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Interhospital transport of critically ill patients in Norway

Taking a chance on behalf of the patient

Thesis for the degree of Philosophiae Doctor (PhD)

Faculty of Medicine
University of Oslo
2023

Series of dissertations submitted to the
Faculty of Medicine, University of Oslo

ISBN 978-82-348-0447-2

Cover: UiO.
Print production: Graphic center, University of Oslo.

Preface

Just three months into my specialisation as an anaesthesiologist I participated in my first interhospital transport of a critically ill patient.

I had been specializing in paediatrics initially but switched to anaesthesiology. The patient was a young child with a tracheostomy and the airway was getting too narrow for him to breathe through, so he was to be transferred to a higher level of care to widen the airway. Because of my “background”, I was trusted with the task.

I was thrilled. I felt ready and confident.

We had to leave at once, so I had no time to check the equipment or read the papers, but this was of course something I could do during transport. The parents were very nice, and we talked all the way, and the child was delivered safely.

Nothing happened.

I had successfully performed my first interhospital transport. This was something. I was inspired to work out of the hospital, and I felt I could handle most challenges in this environment.

Unskilled and unaware.

Taking a chance on behalf of the patient.

After many more transports, this experience led up to my interest in the quality and safety of interhospital transport of critically ill patients and later to my research.

Acknowledgments

This has been a long path, and I would like to express my gratitude to everyone who has generously contributed to my travel, with everything from academic reflections and constructive advice, through sharing of personal experiences, to supportive talks accompanied by coffee. Lots and lots of coffee. I am extremely fortunate to have so many supportive and positive people around me.

First and foremost, I must thank my first main supervisor, Professor emeritus Ulf E. Kongsgaard, who also functioned as my mentor throughout the whole process and contributed comprehensively to all my publications. He continued as supervisor and co-author even after reaching his retirement; thank you for your knowledge and patience. Ulf, you made this possible.

Professor Theresa M. Olasveengen kept up the good work, continuing as my main supervisor in addition to being a co-author and finally led me over the finish line; thank you for your academic approach and efficiency, Theresa.

Senior researcher Fridtjof Heyerdahl joined as a supportive and constructive assistant supervisor. He has contributed massively, not only to my work on the thesis, but as a co-author as well, and especially with his academic and thorough approach to my work; thank you for all your valuable comments and for making me motivated when I needed it the most, Fridtjof.

The first article would never have been published without Anne-Cathrine Braarud`s patience and knowledge. She introduced me to qualitative research and spent hours and hours with me and an infinite number of meaning units; thank you for your stamina, hospitality and commitment, Anne-Cathrine.

With Professor emeritus Olav Røise as co-author, I was introduced to an academic perspective of quality and safety thinking. This changed my scientific approach and became the red line for me throughout the rest of my work; thank you for your inspiration and critical thinking, Olav.

This research is built on the shoulders of ambulance personnel, paramedics, residents, and anaesthesiologist performing these transports every day. I am deeply thankful for your unselfish participation in the studies and by your dedication to patient safety.

Thank you to Astrid Arnesen Hug for your kind help with the data collection and to Trond Thoresen for your impressive ability to extract valuable data.

The Norwegian Air Ambulance Foundation have been supporting me and this project, not only financially, but also by giving me full academic freedom. The proactive and always positive support from Professor Hans Morten Lossius in front, and the always striving and new-thinking foundation as a secure base, have been nothing but inspirational. A very special thanks to Research leader Ingunn Riddervold, who never stopped believing in me; thank you for your motivation and support, Ingunn.

My employers have also made this possible, with Head of Division of Emergencies and Critical Care, Oslo University Hospital, Øyvind Skraastad as one of the initiators of the project and Guro Grindheim as Head of Department at Oslo University Hospital, Rikshospitalet. At 330 SKV Rygge I always met interest and enthusiasm and at Diakonhjemmet, my new employer, Aasmund Godø, has been flexible and understanding all the way. A large thank you to all my supportive colleagues for your reflections and your constructive advices. You have all motivated me at many different levels.

