]. The Norwegian version of the HSOPSC instrument thus has 13 dimensions, 46 items and two single-item 'outcome' items [35, 36, 38]. The response format ranges from 1 (disagree strongly) to 5 (agree strongly) on a Likert scale. There are also seven items relating to the respondents' work characteristics (*work area, geographic location, field of competence, patient contact, work hours, seniority in the prehospital area, seniority in position*).

Pre-test and adjustments of instrument

As the instrument was applied in a prehospital context, we checked the questionnaire on a test group of seven prehospital healthcare workers to ensure correct terminology. In addition, a prehospital patient safety professional helped in finding discrepancies between the hospital and the prehospital setting. The suggested changes are as listed in Table 1.

We evaluated whether to include the option of "unknown/not applicable" to all or some of the items, similar to other studies [33, 35, 43]. The outcome variable "*frequency of event reporting*" was especially debated, as the average response may differ from the true (objective) value, and those personnel who do not know the frequency should have the option of stating so. The French HSOPSC study [43] experienced overall low missing score values, except for this outcome dimension (11%). The experience is similar for the German HSOPSC study [33], where items belonging to this outcome dimension have a relatively higher rate of "not applicable" answers than items belonging to the other HSOPSC dimensions. We believe the intention of this outcome dimension, as of other dimensions, is to gain the personnel's perception of the reality. Therefore, it may be useful to force an answer to the items of this dimension (and other items). Consequently, the option of "unknown/not applicable" was not added, which is in accordance with e.g. the original HSOPSC questionnaire [44].

Considering the aims of the study, we believe it is important to keep the instrument as close to the original Norwegian HSOPSC as possible. Consequently, no items were left out or conceptually changed before distribution of the survey.

Data collection

E-mail addresses for prehospital personnel in the Norwegian GEMS and HEMS were retrieved from prehospital system leaders. We applied a web-based tool (SurveyXact) to conduct the survey, and an individual link to the questionnaire was distributed by e-mail to all personnel. Data were collected between October and December 2016, and non-responders received up to five reminders before the study was closed.

Statistical analysis

Psychometric assessment of validation was applied [45, 46] to evaluate the HSOPSC.

Construct validity

To determine the degree of fit between the sample and the constructed measurement instrument, a confirmatory factor analysis (CFA) was performed to analyze the construct validity, i.e. an assessment of the relationship between items, and between items and an underlying dimension. Negatively worded items were reversed, and covariation was allowed between the underlying dimensions.

The chi-square test is problematic for assessing model fit for large samples [47] and is thus not reported for this study. For assessing global fit, the following indices were

Table 1 Suggested adjustments of the instrument

Component	Basis for change	Description of change
Interpretation of the term 'hospital level'	The dimensions in the HSOPSC are divided into three 'hospital' level dimensions and seven 'unit' level dimensions. The dimensions '*handoffs and transitions*' and '*teamwork across units*' are related to a system of different prehospital units, which, for this context, are better understood as 'the prehospital chain'.	No change; we find this acceptable, as the intended 'hospital' level may be understood as 'organizational' level [35], different from the 'local unit' level.
Interpretation of the term 'unit'	To clarify whether the unit should be understood as the local hospital, the local station/base or the working crew.	The term 'unit' was substituted with the term 'local unit', and 'local unit' is explained as 'localized at same geographic place'.
Interpretation of the term 'shift changes' in item H11[a]	The term is related to the in-hospital challenge of transferring responsibility for the patient from one care team to another, which is similar to the transfer of the patient between units in the prehospital chain (e.g. between an ambulance and the hospital).	The term 'shift changes' was substituted with 'patient handover'.
Interpretation of idioms in items A14[a], C3[a] and H3[a]	It is embedded in prehospital professions to take 'shortcuts' in emergency dispatch situations and work in 'crisis mode' at the action site. Also, the expression 'fall between the cracks' may be difficult to understand in the context of the prehospital chain.	A minor explanation/example was amended to each of the idioms in the questionnaire.
Interpretation of item A5	The item '*staff in this local unit work longer hours than is best for patient care*', is challenging due regulation by the Working Environment Act [65] and not by the EMS management.	No change; the item is trying to capture a facet of the dimension '*staffing*' and its influence on patient safety, independent of practical underlying causes; i.e. the results may indicate a weakness in the regulations.
Interpretation of items A11 and H2	The items A11 '*when one area in this unit gets really busy, others help out*', and H2 '*units in the prehospital chain do not coordinate well with each other*' were both deemed difficult to interpret in a prehospital context. An emergency dispatcher provides and coordinates the assignments for different vehicles, which is not similar to hospital situations where personnel can move and coordinate more freely between units.	No change; this is arguably of little direct relevance for patient safety but relevant for the latent factor '*teamwork within units*'. Emergencies may also exist, where it is possible to offer assistance between vehicles, even if this is not the norm.

Note: [a]The items in full text are found in Table 6

applied: Standardized Root Mean Square Residual (SRMR), Tucker-Lewis Index (TLI), Root Mean Square Error of Approximation (RMSEA) and Comparative Fit Index (CFI). A good fit for RMSEA is a value below 0.5 [48]. Values for TLI and CFI in the 0.90s are generally accepted as guidance values for an acceptable fit, while values above 0.95 reflect a good model fit [48, 49]. It has been suggested to use a two-index strategy by reporting SRMR with one of the fit indices (e.g. CFI or RMSEA), with the guidance criteria CFI > 0.95, SRMR < 0.8 and RMSEA < 0.6 [50]. Guidance values for model fit may prove too strict for complex models with large samples, and the values for TLI and CFI should be reduced accordingly [46]; see Table 2.

Table 2 Guidance values for model fit indices

Indices	m ≥ 30
Standardized Root Mean Square Residual (SRMR)	< .08
Tucker-Lewis Index (TLI)	> .90
Root Mean Square of Approximation (RMSEA)	< .07
Comparative Fit Index (CFI)	> .90

Note: *m* number of items. Based on [46]

Items providing high loadings on a factor would indicate that they converge to a common point, demonstrating convergent validity for a latent construct. All factor loadings should be statistically significant and at least 0.5 or higher (ideally 0.7 or higher) for standardized estimates [46]. It is not desirable to have several loadings at very high levels, and a range of loadings between 0.6 and 0.9 seems reasonable [45].

Discriminant validity means that individual measured items should represent only one latent construct, and the presence of high cross-loadings potentially indicates a lack of discriminant validity. Inter-correlation between the dimensions was examined by Spearman's Rho correlation: 0.0–0.25 little or no relationship; 0.25–0.50 fair degree of relationship; 0.50–0.75 moderate to good relationship; >0.75 very good to excellent relationship [51]. MANOVA (multivariate analysis of variance; Wilks' Lambda) was performed to examine whether the different work characteristics had an overall influence on the overall statistical variance of the HSOPSC dimensions.

To evaluate possible other structures of safety climate dimensions, exploratory factor analysis (EFA) was applied. Varimax rotation was adopted to interpret the factor loadings independently. The latent root criterion (latent root > 1) was applied to identify factors and correlations between measured items [45]. The level for acceptable factor loading was set at ≥ 0.4 [46] and the level for (undesired) cross-loadings at ≥ 0.3. EFA was also forced to extract two factors to examine the grouping of system-level and unit-level dimensions.

To find evidence for criterion-related validity, associations between the safety climate dimensions and the outcome variables are developed by use of linear regression.

Internal consistency

Cronbach's alpha was estimated for the different factors to determine whether they yielded internal consistency and acceptable alpha coefficients between 0.70 and 0.90 [52]. Alpha coefficients may understate reliability [46], but this is relatively inconsequential for practical applications such as meta-analysis [53].

Confirmatory factor analyses (maximum likelihood) were estimated using AMOS 21.0. The other statistical analyses were performed using SPSS 21.0.

Ethics approval and consent to participate

Approval was obtained from the Norwegian Social Science Data Services (NSD; project number 45723). The Regional Committee for Medical and Health Research West-Norway (REK west) evaluated this project as "not mandatory to submit" (Ref. number 2015/2249). The participants received information regarding the purpose of the study; they were assured that the digital questionnaires were to be treated in confidence and that no participants could be identified in the published material. Their written consent to participate in the study was given at the start of the survey.

Results

Sample characteristics

Individuals participating in the survey totaled 1387 (26% response rate from GEMS and 55% from HEMS; combined, 27% of the total population). The GEMS sample was retrieved from questionnaires conducted in 17 (of 18) health trusts. The sample was considered representative, based on variation in demographic variables, e.g. distribution in professional groups, range in seniority, and geographic location.

For the analyses, only returned questionnaires with all items answered were used. The majority of incomplete questionnaires was discontinued early in the survey, and we evaluated that replacing missing values was not expedient. Excluding responses with missing data (listwise deletion) provided 1154 full responses, consisting of the responses from 1045 GEMS employees and 109 HEMS employees. The sample size coincides with suggested criteria: >200 and at least 10 times the estimated parameters [54].

Of the 1154 respondents, a high number worked directly with patients (98%). As shown in Table 3, the largest professional group was EMTs (47%). Most respondents were from the South-East Regional Health Trust (38%), and the rest were evenly divided among the other three regional health trusts. Respondents were distributed evenly among the other seniority intervals, with a median of at least ten years of seniority.