Of all my supporting colleagues and friends, I must thank Per Bredmose, Itai Schalit and Kjell Otto Fremstad especially. You have unconditionally believed in me, supported me, and motivated me with reflections, curiosity, knowledge, kindness, and always friendship. Thank you Per, Itai and Kjell Otto.

My family have been through this as well. My parents, Betti and Tore and my sister, Liv, have always been interested and supportive. Tusen takk for støtten, mamma, pappa og Liven. My children, Fredrik, Sofie and Amanda, and my bonus-children, Philip, Christopher, Tobias, Christine, and Steffen, who have been patient, interested, kind and supportive on an everyday basis. Tusen takk, snille dere.

Most importantly, I want to thank Linn, my wife. It always feels like you are my biggest fan. You believe in me and really want me to succeed. I know you are always there for me. Du og jeg, Linn, du og jeg.

Errata

In paper III there is an error in table 1. The percentage of “non-urgent secondary transports” is reported to be 21 percent, but the correct percentage should be 11.

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1. Thesis summary

1.1 Norsk oppsummering

Bakgrunn
På intensivavdelingene ligger de sykeste pasientene på sykehuset, med kritisk svikt i ett eller flere organsystemer. Noen ganger er disse pasientene så syke at de må flyttes til et høyere behandlingsnivå for ytterligere organstøtte og spesialisert behandling. Når denne behandlingen er igangsatt eller gjennomført tilbakeføres pasienten ofte direkte til intensivavdelingen på sykehuset de tilhører. Disse transportene betegnes som intensivtransport mellom sykehus og utføres daglig i hele Norge. Det finnes ingen nasjonal standard eller nasjonale retningslinjer for denne type transport og det eksisterer ikke noe nasjonalt register for evaluering og kvalitetssikring av intensivtransportene.

Metode og resultater
Vi ønsket å belyse intensivtransport fra intensivavdelingenes, personalets og pasientenes perspektiv, samt fra et kvalitets- og sikkerhetsperspektiv.

Vi begynte med å sende ut et spørreskjema til alle intensivavdelingene i Norge. Der spurte vi hvordan de planla og gjennomførte intensivtransporter og om intensivavdelingene hadde retningslinjer for dette. Vi fant at transportene påvirket sykehusenes beredskap og at de ønsket nasjonale retningslinjer for intensivtransport. Det samme spørreskjemaet sendte vi ut på nytt etter at de andre forskningsprosjektene var gjennomført og fant stort sett uendret resultat, nesten ti år senere.

Ved dybdeintervjuer av representanter fra de forskjellige yrkesgruppene som transporterer intensivpasienter kunne vi utforske deres personlige opplevelser. Mange fortalte at det var forventet at de var med på transportene til tross for at de ikke følte seg kompetente og de formidlet en mangel på, og et et ønske om, opplæring og retningslinjer.

Fra et sikkerhets- og kvalitetsperspektiv registrerte vi egenrapporterte uønskede hendelser under intensivtransporter og fikk deretter en ekspertgruppe til å evaluere disse. Av 294 forskjellige hendelser under 455 transporter ble bare 3 hendelser registrert i helseforetakenes interne avvikssystem. Når uønskede hendelser ikke registreres blir det vanskelig å lære av andres feil og å oppdage systemfeil. Det var uenighet i ekspertgruppen om både alvorlighetsgraden av hendelsene og hvilke hendelser som burde vært rapportert.

Ved å registrere alle gjennomførte intensivtransporter ut av, inn til og mellom alle intensivavdelingene ved Oslo Universitetssykehus i ett år og hente data fra journaler og registre, kunne vi beskrive denne pasientgruppens sykelighet og dødelighet. Vi fant at pasientene som ble intensivtransportert hadde samme grad av sykelighet og dødelighet som de øvrige intensivpasientene i Norge, samtidig som de under transporten ofte hadde mindre tilgjengelige ressurser enn på intensivavdelingene på sykehuset, som er underlagt nasjonale retningslinjer. Dette var spesielt tydelig for tilbakeføringene av de ferdigbehandlede pasientene som virket å være undertriagert, til tross for at man burde ha bedre tid og dermed mulighet for bedre planlegging av transporten.