Descriptive statistics

The mean statistics, standard deviation (SD) and confidence interval (CI) for each of the measurement concepts are presented in Table 4. Among the 1154 respondents, the safety grade was reported as 'excellent'

Table 3 Demographic and professional characteristics of the 1154 employees in the study

Characteristics	*N* (%)
Prehospital domain	
GEMS	1045 (90.6)
HEMS	109 (9.4)
Professional group	
EMT	544 (47.1)
Paramedic	260 (22.5)
Nurse EMT	146 (12.7)
Anesthesiologist	56 (4.9)
Nurse	40 (3.7)
HCM	31 (2.7)
Pilot	25 (2.2)
EMT apprentice	24 (2.1)
Other healthcare	22 (1.9)
Administrative	6 (0.5)
Regional health trust	
North	212 (18.4)
Middle	225 (19.5)
West	280 (24.3)
South-East	436 (37.8)
Other	1 (0.1)
Prehospital seniority	
5 years or less	221 (19.2)
6 to 10 years	285 (24.7)
11 to 15 years	230 (19.9)
16 to 20 years	207 (17.9)
21 years or more	211 (18.3)

Notes: *EMT* emergency medical technician. 'Nurse EMT' represents nurses with authorization as an EMT. 'Nurse' represents nurses without authorization as an EMT. *GEMS* ground emergency medical services, *HEMS* helicopter emergency medical services, *HCM* HEMS crew member

Table 4 Means, standard deviation (SD), 95% confidence interval (CI) and Cronbach's alpha coefficients measured by the HSOPSC

Measurement concepts	Number of items	Mean (SD)	95% CI	Alpha		
				This study	Original[a]	Other N studies[b]
Outcome measures – single item						
Patient safety grade	1	3.59 (.69)	3.55 to 3.63			
Number of events reported (last 12 months)	1	1.87 (.89)	1.82 to 1.92			
Outcome dimensions						
Overall perception of safety	4	3.73 (.76)	3.68 to 3.77	.76	.74	.49-.78
Frequency of error reporting	3	2.82 (.79)	2.77 to 2.86	.80	.84	.75-.83
Stop working in dangerous situations	4	4.06 (.57)	4.02 to 4.09	.77		.63
Safety climate dimensions – unit level						
Manager expectations & actions promoting patient safety	4	3.79 (.81)	3.74 to 3.83	.83	.75	.71-.85
Organizational learning - continuous improvement	3	3.36 (.74)	3.31 to 3.40	.69	.76	.51-.64
Teamwork within units	4	4.03 (.65)	3.99 to 4.07	.78	.83	.74-.77
Communication openness	3	3.54 (.75)	3.49 to 3.58	.75	.72	.61-.68
Feedback and communication about error	3	3.19 (.81)	3.14 to 3.24	.79	.78	.69-.76
Nonpunitive response to error	3	3.44 (.92)	3.38 to 3.49	.81	.79	.60-.67
Staffing	4	3.59 (.75)	3.55 to 3.64	.65	.63	.56-.68
Safety climate dimensions – system level						
Hospital management support for patient safety	3	3.03 (.80)	2.98 to 3.07	.79	.83	.76-.80
Teamwork across units	4	3.64 (.56)	3.61 to 3.68	.64	.80	.65-.73
Handoffs and transitions	4	3.40 (.66)	3.36 to 3.44	.78	.80	.62-.68
Median alpha				.76	.78	.64-.74

Notes The mean score of each of the items belonging to the dimension is calculated, and the mean of these is then taken to give the mean score for the dimension. [a]Retrieved from [43] [b]Norwegian studies: [34, 37, 38, 55]

by 53 (4.6%), 'very good' by 644 (55.8%), 'acceptable' by 389 (33.7%), 'poor' by 63 (5.5%) and 'very poor' by 5 (0.4%). The mean value was observed to be 3.59, where 5 represents 'excellent' and 1 represents 'very poor'. The mean for the ten safety climate dimensions for the HSOPSC ranged from 3.03 to 4.03. The patient safety climate dimensions with highest mean scores, i.e. a higher number of positive answers, were "*teamwork within units*" (4.03) and "*manager expectations & actions promoting patient safety*" (3.79). For the single-item "*number of events reported (last 12 months)*", 460 (39.9%) had filed no reports, 458 (39.7%) had filed 1-2 reports, 177 (15.3%) had filed 3-5 reports, and 59 (5.1%) had filed 6 reports or more. Overall, variance of items was considered adequate.

Internal consistency

Cronbach's alpha coefficients varied from 0.64 (*teamwork across units*) to 0.83 (*manager expectations & actions for promoting patient safety)* for HSOPSC (Table 4). Removing items from the dimensions with alpha value <0.7 proved to provide either no or marginal value increase. Compared with the dimensions of the original HSOPSC (retrieved from [43]), the median coefficients in our study are slightly lower than the original results. The greatest difference from the original is 0.64 vs. 0.80 (*teamwork across units).* Compared to published Norwegian studies [34, 37, 38, 55], a majority of coefficients in the current study are either within or higher than the interval of previous observed results. The dimension "*staffing*" has also been observed with a low coefficient in HSOPSC studies from other countries [43], and our value of 0.65 seems high, relative to these other studies (ranging from 0.44 to 0.65), including the original (0.63). The dimension "*teamwork across units*" had an observed value of 0.64, which is relatively low compared to both the Norwegian studies (0.65-0.73) [34, 37, 38] and those of other countries (0.59-0.80) [43].

Construct validity

CFA was applied to determine the model fit of the HSOPSC. Overall, compared to the guidance values in Table 5, it demonstrates good model fit values.

Factor analyses revealed three items with loadings below 0.5; item H2 (0.41), item A5 (0.43), and item A11 (0.47). The range of the other loading values was 0.56 to 0.87 (Table 6). All the items observed with relative weak factor loading (<0.50) had been pointed out as challenging during the pre-test of the instruments.

Table 5 Model fit

Indices	Guidance values	HSOPSC
Standardized Root Mean Square Residual (SRMR)	< .08	.043
Tucker-Lewis Index (TLI)	> .90	.91
Root Mean Square of Approximation (RMSEA)	< .07 / .05[a]	.043
Comparative Fit Index (CFI)	> .90	.92

Notes: [a]Acceptable / good fit. Guidance values are based on [46, 48]

Although several factor loadings fell below 0.6, none of the factors had more than one value below 0.59. None of the factors had all loadings of high values (>0.80). Following the reasoning that the values should be between 0.6 and 0.9, both versions indicated an overall acceptable convergent validity.

As shown in Table 7, the inter-correlations ranged from 0.18 to 0.68 for the dimensions. Excluding the outcome dimensions, the inter-correlations between the safety climate dimensions ranged from 0.30 to 0.68 (fair to good degree of relationship). No values revealed a very good to excellent relationship between dimensions (>0.75).

In addition, by utilizing MANOVA, a significant Wilk's Lambda ($p < 0.001$) was measured for all different employee characteristics, except for "*seniority in position*" ($p = 0.060$). Overall, acceptable discriminant validity is found.

EFA performed on the 46 items provided eight factors with latent root value greater than 1. The results in full are presented in Additional file 1: Appendix 1. The factors captured 56.2% of the total variance of all the items. The dimensions "*Organizational learning - continuous improvement*", "*Communication openness*", "*Feedback and communication about error*" and three of four items from "*Manager expectations & actions promoting patient safety*" loaded into factor 1. Dimensions "*Teamwork across units*" and "*Handoffs and transitions*" loaded into factor 2, and "*Staffing*" and "*Overall perceptions of safety*" loaded into factor 3. Of 16 cross-loadings (> 0.3), three cross-loadings were greater than 0.4 and also greater than the loading on its primary dimension: items A18 ("*Our procedures and systems are good at preventing errors from happening*"), D6 ("*Staff are afraid to ask questions when something does not seem right*") and A2 ("*We have enough staff to handle the workload*"). Item A18 loaded into factor 1 as specified above, item D6 loaded into factor 4 alongside the dimension "*Nonpunitive response to error*", and item A2 loaded into factor 5 alongside the dimension "*Teamwork within units*". Two items showed overall loading below 0.4; items A11 ("*When one area in this unit gets really busy, others help out*") and C3 ("*Whenever pressure builds up, my manager wants us to work faster, even if it means taking shortcuts*").

EFA was also applied to confirm the second-order two-factor structure for the seven unit-level dimensions and three system-level dimensions. While most dimensions loaded into the designated factor in the postulated model, the dimension "*Hospital management support for patient safety*" loaded into the unit-level factor (loading 0.57), with a cross-loading on the system-level factor (loading 0.39). Of the total variance, 63.4% was captured by these factors. Evidently, we did not find full second-order level factors as in previous published results for HSOPSC [43].

A regression analysis was conducted for each of the outcome variables (Table 8). The safety climate dimensions had an overall positive effect on the outcome variables, except for the "*number of events reported (last 12 months)*", which revealed negative influence from the safety dimensions. In addition, this dimension had low explanatory power, relative to the other outcome dimensions. The dimensions "*nonpunitive response to error*" and "*teamwork across units*" were both significant for only one outcome variable.