Konklusjon
Intensivpasienter som transporteres mellom sykehus har samme morbiditet og mortalitet som den øvrige intensivpopulasjonen i Norge. Dette innebærer at de har samme behov for overvåkning, intensivbehandling og eventuell intervensjon under transport som på intensivavdelingen. Vi fant at det skjer mange og til dels alvorlige hendelser under disse transportene uten at dette gir systematisk og erfaringsbasert læring. Helsepersonell kan føle seg tvunget til å delta uten at de har nødvendig erfaring og kompetanse og personalets deltagelse på transportene kan påvirke sykehusets beredskap.

For å øke kvaliteten og sikkerheten for intensivpasientene som transporteres bør det utarbeides konsensusbaserte nasjonale retningslinjer og standarder for intensivtransport og iverksettes systematisk og erfaringsbasert opplæring av personalet.

1.2 English summary

Background
The most severely ill patients, with failure in one or several organ systems and in need of critical care, are treated at the Intensive Care Unit. Sometimes these patients must be transferred to a higher level of intensive care with even more specialised treatment. After completed treatment and stabilisation, these patients are often transferred back to the referring hospital. All these transfers are defined as interhospital transports of critically ill patients and are performed daily throughout Norway. Standards on how to perform anaesthesia and guidelines for in-hospital critical care exist in Norway, but there are no national standards for interhospital transport.

Methods and results
To examine and describe these interhospital transports in Norway, we obtained a triangulated view through questionnaires, in-depth-interviews, registration of incidents, and examination of databases.

Questionnaires were sent to all intensive care units in Norway with queries regarding planning and implementing interhospital transports. The responses disclosed how these transports made an impact on the hospitals` resources. National guidelines regarding management of transport of critically ill patients were frequently requested.

In-depth-interviews of the participating personnel revealed experiences at a personal level. Many had experienced participation in these transport despite limited education and competence, and they were often executed without guidelines.

Two-hundred and ninety-four adverse events were self-reported during 455 interhospital transfers of critically ill patients. Only three of these adverse events were registered in the hospital`s electronic incident reporting system. The expert group set to evaluate the adverse events were inconsistent in the grading of severity and in their assessment of which incidents should have been reported.

The review of all consecutive interhospital transports of critically ill patients to and from all the intensive care units at Oslo University Hospital during one year demonstrated the same morbidity and mortality in the transported group compared to the total intensive care population in Norway. The available medical and technical resources during the transports were most often lower compared to the resources at the intensive care units, typically transfer of patients back to the referring hospital.

Conclusion

Critically ill patients transported between hospitals are comparable to the Norwegian intensive care population regarding morbidity and mortality and should therefore receive the same level of surveillance, critical care, and treatment during transport as in the intensive care unit. During the transports several adverse events occur without leading to systematic and experience-based education and training. The participating personnel may lack necessary experience and competence needed for these transports. The transports may drain the hospital for resources as they are often not performed by designated prehospital personnel.

To increase the quality and safety of interhospital transport of critically ill patients in Norway, consensus based national guidelines and standards should be developed and implemented. The personnel participating in the transports should receive systematic and experience-based education.

2. Selected Abbreviations and Definitions

AED	Automated External Defibrillator
AMIS	Akuttmedisinsk Informasjonssystem (Emergency Medical Communication Centre)
AMK	Akuttmedisinsk Kommunikasjonssentral
ARDS	Acute Respiratory Distress Syndrome
CRRT	Continuous Renal Replacement Therapy
ECMO	Extracorporeal Membrane Oxygenation
EMCC	Emergency Medical Communication Centre
EMD	Emergency Medical Dispatch centre
EMS	Emergency Medical Services
EMT	Emergency Medical Technician
EPJ	Hospital Electronic Patient Journal
ESICM	The European Society of Intensive Care Medicine
HEMS	Helicopter Emergency Medical Service
ICU	Intensive Care Unit
IABP	Intra-Aortic Balloon Pump
IHD	Intermittent Haemodialysis
LABAS	Air Ambulance journal system
MICU	Mobile Intensive Care Unit
MOF	Multi-Organ Failure
NACA	National Advisory Committee for Aeronautics score
NIR	The Norwegian Intensive Care Registry
NIPaR	The Norwegian Intensive Care and Pandemic Registry
NO-gas	Nitric Oxide gas
OUH	Oslo University Hospital
PVO	Personvernombudet (Local Data Protection Officials)
REC	Regional Committees for Medical and Health Research Ethics
ROSC	Return of Spontaneous Circulation
SAPS II	Simplified Acute Physiology Score, version II
SOFA	Sequential Organ Failure Assessment Score
SOP	Standard Operating Procedure

3. List of publications

3.1 Paper I

Eiding H, Kongsgaard UE, Braarud A-C. Interhospital transport of critically ill patients: experiences and challenges, a qualitative study. Scandinavian journal of trauma, resuscitation and emergency medicine. 2019;27(1):27

DOI: 10.1186/s13049-019-0604-8

3.2 Paper II

Eiding H, Røise O, Kongsgaard UE. Potentially Severe Incidents During Interhospital Transport of Critically Ill Patients, Frequently Occurring But Rarely Reported: A Prospective Study. J Patient Saf. 2022;18(1):e315-e9

DOI: 10.1097/pts.0000000000000769

3.3 Paper III

Eiding H, Kongsgaard UE, Olasveengen TM, Heyerdahl F. Interhospital transport of critically ill patients: A prospective observational study of patient and transport characteristics. Acta anaesthesiologica Scandinavica. 2022;66(2):248-55

DOI: 10.1111/aas.14005

4. Introduction

4.1 Background

4.1.1 Patient transport history

Transportation of patients has a long history, starting with horse and carriage on the battlefields during wartime. Archaeological evidence shows people have aided the injured or sick since prehistoric times. Although there were field hospitals for their armies, there was no organization in place for the evacuation of wounded soldiers. The organized transport of patients to where they could be treated safely emerged later, along with a deeper understanding of the needs of patients. There is documentation of patient transport back in history to the 11th century and the Crusades. During the 15th century in Spain, specially constructed wagons (ambulances) for transporting wounded soldiers to mobile army hospitals located close to the battlefield were used, providing immediate care to the wounded (1-3).

The need for patient transportation during wars has led to the development and evolution of civilian patient transport as we now know it (4, 5). Following a train crash in Great Britain in 1952, causing many deaths, the importance of having readily available well-equipped ambulances was highlighted (1, 6). Ambulances were gradually restructured for transport and as mobile hospitals and thus, patient transport by car slowly developed in the 20th century. Larger and better-equipped ambulances were needed to implement new lifesaving techniques such as cardiopulmonary resuscitation, defibrillation, and oxygen delivery (1). In 1966 a “Mobile Coronary Care Unit” staffed with nurses and physicians was started in Belfast, mainly for cardiopulmonary resuscitation (7). Other countries followed from the late 1960s through the 1970s, parallel to the evolving of emergency medical systems and the equipment upgrading of ambulances.

In 1915 the first patient transport by air was performed and the first fixed-wing civilian air ambulance service was established in 1928 in Australia (8). The first transport of a patient by helicopter was in 1944 by a US Army Sikorski YR-4B-helicopter, moving a wounded British soldier from behind enemy lines in Burma (2).

In Norway, the geography and long distances led to a variety of solutions for patient transport (9), with Viggo Widerøe performing the first airborne patient transport in 1932. The physician-staffed helicopter-based patient transport in Norway, the Air Ambulances, was launched in 1978 as a private initiative by physician Jens Moe. In addition, the military-based Search and Rescue helicopters at the 330 Squadron have performed patient transports as secondary assignments since 1973 (10).

In 2004 all the airborne transportation of patients was organized by the Norwegian government as one national service in The National Air Ambulance Services, initially called “Luftambulansetjenesten ANS” and later “Luftambulansetjenesten HF”. This service performs approximately 20 000 transports each year (10). Parallel to this, different solutions for interhospital transports by ground have evolved.

4.1.2 The critically ill patient

With the continuous development of medicine and the surge of possibilities of inpatient treatment, intensive care medicine has changed accordingly. It is now possible to treat extremely sick patients with complex diagnoses.