Discussion

This study produced two major findings. Firstly, the study provided overall acceptable psychometric properties, i.e. acceptable internal consistencies and construct validity. However, there were a few exceptions related to weak loadings for some items. Secondly, the explanatory power was strong for several of the outcome dimensions; i.e., it offers stronger predictions regarding which safety climate dimensions have an effect on which outcome variables. Based on these two findings, we provide the EMS environment with a suitable instrument for assessing the patient safety climate in prehospital settings – the Prehospital Survey on Patient Safety Culture (PreHSOPSC).

Validity of the PreHSOPSC

The observed Cronbach's alphas were between the recommended limits of 0.70 to 0.90 for all but three dimensions (0.64, 0.65 and 0.69), but only the dimension "*teamwork across units*" had a relatively low alpha value, compared to those of other studies. EFA pointed towards an eight-factor construct, instead of the 13 dimensions that constitute the Norwegian HSOPSC. However,

Table 6 HSOPSC dimensions and items

Dimension / Item		Factor loadings
Manager expectations & actions promoting patient safety		
C1	My manager says a good word when he/she sees a job done according to established patient safety procedures.	.80
C2	My manager seriously considers staff suggestions for improving patient safety.	.87
C3	Whenever pressure builds up, my manager wants us to work faster, even if it means taking shortcuts*. (*Do not follow all procedures, for example, not implement the dual control of drugs prior to administration.)	.57
C4	My local manager overlooks patient safety problems that happen over and over.	.73
Organizational learning - continuous improvement		
A6	We are actively doing things to improve patient safety.	.68
A9	Mistakes have led to positive changes here.	.59
A13	After we make changes to improve patient safety, we evaluate their effectiveness.	.70
Teamwork within units		
A1	People support one another in this local unit.	.82
A3	When a lot of work needs to be done quickly, we work together as a team to get the work done.	.73
A4	In this local unit, people treat each other with respect.	.81
A11	When one area in this unit gets really busy, others help out.	.47
Communication openness		
D2	Staff will freely speak up if they see something that may negatively affect patient care.	.65
D4	Staff feel free to question the decisions or actions of those with more authority.	.78
D6	Staff are afraid to ask questions when something does not seem right.	.72
Feedback and communication about error		
D1	We are given feedback about changes put into place based on event reports.	.66
D3	We are informed about errors that happen in this local unit.	.76
D5	In this local unit, we discuss ways to prevent errors from happening again.	.79
Nonpunitive response to error		
A8	Staff feel like their mistakes are held against them.	.80
A12	When an event is reported, it feels like the person is being written up, not the problem.	.77
A16	Staff worry that mistakes they make are kept in their personnel file.	.71
Staffing		
A2	We have enough staff to handle the workload.	.59
A5	Staff in this local unit work longer hours than is best for patient care.	.43
A7	We use more agency/temporary staff than is best for patient care.	.61
A14	We work in "crisis mode"* trying to do too much, too quickly. (*The experience of workload beyond what should be normal.)	.65
Hospital management support for patient safety		
H1	Hospital management provides a work climate that promotes patient safety.	.78
H8	The actions of hospital management show that patient safety is a top priority.	.84
H9	Hospital management seems interested in patient safety only after an adverse event happens.	.63
Teamwork across units		
H2	Units in the prehospital chain do not coordinate well with each other.	.41
H4	There is good cooperation among units that need to work together.	.64
H6	It is often unpleasant to work with staff from other units in the prehospital chain.	.64
H10	Units in the prehospital chain work well together to provide the best care for patients.	.59

Table 6 HSOPSC dimensions and items *(Continued)*

Dimension / Item		Factor loadings
Handoffs and transitions		
H3	Things "fall between the cracks"* when transferring patients from one unit to another. (*For example, patient information is not transmitted, unclear responsibility for tasks and procedures in patient handover.)	.64
H5	Important patient care information is often lost during shift changes.	.71
H7	Problems often occur in the exchange of information across units in the prehospital chain.	.73
H11	Patient handovers are problematic for patients in the prehospital chain.	.65
Overall perception of safety		
A10	It is just by chance that more serious mistakes don't happen in this local unit.	.72
A15	Patient safety is never sacrificed to get more work done.	.56
A17	We have patient safety problems in this local unit.	.73
A18	Our procedures and systems are good at preventing errors from happening.	.70
Frequency of error reporting		
F1	When a mistake is made, but is caught and corrected before affecting the patient, how often is this reported?	.76
F2	When a mistake is made, but has no potential to harm the patient, how often is this reported?	.75
F3	When a mistake is made that could harm the patient, but does not, how often is this reported?	.75
Stop working in dangerous situations		
A19	I ask my colleagues to stop work when I think the job is being done in a risky manner.	.63
A20	I report dangerous situations when I see them.	.69
B1	My colleagues stop me if I'm working in a dangerous manner.	.79
B2	I stop working if I think it can be dangerous for me or others to continue.	.57

Note: Dimensions and items based on the original HSOPSC [44], except for the dimension "*Stop working in dangerous situations*", which is based on the Norwegian HSOPSC extension [36] *Idioms expressed by a minor explanation/example in the bracket text following the statements C3, A14 and H3

Table 7 Inter-correlations (Spearman's Rho) of the HSOPSC dimensions

Dimension	1	2	3	4	5	6	7	8	9	10	11	12
1. Overall perception of safety												
2. Frequency of error reporting	.32											
3. Stop working in dangerous situations	.46	.30										
4. Manager expectations & actions promoting patient safety	.59	.31	.43									
5. Organizational learning - continuous improvement	.58	.40	.42	.57								
6. Teamwork within units	.55	.29	.41	.55	.52							
7. Communication openness	.55	.39	.42	.62	.57	.52						
8. Feedback and communication about error	.55	.47	.39	.60	.63	.48	.68					
9. Nonpunitive response to error	.52	.31	.33	.54	.48	.46	.59	.52				
10. Staffing	.59	.26	.29	.52	.44	.51	.46	.45	.52			
11. Hospital management support for patient safety	.51	.32	.30	.50	.51	.39	.45	.50	.41	.41		
12. Teamwork across units	.45	.21	.36	.45	.38	.41	.42	.38	.35	.37	.41	
13. Handoffs and transitions	.43	.18	.29	.38	.30	.32	.33	.29	.33	.34	.40	.59

Note: Correlations are significant at the 0.01 level (2-tailed)

Table 8 Regression analysis testing the concurrent validity of HSOPSC

Safety climate dimensions	Outcome variables				
	Patient safety grade	Number of events reported (last 12 months)	Overall perceptions of safety	Frequency of error reporting	Stop working in dangerous situations
Manager expectations & actions promoting patient safety	.12***	-.17***	.15***		.07*
Organizational learning - continuous improvement	.22***		.22***	.13***	.12***
Teamwork within units	.13***		.10***		.11***
Communication openness				.12**	.13***
Feedback and communication about error	.07*		.06*	.31***	
Nonpunitive response to error	-.05*				
Staffing	.09***	-.13**	.24***		
Hospital management support for patient safety	.11***		.08***	.07*	
Teamwork across units					.11***
Handoffs and transitions	.10***	-.12*	.11***		.06*
Explanatory power (R squared)	.46	.03	.59	.26	.29
F-test	98.2***	4.6***	166.9***	42.2***	48.5***

Note: $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$; empty fields are non-significant ($p > 0.05$)

with a few exceptions, the results indicated acceptable convergent and discriminant validity, and the CFA demonstrated overall good model fit compared to the recommended values. The regression analyses showed that the outcome variables had explanatory power values in the range 0.26 to 0.59 (26-59%), except for the outcome dimension "*Number of events reported (last 12 months)*" at 0.03 (3%). The latter result is consistent with those of other HSOPSC studies [34, 56]. Rather than being a risk indicator for patient safety, this outcome variable serves better as a change measure to monitor the degree of reporting over time [57].

Implications

The HSOPSC instrument was primarily developed by AHRQ for hospitals [32]. Although the HSOPSC is tested for different contexts within the healthcare system, it is not applicable for all contexts in general. Further research should test and validate the instrument for other safety contexts to obtain a generalized instrument for measuring safety climate. An implication followed by the difference between the prehospital and the hospital context is to test the network of relationships between the variables; i.e. the existence of a "nomological network" [45]. Future research should investigate further the existence of such a network, and more evidence for nomological validity should be produced.

Another topic for future research is to take a closer look at the weak items identified by the CFA and the EFA, especially the items pointed out as challenging during the pre-test of the instrument. Still, post hoc modification, by means of e.g. modification indices and standardized residuals [45], should be carried out sparingly and based on theoretical and practical plausibility (e.g. [58]). The use of the HSOPSC instrument in a new context is a challenge in itself, and, instead of performing adjustments and modifications, the development of a new instrument targeted on an EMS context may be a better solution. In particular re-evaluating the position of the prehospital chain in relation to the unit level and hospital level, as indicated by both the lack of evidence of second-order level factors and the relatively low alpha value of the safety dimension "*teamwork across units*", compared to other studies. A disadvantage of developing a new instrument is the lack of opportunity to compare it with other studies.