The expressions critical illness and critical care are widely used but may have different definitions worldwide. In 2022 an international working group reviewed literature and combined this with inputs from more than 100 clinical experts worldwide to propose the following definitions (11):

> Critical illness: "A state of ill health with vital organ dysfunction, a high risk of imminent death if care is not provided and the potential of reversibility".
>
> Critical care: "The identification, monitoring and treatment of patients with critical illness through the initial and sustained support of vital organ functions".

The critically ill patients are usually moved to an Intensive Care Unit. This is a specialised unit within the hospital, treating a selection of the sickest patients in a multidisciplinary modus operandi, with the possibilities of medical and technical support of one or more organ systems (12).

The multidisciplinary approach to these patients is often led by an intensivist or anaesthesiologist in collaboration with other specialists (13), to optimize treatment and organ support. In addition, specialized intensive care nurses are responsible for the continuous and often demanding care and observation of critically ill patients. The observation of these patients is managed through medical, laboratory, and advanced technical equipment, ranging from clinical laboratory testing and radiological investigations to non-invasive and continuous invasive monitoring.

The treatment needed for these patients ranges from observation and nursing care to specialized organ support, such as respiratory and circulatory support, renal replacement therapy, and induced coma. Some patients need to be isolated to avoid contagion of personnel and other patients; others need to be isolated to avoid infections they may not survive due to their condition.

The patient's condition may not only be determined by the degree of one organ failing but often by multi-organ failure (MOF) (12), which increases the morbidity and hence the risk of mortality (14).

To grade the severity of illness it is possible to use different scoring systems based on parameters such as defined organ failure, age, and comorbidity. There are many different validated scoring systems, with Simplified Acute Physiology Score II (SAPS II) (15) and Sequential Organ Failure Assessment (SOFA) (16) being commonly used in Norway for registration and statistics, in addition to the NEWS score (17) for clinical

decisions. It is possible to calculate predicted mortality from these scoring systems which may be used by ICU administrators to justify staffing and funding. At a higher level these scoring systems can be used for benchmarking ICUs, and as such, it is included in the Norwegian Intensive Care Registry established in 1998 (18). If the patient stays at the ICU for more than 24 hours, dies in the ICU, is moved to another ICU within 24 hours, or receives a continuous infusion of vasoactive drugs or ventilatory support, the patient is defined as an ICU patient and is enrolled in the registry. The registry captures patient data and SAPS II scores that may be used to compare different ICU populations and outcomes and assesses measured vs. expected mortalities to promote quality and safety at each ICU (19).

The critically ill patient is resource-demanding regarding equipment, medication, and staff and demands continuous supervision and care. The ICUs at the different hospitals offer different levels of care and different level of available treatment and auxiliary services. After the patient is stabilised or the examinations and treatments are accomplished, the patient may be ready to be discharged from the ICU. The patient is then usually referred to a lower level of care, such as an intermediate ward, or is sometimes transferred to another ICU, according to the degree of illness and further care requirements. The drive for transferring the patient may be motivated by the resources available at the ICU and the need to make room for the next patient in need of critical care (20).

In Norway, most ICUs are led or supported by anaesthesiologists, often with additional education in intensive care medicine, and intensive care is part of the mandatory education of anaesthesiologists (21). Other specialties, such as internal medicine, surgery, and paediatrics are involved to various degrees, depending on local needs and traditions. The standard of care at an ICU in Norway is described in the Norwegian guidelines from 2014 (12).

4.1.3 Interhospital transports of patients

There is a trend towards centralisation in health care in general. One strategy is to reorganise into fewer specialised units, to increase the volumes and thereby increase experience and efficiency (22). Hospitals with high case volume show reduced mortality (23) and better outcome across a wide range of procedures and conditions (24). The associated benefit of centralisation, however, varies greatly (23), as high hospital volume is not necessarily only beneficial (25) and could be challenged.

Within the critically ill patient group, regionalisation is expected to improve outcomes for certain subgroups (24, 26, 27), and regionalisation is an ongoing process in Norway (28-30). This patient group may have complex medical conditions in need of special treatment only offered at tertiary centres, or the technical or medical care may not be available at the patient's location. To facilitate these interhospital patient transports, it is necessary to have a transport system staffed, equipped and available. The transport can be executed either by ground, helicopter, or fixed wing, dependent on patient-, distance- and weather factors. The cost-effectiveness of choosing the correct transport modus in the correct time window for transportation also needs to be taken into consideration (31-33).

The regionalisation corresponds to the intentions of the Norwegian government described in the National Health- and hospital plan for 2016-2019 (34), however, not mentioned in the later health- and hospital plan for 2020-2023 (35). Medical specialties in fields like neonatal intensive care, cancer treatment, and transplantation surgery tend to become increasingly centralised in Norway (30, 36, 37).

To improve patient outcomes, transfer from the hospital department or the initial intensive care unit to a higher level of care is sometimes necessary. This means transportation, first within the hospital (38), then outside the hospital, exposed to the prehospital environment with fewer resources available than inside the hospital. The transport itself may have an impact on the patient's morbidity and even mortality, and there is an association between a longer stay in the ICU and hospital after acute interhospital transfers (39, 40).

After investigation, treatment, and stabilisation at the higher level of care, the patient is transferred back to the referring or local hospital by a return transfer. This is an elective transport, and the receiving hospital is expected to manage further treatment and care and have the capacity for this.

Some hospitals, some transport services, and some countries have guidelines, standard operating procedures (SOPs), and checklists (41) to ensure that all equipment and medication are brought along and that the correct personnel with the right competence is attending to the patient transported. How to perform each transport should ideally be tailored to the patient's condition and not coincidentally to what equipment and personnel are available. The decision and timing of the transport should always be weighed up against the urgency and necessity of the transfer and resources available in- and out-of-hospital to perform the transport.

The different transport modes should be set up with the right medical and technical equipment to meet the standards of intensive care. In addition, there must be a sufficient supply of medical gas and electricity and enough space to perform necessary interventions en route. For more specialised intensive care transports, i.e. patients supported with Intra-Aortic Balloon Pump (IABP) or Extracorporeal Membrane Oxygenation (ECMO) and patients receiving Nitrogen Monoxide gas (NO-gas), there must be additional equipment demanding even more space, electricity, and gas. The equipment needs to be secured during transport to fulfil flight- and vehicle-safety requirements, described in "Krav til godkjenning og bruk av ambulanser og andre helserelaterte kjøretøyer i de akuttmedisinske tjenestene" (42).

The process of transfer can be broken down into the following stages: a) Identify the need to transfer a patient, b) Agreement between referring and accepting hospitals, c) Transfer between care facilities, d) Handover from transfer team to accepting team, e) Return transfer team and equipment to base. Each stage can jeopardize the welfare of the patient as well as the optimal use of health care resources.

4.1.4 Different types of interhospital transports

In general, there are several ways of transporting a patient between hospitals. It can be performed by ambulance, helicopter, aeroplane, or even boat, and sometimes the different transport modes are combined. The safest and most effective transport should ideally be chosen for each patient, considering the patient's condition and possible vulnerability to the prehospital environment, need for care, stability, urgency, and the possible need for interventions.

The types of transports can be described as (43):

1. Primary; from out-of-hospital to in-hospital
2. Secondary, acute; urgent interhospital transfer
3. Secondary, non-acute; non-urgent interhospital transfer
4. Return transfers; repatriation, back to referring or local hospital

Patient transports from out-of-hospital to in-hospital are defined as primary transports and are not considered ICU transports. An example of a primary transport can be a trauma patient brought to the hospital from the site of the accident. Secondary transports are interhospital transfers to a higher level of care, and return transfers are interhospital transfers to a lower level of care, usually to the patient's local hospital. Secondary and return transfers could be either ICU transports or normal transports, depending on the patients' needs (44).

When the patient is admitted to an intensive care unit and then moved to another intensive care unit, independently of treatment given, the transport should be defined as an interhospital transport of a critically ill patient (45). The patient will have the need for surveillance, care, stabilisation, and certain interventions between the hospitals as in the transferring and receiving ICU. In consequence, a critically ill patient at the ICU will be a critically ill patient during the transport as well, independent of transport modus.

The urgency of the interhospital transport of a patient from one hospital to another will depend on the severity of the patient's illness, the pathophysiology, and the need for additional treatment offered at the other hospital. The transport will then be either acute or non-acute and should be carried out accordingly to avoid further deterioration or death.