The dimensionality revealed by the EFA may also prove useful if developing a new instrument. Although testing within the prehospital domain, our results are similar to those of European hospital adaptations of HSOPSC, where the original postulated dimensions were not fully identified. Several studies support the factor combination of "*Teamwork across units*" and "*Handoffs and transitions*" [33, 35, 43, 59]. Other studies found a similar factor combination of the dimensions "*Staffing*" and "*Overall perception of safety*" [33, 39, 54]. The factor combination of dimensions "*Communication openness*", "*Feedback and communication about error*" and "*Organizational learning - continuous improvement*" is similar to the findings of the Swedish version [54] and partly similar to the findings of several other studies [33, 35, 39, 43, 59, 60]. Our findings for the dimension "*Manager expectations & actions promoting patient safety*" added to the factor combination above did not support other European versions (to our knowledge); alongside the other factor combinations, it should be investigated further in future studies.

In adjusting the terminology of the original Norwegian HSOPSC for a prehospital context before performing the survey, the purpose was to perform as few adjustments as necessary and not to change the instrument conceptually. Based on this, the option of answering "unknown/not applicable" was not included for any of the items in the questionnaire. Although such an approach decreases the risk of missing score values for the items, it may increase the risk of missing other valuable data. Some aspects of patient safety may be less relevant for the prehospital domain compared to the hospital domain and, in 'forcing' respondents to provide an answer, there is a risk of not capturing items that either require an amended explanation in the survey or should be considered candidates for modification or removal. AHRQ is developing a new version of the HSOPSC, in which one of the concerns they are focusing on is to add a "does not apply/don't know" response option [61]. Their argument is that respondents do not know how to answer if an item does not apply to them. In such cases, a "does not apply" option is reasonable, and adopting this option in future testing of the Pre-HSOPSC should be considered. However, a "don't know" option may lead respondents to believe that they should objectively know how to respond, which may increase the risk of missing score values. If adding this option, the items of the questionnaire should be worded in such a way that they lead the respondent to answer according to their social-cognitive observation and evaluation of the environment.

A contextual challenge within acute healthcare is related to the outcome dimension "*stop working in dangerous situations*" [35]; employees are expected to continue working in order to e.g. rescue a patient. In general, this may follow three lines in this context, with increased risk for either the patient or the critical care provider/team – or for both. This may arise if the chosen approach to providing critical care is considered riskier, relative to alternative approaches. An example of this is to perform a rescue operation with a line from a helicopter in challenging terrain, due to e.g. elevations or tree height, while a possible option is to carry the patient out to a safer pick-up point. Another example is reckless driving of a car ambulance during an emergency response. A different view may be provided on this challenge; that safety and emergent care are not discordant concepts and EMS quality patient care can be administered in a safe manner [62]. Consequently, the results of this outcome dimension should be evaluated with the purpose of increasing safety for both patients and personnel.

Despite an adequate number of respondents, the response rate was at the lower end of satisfactory. One cause may be related to being distributed only digitally and not on paper. The majority of the email addresses were work email addresses, which may have caused technical difficulties in opening the questionnaires. In addition, if internal communication is not performed by email, a number of respondents may not have opened their email account during the sample period. Due to the scattered geographic nature of the prehospital environment, paper distribution would have been rather difficult to perform, but it would probably have increased the number of respondents. Another attribute in the prehospital environment is the embedded 'fast pace working' culture, and what is perceived as a time-demanding survey may cause the employee to not start or complete the questionnaire. This may explain why the majority of the respondents that did not complete the survey also stopped relatively early in the questionnaire. Another observation that may be related to this culture is the following; before starting the survey, the respondents were asked to provide their consent to participate – and nearly 200 responded negatively to this. Consequently, shorter surveys such as the Norwegian HSOPSC-Short [35] may be preferable. Another aspect of the low number of respondents, in addition to the health region not participating, may also be a cultural link to undesired 'outside' observations or that the survey is not prioritized due to ongoing staffing processes.

The aforementioned new version of HSOPSC (version 2.0) under development by AHRQ is based on some of the same considerations made in this article, e.g. issues regarding the use of idioms, alignment to other contexts, and length of survey [61]. Although the instrument is still mainly developed for hospitals, this article demonstrates the benefit of testing the suggested changes and a new safety climate instrument in the ongoing patient safety climate research in the prehospital domain.

Limitations

There are limitations to the data, which must be borne in mind. Firstly, as previously mentioned, the response rate was low relative to other HSOPSC studies (e.g. [33, 34, 39, 43, 54]). Low response rate may cause non-response bias, i.e. a discrepancy between the employees that responded and the those that did not.

Secondly, the study was limited to the main transport part of the prehospital environment (GEMS and HEMS), thus excluding other parties more or less linked to the prehospital chain (e.g. emergency rooms or emergency medical communications center). Hence, the safety climate for the full prehospital environment is not fully measured.

Thirdly, the instrument has not been tested for predictive validity, i.e. provided evidence of correlation with an external criterion separated in time [45], e.g. reporting of errors, degree of patient compensation, or other patient safety outcomes. Until the instrument has been tested against other external criteria in the prehospital setting, the impact on the EMS safety climate is not fully known.

Conclusion

Conducting safety climate research provides an opportunity to identify and address areas for improving patient safety. Often, an improved safety climate is accomplished through a number of interventions, targeting one or more dimensions at a time [21]. Using surveys to measure the current status is a suggested first step [63, 64]. To our knowledge, this is the first systematic study of patient safety climate in a Norwegian EMS environment by use of the HSOPSC. The HSOPSC has been previously validated for a Norwegian hospital setting, but, as the prehospital context is different, it generates a need to test the instrument for psychometric properties. Both threats to patient safety and new patient safety improvements/interventions require effective validated instruments to evaluate their impact on the prehospital patient safety climate. Hence, it is a satisfactory result of this study to provide the prehospital environment with a validated instrument, the PreHSOPSC, for measuring the prehospital patient safety climate. This is beneficial in the continuous work of improving patient safety, as the application of the PreHSOPSC may both indicate and predict safety behavior and safety-related outcomes.

Additional file

Additional file 1: Exploratory factor analysis of the Norwegian Prehospital Survey of Patient Safety Culture (PreHSOPSC). Rotated component matrix (DOCX 15 kb)

Abbreviations

AHRQ: Agency for Healthcare Research and Quality; CFA: Confirmatory Factor Analysis; CFI: Comparative Fit Index; CI: Confidence Interval; ECTS: European Credit Transfer and Accumulation System; EFA: Exploratory Factor Analysis; EMS: Emergency Medical Services; EMT: Emergency Medical Technician; FW: Fixed Wing; GEMS: Ground Emergency Medical Services; HCM: HEMS Crew Member; HEMS: Helicopter Emergency Medical Services; HSOPSC: Hospital Survey on Patient Safety Culture; MANOVA: Multivariate Analysis of Variance; NORSCI: Norwegian Offshore Risk and Safety Climate Inventory; PreHSOPSC: Prehospital Survey on Patient Safety Culture; RMSEA: Root Mean Square Error of Approximation; SAR: Search and Rescue Services; SD: Standard Deviation; SRMR: Standardized Root Mean Square Residual; TLI: Tucker-Lewis Index

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Availability of data and materials

The data sets generated and analyzed during the current study are not publicly available, as further papers will be written based on the data sets, but are available from the corresponding author on reasonable request.

Authors' contributions

LIKS, EBA, HBA and SJMS conceived of and designed the study. HBA and SJMS have been involved in performing changes to the instrument. LIKS performed the data collection and drafted the manuscript. LIKS performed the data analysis and EO contributed to the interpretation. EBA, HBA and EO contributed to and revised the manuscript critically for intellectual content. All authors read and approved the final draft.

Ethics approval and consent to participate

Approval was obtained from the Norwegian Social Science Data Services (NSD; project number 45723). The Regional Committee for Medical and Health Research West-Norway (REK west) evaluated this project as "not mandatory to submit" (Ref. number 2015/2249). The participants received information regarding the purpose of the study; they were assured that the digital questionnaires were to be treated in confidence and that no participants could be identified in the published material. Their written consent to participate in the study was given at the start of the survey.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Additional file 1: Exploratory factor analysis of the Norwegian Prehospital Survey of Patient Safety Culture (PreHSOPSC).

Rotated component matrix

Dimension	Item	8-factor solution							
		1	2	3	4	5	6	7	8
Manager expectations & actions promoting patient safety	C1	.699							
	C2	.709							
	C3			.362	.357				
	C4	.466		.375					
Organizational learning - continuous improvement	A6	.434							
	A9	.475			.314				
	A13	.556							.307
Communication openness	D2	.489							
	D4	.613			.336				
	D6	.452			.556				
Feedback and communication about error	D1	.540						.334	
	D3	.612						.327	
	D5	.646							
Teamwork across units	H2		.407						
	H4		.584						
	H6		.660						
	H10		.424	.352					
Handoffs and transitions	H3		.660						
	H5		.720						
	H7		.726						
	H11		.663						
Staffing	A2			.445		.477			
	A5			.544					
	A7			.420	.398				
	A14			.602	.382				
Overall perception of safety	A10			.528					
	A15			.552					
	A17			.527					
	A18	.417		.411					
Nonpunitive response to error	A8	.311			.680				
	A12				.679				
	A16				.701				
Teamwork within units	A1					.773			
	A3					.745			
	A4					.773			
	A11	.338				.320			
Stop working in dangerous situations	A19						.762		
	A20						.720		
	B1						.626		
	B2						.687		
Frequency of error reporting	F1							.783	
	F2							.773	
	F3							.760	
Hospital management support for patient safety	H1	.335							.653
	H8								.734
	H9								.710

Note: Extraction method: Principal Component Analysis. Rotation method: Varimax with Kaiser Normalization (Latent root). Rotation converged in 8 iterations.

Paper V

Assessing safety climate in prehospital settings: testing psychometric properties of a common structural model in a cross-sectional and prospective study

Authors: Leif Inge K. Sørskår, Espen Olsen, Eirik B. Abrahamsen & Håkon B. Abrahamsen

Submitted for possible publication

Not yet available in Brage, in submission to a journal.

Appendix I

Questionnaire on prehospital patient safety

Norwegian version

Takk for at du tar deg tid til å svare på denne **nasjonale undersøkelsen** fra Universitetet i Stavanger

Undersøkelsen kartlegger **ditt syn** på pasientsikkerhet, uønskede hendelser og hendelsesrapportering i den prehospitale tjenesten der du jobber

Din besvarelse behandles strengt konfidensielt og din identitet vil ikke kunne spores i publiserte resultater. Undersøkelsen vil ta inntil 15 minutter å gjennomføre. Det er mulig å pause besvarelsen, og fortsette på et senere tidspunkt

På vegne av prosjektgruppen
Leif Inge K. Sørskår
Universitetet i Stavanger

Jeg har mottatt informasjon om studien, og er villig til å delta
❑ Ja, jeg vil delta (undersøkelsen fortsetter)
❑ Nei, jeg vil ikke delta

Bakgrunnsinformasjon

Hva er ditt primære arbeidsområde/fagområde? (Ved flere aktuelle primære arbeidsområder/fagområder, velg alternativet som passer best med det du vil svare for)
❑ Ambulansebil
❑ Legebemannet bil/ambulanse
❑ Ambulansebåt
❑ Ambulansehelikopter
❑ Redningshelikopter (SAR)
❑ Ambulansefly
❑ Annet, vennligst spesifiser _____

Generelt om arbeidet og pasientsikkerhet

NB! Aktuell definisjon;
- **"Din lokale enhet"** er definert som den enheten du primært arbeider ved. EKSEMPEL: En ambulansestasjon, prehospital base eller avdeling, eller lignende som er lokalisert på samme geografiske sted.

- En **"uønsket hendelse"** er definert som en utilsiktet hendelse som følge av medisinsk undersøkelse og/eller behandling.

Hvor enig eller uenig er du i følgende uttalelser?

Tenk på din lokale enhet	**Helt uenig**	**Uenig**	**Både/og**	**Enig**	**Helt enig**
I vår lokale enhet støtter vi hverandre	❑	❑	❑	❑	❑
Vi er tilstrekkelig personell til å håndtere arbeidsmengden	❑	❑	❑	❑	❑

Tenk på din lokale enhet	Helt uenig	Uenig	Både/og	Enig	Helt enig
Når det er mange oppgaver som skal gjøres raskt arbeider vi sammen som et team for å løse oppgavene	❑	❑	❑	❑	❑
I vår lokale enhet behandler vi hverandre med respekt	❑	❑	❑	❑	❑
I vår lokale enhet jobber vi lengre vakter enn hva som er best for pasientene	❑	❑	❑	❑	❑
Vi jobber aktivt for å forbedre pasientsikkerheten	❑	❑	❑	❑	❑
Vi bruker flere vikarer enn det som er til det beste for pasientbehandlingen	❑	❑	❑	❑	❑
Ansatte føler at feil blir brukt mot dem	❑	❑	❑	❑	❑
Feil (og uønskede hendelser) er blitt brukt for å få til positive forandringer her	❑	❑	❑	❑	❑
Det er kun en tilfeldighet at det ikke skjer flere alvorlige feil her i denne lokale enheten	❑	❑	❑	❑	❑
Når ett område i enheten er overbelastet hjelper andre i enheten til	❑	❑	❑	❑	❑
Når en uheldig hendelse blir rapportert, føles det som om personen og ikke problemet kommer i sentrum	❑	❑	❑	❑	❑
Når vi har gjennomført endringer for å forbedre pasientsikkerheten, evaluerer vi effekten	❑	❑	❑	❑	❑
Vi arbeider i "krisemodus*" hvor vi forsøker å gjøre for mye, alt for raskt (*Opplevelsen av arbeidsmengde ut over det som burde være normalt)	❑	❑	❑	❑	❑
Pasientsikkerhet blir aldri nedprioritert for å få unna mer arbeid	❑	❑	❑	❑	❑
Ansatte er bekymret for at feilene de gjør blir registrert i deres personalmapper	❑	❑	❑	❑	❑
Vi har problemer med pasientsikkerheten i vår lokale enhet	❑	❑	❑	❑	❑
Våre prosedyrer og systemer fungerer godt for å forhindre uønskede hendelser	❑	❑	❑	❑	❑
Jeg ber mine kollegaer stanse arbeid som jeg mener blir utført på en risikabel måte	❑	❑	❑	❑	❑

Tenk på din lokale enhet	Helt uenig	Uenig	Både/og	Enig	Helt enig
Jeg melder fra dersom jeg ser farlige situasjoner	❑	❑	❑	❑	❑

Om sikkerheten til de ansatte

Hvor enig eller uenig er du i følgende uttalelser?

Tenk på din lokale enhet	Helt uenig	Uenig	Både/og	Enig	Helt enig
Mine kollegaer stopper meg dersom jeg arbeider på en farlig måte	❑	❑	❑	❑	❑
Jeg stopper å arbeide dersom jeg mener at det kan være farlig for meg eller andre å fortsette	❑	❑	❑	❑	❑

Din nærmeste leder

NB! Aktuell definisjon;
- Med uttrykkene **"hos oss"** og **"ledelsen"** refereres fortrinnsvis til den lokale enheten (ambulansestasjon, prehospital base eller avdeling, eller lignende) hvor du arbeider primært, og til lederne i denne enheten.

Hvor enig eller uenig er du i følgende uttalelser om din nærmeste overordnede eller den person som du refererer til?

Tenk på din lokale enhet	Helt uenig	Uenig	Både/og	Enig	Helt enig
Min lokale leder uttrykker seg positivt når han/hun ser arbeidet blir utført i overensstemmelse med våre prosedyrer for å ivareta pasientens sikkerhet	❑	❑	❑	❑	❑
Min lokale leder vurderer personalets forslag om forbedringer av pasientsikkerheten	❑	❑	❑	❑	❑
Når arbeidspresset øker, ønsker vår lokale leder at vi arbeider raskere selv om det kan bety at man må ta "snarveier*" (*Ikke følger alle prosedyrer, eksempelvis ikke gjennomføre dobbeltkontroll av medikamenter før administrering)	❑	❑	❑	❑	❑
Min lokale leder overser problemer med hensyn til pasientenes sikkerhet selv om en hendelse skjer gang på gang	❑	❑	❑	❑	❑

Kommunikasjon

Hvor ofte skjer følgende innenfor ditt arbeidsområde/fagområde?

Tenk på din lokale enhet	**Aldri**	**Sjelden**	**Av og til**	**Ofte**	**Alltid**
Vi får tilbakemeldinger om endringer som blir igangsatt basert på rapporterte uønskede hendelser	❑	❑	❑	❑	❑
Ansatte snakker åpent ut hvis de ser noe som kan påvirke pasientbehandlingen i negativ retning	❑	❑	❑	❑	❑
Vi blir informert om uønskede hendelser som skjer i vår lokale enhet	❑	❑	❑	❑	❑
Ansatte kan fritt stille spørsmål vedrørende beslutninger og handlinger tatt av personer med mer autoritet	❑	❑	❑	❑	❑
I denne lokale enheten diskuterer vi hvordan vi kan forebygge at de samme uønskede hendelsene gjentas	❑	❑	❑	❑	❑
Ansatte er redde for å stille spørsmål når det er noe som virker feil	❑	❑	❑	❑	❑

Vurdering av pasientsikkerheten

Gi en generell vurdering av pasientsikkerheten i din lokale enhet

❑ Fremragende
❑ Meget god
❑ Akseptabel
❑ Dårlig
❑ Meget dårlig

Hyppighet av rapporterte uønskede hendelser

Hvor ofte blir nærhendelser ("near miss") rapportert?

Tenk på din lokale enhet	**Aldri**	**Sjelden**	**Av og til**	**Ofte**	**Alltid**
Hvor ofte blir nærhendelser rapportert - det vil si hendelser som blir oppdaget og avverget så pasienten ikke rekker å bli skadet	❑	❑	❑	❑	❑
Hvor ofte blir feil som på ingen måte kan skade en pasient rapportert?	❑	❑	❑	❑	❑
Hvor ofte blir potensielt skadevoldende feil rapportert - det vil si feil som kunne skade pasienten, men som ikke gjorde det?	❑	❑	❑	❑	❑

Antall uønskede hendelser som blir rapportert

Hvor mange rapporter om uønskede hendelser har du utfylt og videresendt innenfor de seneste 12 månedene?

- ❑ Ingen rapporter
- ❑ 1-2 rapporter
- ❑ 3-5 rapporter
- ❑ 6-10 rapporter
- ❑ 11-20 rapporter
- ❑ 21 rapporter eller flere

Om den prehospitale kjeden

Er du enig eller uenig i følgende uttalelser om den prehospitale kjeden?

Tenk på kjeden som helhet - ambulanse, luftambulanse, AMK, akuttmottak, legevakt etc.	**Helt uenig**	**Uenig**	**Både/og**	**Enig**	**Helt enig**
Sykehusledelsen tilrettelegger for et arbeidsklima som fremmer pasientsikkerheten	❑	❑	❑	❑	❑
Enheter i den prehospitale kjeden er ikke flinke til å koordinere seg med hverandre	❑	❑	❑	❑	❑
Ting "faller mellom stoler*" når pasienter blir overflyttet fra en enhet til en annen (*Eksempelvis pasientinformasjon som ikke overføres, uklart ansvar for oppgaver og rutiner i pasientoverføring)	❑	❑	❑	❑	❑
Samarbeidet fungerer godt mellom enheter som har behov for å jobbe sammen	❑	❑	❑	❑	❑
Informasjon som er viktig i pasientbehandlingen går ofte tapt ved pasientoverlevering	❑	❑	❑	❑	❑
Det er ofte vanskelig å arbeide sammen med personale fra andre enheter i den prehospitale kjeden	❑	❑	❑	❑	❑
Det oppstår ofte problemer i forbindelse med utveksling av informasjon mellom enheter i den prehospitale kjeden	❑	❑	❑	❑	❑
Sykehusledelsens handlinger viser at pasientsikkerheten har topp prioritet	❑	❑	❑	❑	❑

Tenk på kjeden som helhet - ambulanse, luftambulanse, AMK, akuttmottak, legevakt etc.	**Helt uenig**	**Uenig**	**Både/og**	**Enig**	**Helt enig**
Sykehusledelsen virker kun interessert i pasientsikkerhet etter at en uønsket hendelse har skjedd	❑	❑	❑	❑	❑
Enheter i den prehospitale kjeden arbeider godt sammen for å sikre at pasienten får den beste behandlingen	❑	❑	❑	❑	❑
Pasientoverlevering er problematisk for pasientene i den prehospitale kjeden	❑	❑	❑	❑	❑

Opplæring og trening

I hvilken eller hvilke av de prehospitale ferdighetene nedenfor fikk du systematisk opplæring FØR du begynte å jobbe prehospitalt?

	Opplæring	**INGEN opplæring**
Beslutningstaking	❑	❑
Ledelse	❑	❑
Kommunikasjon	❑	❑
Situasjonsbevissthet	❑	❑
Teamarbeid	❑	❑
Mestring av stress	❑	❑
Mestring av tretthet (fatigue)	❑	❑

Hvor mange ganger har du, i løpet av de siste 12 månedene, deltatt på reelle prehospitale oppdrag sammen med en kollega fra samme yrkesgruppe, for erfaringsutveksling?

❑ Ingen
❑ 1-2 ganger
❑ 3-5 ganger
❑ Mer enn 5 ganger

Angi omfanget av teoretisk opplæring du har fått i hver av de prehospitale ferdighetene nedenfor

	0 timer	0-3 timer	3-7 timer	7-14 timer	Mer enn 14 timer
Beslutningstaking	❑	❑	❑	❑	❑
Ledelse	❑	❑	❑	❑	❑
Kommunikasjon	❑	❑	❑	❑	❑
Situasjonsbevissthet	❑	❑	❑	❑	❑
Teamarbeid	❑	❑	❑	❑	❑
Mestring av stress	❑	❑	❑	❑	❑
Mestring av tretthet (fatigue)	❑	❑	❑	❑	❑

Angi omfanget av praktisk opplæring du har fått i hver av de prehospitale ferdighetene nedenfor

	0 timer	0-3 timer	3-7 timer	7-14 timer	Mer enn 14 timer
Beslutningstaking	❑	❑	❑	❑	❑
Ledelse	❑	❑	❑	❑	❑
Kommunikasjon	❑	❑	❑	❑	❑
Situasjonsbevissthet	❑	❑	❑	❑	❑
Teamarbeid	❑	❑	❑	❑	❑
Mestring av stress	❑	❑	❑	❑	❑
Mestring av tretthet (fatigue)	❑	❑	❑	❑	❑

Opplever du, per i dag, noen av dine prehospitale ferdigheter som mangelfulle i forhold til de utfordringene som er påregnelige i jobben prehospitalt?

	Mangelfull	IKKE mangelfull
Beslutningstaking	❑	❑
Ledelse	❑	❑
Kommunikasjon	❑	❑
Situasjonsbevissthet	❑	❑
Teamarbeid	❑	❑
Mestring av stress	❑	❑
Mestring av tretthet (fatigue)	❑	❑

Hvor mange ganger i løpet av 2015 deltok du på tverrfaglig prehospital simuleringstrening der du helt spesifikt fikk trent en eller flere av følgende ferdigheter, sammen med dine naturlige samarbeidspartnere?

	0 ganger	1-2 ganger	3-5 ganger	Mer enn 5 ganger
Beslutningstaking	❑	❑	❑	❑
Ledelse	❑	❑	❑	❑
Kommunikasjon	❑	❑	❑	❑
Situasjonsbevissthet	❑	❑	❑	❑
Teamarbeid	❑	❑	❑	❑
Mestring av stress	❑	❑	❑	❑
Mestring av tretthet (fatigue)	❑	❑	❑	❑

Hvor mange ganger i løpet av 2015 ble følgende av dine prehospitale ferdigheter systematisk observert og evaluert?

	0 ganger	1-2 ganger	3-5 ganger	Mer enn 5 ganger
Beslutningstaking	❑	❑	❑	❑
Ledelse	❑	❑	❑	❑
Kommunikasjon	❑	❑	❑	❑
Situasjonsbevissthet	❑	❑	❑	❑
Teamarbeid	❑	❑	❑	❑
Mestring av stress	❑	❑	❑	❑
Mestring av tretthet (fatigue)	❑	❑	❑	❑

Tilfredsstiller dine prehospitale ferdigheter gjeldende anbefalinger til kompetanse, for din yrkesgruppe, innenfor kategoriene nedenfor?

	Ja	Nei	Vet ikke
Beslutningstaking	❑	❑	❑
Ledelse	❑	❑	❑
Kommunikasjon	❑	❑	❑
Situasjonsbevissthet	❑	❑	❑
Teamarbeid	❑	❑	❑
Mestring av stress	❑	❑	❑
Mestring av tretthet (fatigue)	❑	❑	❑

Har du deltatt i simulering (på basen) med Luftambulansen (i regi av et års lokalt simuleringsprosjekt ledet av lokal luftambulanselege)?

- ❑ Ja
- ❑ Nei

Grader nytten av simuleringsprosjekt sett i relasjon med egen kompetanse

- ❑ 1 (svært liten nytte)
- ❑ 2
- ❑ 3
- ❑ 4
- ❑ 5
- ❑ 7 (svært stor nytte)

Bakgrunnsinformasjon

Hvor er din primære prehospitale enhet geografisk lokalisert?

- ❑ Alta
- ❑ Arendal
- ❑ Banak
- ❑ Bergen
- ❑ Bodø
- ❑ Brønnøysund
- ❑ Dombås
- ❑ Florø
- ❑ Førde
- ❑ Gardermoen
- ❑ Kirkenes
- ❑ Lørenskog
- ❑ Rygge
- ❑ Sola
- ❑ Stavanger
- ❑ Tromsø
- ❑ Trondheim
- ❑ Ørland
- ❑ Ål
- ❑ Ålesund
- ❑ Annet, vennligst spesifiser ______

Hvor er din primære prehospitale enhet geografisk lokalisert?

- ❑ Nordlandssykehuset HF
- ❑ Universitetssykehuset Nord-Norge HF
- ❑ Helgelandssykehuset HF
- ❑ Finnmarkssykehuset HF
- ❑ St. Olavs Hospital HF
- ❑ Helse Nord-Trøndelag HF
- ❑ Helse Møre og Romsdal HF
- ❑ Helse Fonna HF
- ❑ Helse Førde HF
- ❑ Helse Stavanger HF
- ❑ Helse Bergen HF
- ❑ Oslo Universitetssykehus HF
- ❑ Vestre Viken HF
- ❑ Sørlandet sykehus HF
- ❑ Sykehuset Innlandet HF
- ❑ Sykehuset Telemark HF
- ❑ Sykehuset Vestfold HF
- ❑ Sykehuset Østfold HF
- ❑ Annet, vennligst spesifiser ______

Hvilken faggruppe tilhører du? Velg det svaret som best beskriver din stilling

- ❑ Pilot
- ❑ Redningsmann
- ❑ Spesialsykepleier, anestesi
- ❑ Spesialsykepleier, intensiv
- ❑ Sykepleier
- ❑ Lege i spesialisering, anestesiologi
- ❑ Lege, spesialist i anestesiologi
- ❑ Ambulansearbeider
- ❑ Paramedic
- ❑ Systemoperatør
- ❑ Maskinist
- ❑ Annet, vennligst spesifiser ______

Hvilken faggruppe tilhører du? Velg det svaret som best beskriver din stilling

- ❑ Fagbrev ambulansearbeider
- ❑ Paramedic (fagintern)
- ❑ Paramedic (høyskole)
- ❑ Redningsmann
- ❑ Spesialsykepleier, anestesi (med fagbrev ambulansearbeider)
- ❑ Spesialsykepleier, anestesi (uten fagbrev ambulansearbeider)
- ❑ Spesialsykepleier, intensiv (med fagbrev ambulansearbeider)
- ❑ Spesialsykepleier, intensiv (uten fagbrev ambulansearbeider)
- ❑ Sykepleier (med fagbrev ambulansearbeider)
- ❑ Sykepleier (uten fagbrev ambulansearbeider)
- ❑ Lege i spesialisering, anestesiologi
- ❑ Lege, spesialist i anestesiologi
- ❑ Annet, vennligst spesifiser _____

Er din stilling forbundet med direkte kontakt med pasienter?

- ❑ JA, jeg har direkte kontakt med pasienter
- ❑ NEI, jeg har ikke direkte kontakt med pasienter

Hvor lenge har du arbeidet prehospitalt?

- ❑ Mindre enn 1 år
- ❑ 1 til 5 år
- ❑ 6 til 10 år
- ❑ 11 til 15 år
- ❑ 16 til 20 år
- ❑ 21 år eller mer

Hva er det maksimale antallet timer du rutinemessig har sammenhengende vakt prehospitalt?

- ❑ 7 - 12 timer
- ❑ 13 - 24 timer
- ❑ 25 - 48 timer (1-2 døgn)
- ❑ 49 - 72 timer (2-3 døgn)
- ❑ 73 - 96 timer (3-4 døgn)
- ❑ 97 - 168 timer (4-7 døgn)
- ❑ Over 169 timer (over 7 døgn)

Hva er det maksimale antallet timer du rutinemessig har sammenhengende vakt prehospitalt?

- ❑ Inntil 8 timer
- ❑ 9 - 12 timer
- ❑ 13 - 16 timer
- ❑ 17 - 24 timer (inntil 1 døgn)
- ❑ 25 - 48 timer (inntil 2 døgn)
- ❑ 49 - 72 timer (inntil 3 døgn)
- ❑ Inntil 7 døgn

Hvor lenge har du arbeidet i den stillingen du svarer for i denne undersøkelsen?

- ❑ Mindre enn 1 år
- ❑ 1 til 5 år
- ❑ 6 til 10 år
- ❑ 11 til 15 år
- ❑ 16 til 20 år
- ❑ 21 år eller mer

Dine kommentarer (valgfritt)

Nevn inntil tre av de hyppigst forekommende uønskede hendelser som du har observert eller forårsaket prehospitalt

____
____
____

Nevn inntil tre tiltak som du mener vil kunne bedre pasientsikkerheten prehospitalt

____
____
____

Her kan du fritt skrive dine kommentarer til pasientsikkerhet, feil/uønskede hendelser, rapportering etc.

____
____
____

Takk for din respons!

Appendix II

Questionnaire on prehospital patient safety

English version

Thank you for taking the time to respond to this **national survey** from the University of Stavanger

The survey maps **your opinion** on patient safety, adverse events and incident reporting in your local prehospital service.

Your response will be treated strictly confidentially and your identity will not be traceable in published results. The questionnaire should take approximately 15 minutes to complete. It is possible to pause and continue later.

On behalf of the project group
Leif Inge K. Sørskår
University of Stavanger

I have received information about the study and I am willing to participate
- ❑ Yes, I want to participate
- ❑ No, I do not want to participate

Background information

What is your primary work area? (If more primary work areas, choose the option that best fits what you want to answer)

- ❑ Ground EMS/ambulance
- ❑ Physician manned rapid response car/ambulance
- ❑ Ambulance boat
- ❑ Helicopter emergency medical service (HEMS)
- ❑ Search and rescue helicopter (SAR)
- ❑ Fixed wing air ambulance
- ❑ Other, please specify: _____

Your work area/unit and patient safety

Relevant definitions;
- "**Your local unit**" is defined as the unit where you primarily work. EXAMPLE: An ambulance station, a prehospital base or department or similar located in the same geographical location.

- An "**adverse event**" is defined as an accidental event due to medical examination and/or treatment.

Please indicate your agreement or disagreement with the following statements

Think about your unit	Strongly disagree	Disagree	Neither	Agree	Strongly agree
People support one another in this local unit	❑	❑	❑	❑	❑

Think about your unit	Strongly disagree	Disagree	Neither	Agree	Strongly agree
We have enough staff to handle the workload	❑	❑	❑	❑	❑
When a lot of work needs to be done quickly, we work together as a team to get the work done	❑	❑	❑	❑	❑
In this local unit, people treat each other with respect	❑	❑	❑	❑	❑
Staff in this local unit work longer hours than is best for patient care	❑	❑	❑	❑	❑
We are actively doing things to improve patient safety	❑	❑	❑	❑	❑
We use more agency/temporary staff than is best for patient care	❑	❑	❑	❑	❑
Staff feel like their mistakes are held against them	❑	❑	❑	❑	❑
Mistakes have led to positive changes here	❑	❑	❑	❑	❑
It is just by chance that more serious mistakes don't happen in this local unit.	❑	❑	❑	❑	❑
When one area in this unit gets really busy, others help out	❑	❑	❑	❑	❑
When an event is reported, it feels like the person is being written up, not the problem	❑	❑	❑	❑	❑
After we make changes to improve patient safety, we evaluate their effectiveness	❑	❑	❑	❑	❑
We work in "crisis mode*" trying to do too much, too quickly (*The experience of workload beyond what should be normal)	❑	❑	❑	❑	❑
Patient safety is never sacrificed to get more work done	❑	❑	❑	❑	❑
Staff worry that mistakes they make are kept in their personnel file	❑	❑	❑	❑	❑
We have patient safety problems in this local unit	❑	❑	❑	❑	❑
Our procedures and systems are good at preventing errors from happening	❑	❑	❑	❑	❑
I ask my colleagues to stop work when I think the job is being done in a risky manner	❑	❑	❑	❑	❑
I report dangerous situations when I see them	❑	❑	❑	❑	❑

Safety of employees

Please indicate your agreement or disagreement with the following statements

Think about your unit	Strongly disagree	Disagree	Neither	Agree	Strongly agree
My colleagues stop me if I'm working in a dangerous manner	❑	❑	❑	❑	❑
I stop working if I think it can be dangerous for me or others to continue	❑	❑	❑	❑	❑

Your supervisor/manager

Relevant definition;
- The terms "**with us**" and "**management**" refer to the local unit where you primarily work, and to the management in this unit, respectively. An ambulance station, a prehospital base or department or similar located in the same geographical location.

Please indicate your agreement or disagreement with the following statements about your immediate supervisor/manager or person to whom you directly report?

Think about your unit	Strongly disagree	Disagree	Neither	Agree	Strongly agree
My manager says a good word when he/she sees a job done according to established patient safety procedures	❑	❑	❑	❑	❑
My manager seriously considers staff suggestions for improving patient safety	❑	❑	❑	❑	❑
Whenever pressure builds up, my manager wants us to work faster, even if it means taking shortcuts* (*Do not follow all procedures, for example, not implement the dual control of drugs prior to administration)	❑	❑	❑	❑	❑
My local supervisor/manager ignores patient-safety problems that happen over and over	❑	❑	❑	❑	❑

Communication

How often do the following things happen in your work area/local unit?

Think about your unit	Never	Rarely	Sometimes	Most of the time	Always
We are given feedback about changes put into place based on event reports	❑	❑	❑	❑	❑
Staff will freely speak up if they see something that may negatively affect patient care	❑	❑	❑	❑	❑

Think about your unit	Never	Rarely	Sometimes	Most of the time	Always
We are informed about errors that happen in this local unit	❑	❑	❑	❑	❑
Staff feel free to question the decisions or actions of those with more authority	❑	❑	❑	❑	❑
In this local unit we discuss ways to prevent errors from happening again	❑	❑	❑	❑	❑
Staff are afraid to ask questions when something does not seem right	❑	❑	❑	❑	❑

Your evaluation of the patient safety

Please give your work area/local unit an overall grade on patient safety

❑ Excellent
❑ Very good
❑ Acceptable
❑ Poor
❑ Very poor

Frequency of events reported

When the following incidents happen, how often are they reported?

Think about your unit	Never	Rarely	Sometimes	Most of the time	Always
When a mistake is made, but is caught and corrected before affecting the patient, how often is this reported?	❑	❑	❑	❑	❑
When a mistake is made, but has no potential to harm the patient, how often is it reported?	❑	❑	❑	❑	❑
When a mistake is made that could harm the patient, but does not, how often is this reported?	❑	❑	❑	❑	❑

Number of events reported

In the past 12 months, how many event reports have you filled out and submitted?

❑ No rapports
❑ 1-2 rapports
❑ 3-5 rapports
❑ 6-10 rapports
❑ 11-20 rapports
❑ 21 rapports or more

The prehospital chain

Please indicate your agreement or disagreement with the following statements

Think about the prehospital chain. (Ground EMS, HEMS dispatch center, emergency department, GP on call etc.)	Strongly disagree	Disagree	Neither	Agree	Strongly agree
Hospital management provides a work climate that promotes patient safety	❑	❑	❑	❑	❑
Units in the prehospital chain do not coordinate well with each other	❑	❑	❑	❑	❑
Things "fall between the cracks*" when transferring patients from one unit to another (*For example, patient information is not transmitted, unclear responsibility for tasks and procedures in patient handover)	❑	❑	❑	❑	❑
There is good cooperation among units that need to work together	❑	❑	❑	❑	❑
Important patient care information is often lost during patient handover	❑	❑	❑	❑	❑
It is often unpleasent to work with staff from other units in the prehospital chain	❑	❑	❑	❑	❑
Problems often occur in the exchange of information across units in the prehospital chain	❑	❑	❑	❑	❑
The actions of hospital management show that patient safety is a top priority	❑	❑	❑	❑	❑
Hospital management seems interested in patient safety only after an adverse event happens	❑	❑	❑	❑	❑
Units in the prehospital chain work well together to provide the best care for patients	❑	❑	❑	❑	❑
Patient handovers are problematic for patients in the prehospital chain	❑	❑	❑	❑	❑

Education and training

Which of the skills below have you received training in BEFORE you started working in the prehospital system?

	Training	NO training
Decision-making	❑	❑
Leadership	❑	❑
Communication	❑	❑
Situation awareness	❑	❑
Teamwork	❑	❑
Managing stress	❑	❑
Coping with fatigue	❑	❑

During the last 12 months, how many times have you observed a colleague at work for exchange of experience?

❑ None
❑ 1-2 times
❑ 3-5 times
❑ More than 5 times

Specify the extent of theoretical training you have been given in each of the prehospital skills below

	0 hour	0-3 hours	3-7 hours	7-14 hours	More than 14 hours
Decision-making	❑	❑	❑	❑	❑
Leadership	❑	❑	❑	❑	❑
Communication	❑	❑	❑	❑	❑
Situation awareness	❑	❑	❑	❑	❑
Teamwork	❑	❑	❑	❑	❑
Managing stress	❑	❑	❑	❑	❑
Coping with fatigue	❑	❑	❑	❑	❑

Specify the extent of practical training you have been given in each of the prehospital skills below

	0 hours	0-3 hours	3-7 hours	7-14 hours	More than 14 hours
Decision-making	❑	❑	❑	❑	❑
Leadership	❑	❑	❑	❑	❑
Communication	❑	❑	❑	❑	❑
Situation awareness	❑	❑	❑	❑	❑
Teamwork	❑	❑	❑	❑	❑
Managing stress	❑	❑	❑	❑	❑
Coping with fatigue	❑	❑	❑	❑	❑

Do you feel that your prehospital skills are deficient related to challenges you have to face in your daily work?

	Deficient	NOT deficient
Decision-making	❑	❑
Leadership	❑	❑
Communication	❑	❑
Situation awareness	❑	❑
Teamwork	❑	❑
Managing stress	❑	❑
Coping with fatigue	❑	❑

How many times during 2015 did you participate in multidisciplinary prehospital simulation-based training of one or more of the skills below, along with your professional partners?

	0 times	1-2 times	3-5 times	More than 5 times
Decision-making	❑	❑	❑	❑
Leadership	❑	❑	❑	❑
Communication	❑	❑	❑	❑
Situation awareness	❑	❑	❑	❑
Teamwork	❑	❑	❑	❑
Managing stress	❑	❑	❑	❑
Coping with fatigue	❑	❑	❑	❑

How many times during 2015 were your prehospital skills systematically observed and evaluated?

	0 times	1-2 times	3-5 times	More than 5 times
Decision-making	❑	❑	❑	❑
Leadership	❑	❑	❑	❑
Communication	❑	❑	❑	❑
Situation awareness	❑	❑	❑	❑
Teamwork	❑	❑	❑	❑
Managing stress	❑	❑	❑	❑
Coping with fatigue	❑	❑	❑	❑

Do your prehospital skills satisfy the skills requirement for your profession

	Yes	No	Do not know
Decision-making	❑	❑	❑
Leadership	❑	❑	❑
Communication	❑	❑	❑
Situation awareness	❑	❑	❑
Teamwork	❑	❑	❑
Managing stress	❑	❑	❑
Coping with fatigue	❑	❑	❑

Have you participated in simulation-based training (on base) with Norwegian HEMS (in line with a year's local simulation project led by a local HEMS physician)?

❑ Yes
❑ No

Rank the utility of the simulation-based training in relation to your own competence

❑ 1 (very low utility)
❑ 2
❑ 3
❑ 4
❑ 5
❑ 7 (very high utility)

Bakgrunnsinformasjon

Where is your primary prehospital unit located?

- ❑ Alta
- ❑ Arendal
- ❑ Banak
- ❑ Bergen
- ❑ Bodø
- ❑ Brønnøysund
- ❑ Dombås
- ❑ Florø
- ❑ Førde
- ❑ Gardermoen
- ❑ Kirkenes
- ❑ Lørenskog
- ❑ Rygge
- ❑ Sola
- ❑ Stavanger
- ❑ Tromsø
- ❑ Trondheim
- ❑ Ørland
- ❑ Ål
- ❑ Ålesund
- ❑ Other, please specify: _____

Where is your primary prehospital unit located?

- ❑ Nordlandssykehuset HF
- ❑ Universitetssykehuset Nord-Norge HF
- ❑ Helgelandssykehuset HF
- ❑ Finnmarkssykehuset HF
- ❑ St. Olavs Hospital HF
- ❑ Helse Nord-Trøndelag HF
- ❑ Helse Møre og Romsdal HF
- ❑ Helse Fonna HF
- ❑ Helse Førde HF
- ❑ Helse Stavanger HF
- ❑ Helse Bergen HF
- ❑ Oslo Universitetssykehus HF
- ❑ Vestre Viken HF
- ❑ Sørlandet sykehus HF
- ❑ Sykehuset Innlandet HF
- ❑ Sykehuset Telemark HF
- ❑ Sykehuset Vestfold HF
- ❑ Sykehuset Østfold HF
- ❑ Other, please specify: _____

What is your staff position? Select one answer that best describes your staff position.

- ❑ Pilot
- ❑ HEMS Crew Member (HCM)
- ❑ Nurse anesthetist
- ❑ Nurse, intensive care
- ❑ Registered nurse
- ❑ Physician in training, anesthesiology
- ❑ Physician, anesthesiologist
- ❑ Emergency medical technician (EMT)
- ❑ Paramedic
- ❑ System operator
- ❑ Engineer
- ❑ Other, please specify: _____

What is your staff position? Select one answer that best describes your staff position.

- ❑ Emergency medical technician (EMT)
- ❑ Paramedic (vocational competence)
- ❑ Paramedic (college degree)
- ❑ HEMS Crew Member (HCM)
- ❑ Nurse anesthetist, EMT
- ❑ Nurse anesthetist
- ❑ Nurse, intensive care, EMT
- ❑ Nurse, intensive care
- ❑ Registered nurse, EMT
- ❑ Registered nurse
- ❑ Physician in training, anesthesiology
- ❑ Physician, anesthesiologist
- ❑ Other, please specify: _____

In your staff position, do you typically have direct interaction or contact with patients?

- ❑ YES, I typically have direct interaction or contact with patients
- ❑ NO, I typically do NOT have direct interaction or contact with patients

How long have you worked in the prehospital system?

- ❑ Less than 1 year
- ❑ 1 to 5 years
- ❑ 6 to 10 years
- ❑ 11 to 15 years
- ❑ 16 to 20 years
- ❑ 21 years or more

How many consecutive hours do your regularly scheduled on-call duty last at most?

- ❑ 7 - 12 hours
- ❑ 13 - 24 hours
- ❑ 25 - 48 hours (1-2 days)
- ❑ 49 - 72 hours (2-3 days)
- ❑ 73 - 96 hours (3-4 days)
- ❑ 97 - 168 hours (4-7 days)
- ❑ More than 169 hours (more than 7 days)

How many consecutive hours do your regularly scheduled on-call duty last at most?

- ❑ Up to 8 hours
- ❑ 9 - 12 hours
- ❑ 13 - 16 hours
- ❑ 17 - 24 hours (Up to 1 day)
- ❑ 25 - 48 hours (Up to 2 days)
- ❑ 49 - 72 hours (Up to 3 days)
- ❑ Up to 7 days

How long have you worked in your current specialty or profession?

- ❑ Less than 1 year
- ❑ 1 to 5 years
- ❑ 6 to 10 years
- ❑ 11 to 15 years
- ❑ 16 to 20 years
- ❑ 21 years or more

Your comments

Name up to three of the most common unwanted events that you have observed or caused in the prehospital environment

____
____
____

Name up to three measures that you think could improve prehospital patient safety

____
____
____

Please feel free to write any comments about patient safety, error, or event-reporting in your prehospital system

____
____
____

Thank you for your response!