If a patient's condition demands urgent transport, the risk for the patient to deteriorate between the two hospitals is most likely increased and this should be taken into consideration when personnel and transport modus are selected. The accompanying personnel should be chosen according to the patient's level of care and potential needs. Ideally, the care and medical competence during such transport should be at the same level as at the receiving intensive care unit. As an example, this could be a patient in respiratory or circulatory failure in urgent need of mechanically supported ventilation or circulation such as Extra Corporal Membranous Oxygenation (ECMO).

When the degree of urgency is low, the transport is non-acute, and it should be feasible to perform a planned and safe transport, with the possibility to choose the right transport modus, the right timing for departure, and the right personnel. This may be the stable

patient with transient kidney failure in need of Continuous Renal Replacement Therapy (CRRT) not available at the referring hospital.

A return transfer is a planned transfer from a higher level of care to a lower level of care. This transport will not be acute for the patient but the transport itself can be defined as acute if the ICU urgently needs room for a new patient and the transportation must be executed quickly, this may be called a capacity transfer. The quality and safety in a return transfer should be at a high level with minimal risk to the patient as the patient is not transported for medical reasons but for logistic, resource utility, or economic reasons.

4.1.5 Organisation of ICU transports

Geography
Transport medicine is influenced by geographical characteristics, population densities, and distances between the hospitals.

The Scandinavian countries have solved this differently, with helicopters, aeroplanes, road vehicles, and even boats. One example is Denmark which is a small and flat country with short distances between hospitals. This makes it possible to perform most of the transports by road vehicles, especially the planned and non-acute interhospital transports (46). Despite this, a Helicopter Emergency Medical Service (HEMS) was implemented in Denmark in 2014 (47). This was initially initiated to offer better service to the population living in remote areas such as the islands and is mainly dispatched for emergency medical care and primary transport, in contrast to the challenges of the larger distances in most of rural Scandinavia, demanding an established air-transport system.

Other examples are countries like Canada and Australia, with vast areas of land scarcely populated and with few if any local hospitals. This geography demands transport by air, not just because of the terrain, but also as a consequence of the time-consuming distances (48).

Economic considerations
Interhospital transports are resource-demanding, regarding both in- and out-of-hospital resources. The funding of these transports varies from either public or private funding to a combination of both.

The Scandinavian countries are an example of public funding, where the hospital systems, including interhospital transports, are publicly funded by the government and are mostly free of charge for the patients.

In other countries, like the United States, the transports are privately funded. With private funding, the determinants in decision-making may be influenced by insurance status and hospital ownership, in addition to the medical indications (31, 49, 50).

In the United States, this led to a phenomenon called dumping (51). The private hospitals are financed by insurance and private funding and are dependent on patients paying for treatment. In the 1980s the federal and state funding of hospitals was reduced and public hospitals were undermined financially. This reduction led to a flow of

uninsured patients, or patients incapable of financing care and treatment, to the public hospitals that were forced to receive them. Several incidents of patients receiving delayed care or missing treatment occurred, and the unnecessary transport of unstable critically ill patients was a part of this, probably affecting the outcome (52).To avoid this, the Consolidated Omnibus Budget Reconciliation Act (COBRA) was passed in 1985 requiring all hospitals to examine and provide care and treatment necessary for stabilisation, regardless of the patient's ability to pay (51).

Personnel

When it comes to education level, competence, and number of accompanying personnel, there are substantial differences between countries. The configuration of transport teams may vary within a country as well, often dependent on the patient's need for care and the need for technical knowledge, such as in mechanical circulatory support.

Examples of personnel constellations can be from Sweden, where a Regional Interhospital Critical Care Transport system consists of an anaesthesiologist or emergency physician, specially trained nurses, and an air ambulance nurse (53). Another example is from the USA, where paramedics usually accompany critically ill patients during transports and not physicians (54).

Guidelines and standards

The existence of national guidelines or standards for the transport of critically ill patients varies from country to country. In addition, guidelines may exist at local hospitals or transport services. Some countries, such as USA and the United Kingdom (55, 56), have national procedures or recommendations for the transport of critically ill patients. These guidelines are based on consensus from a broad national board.

4.1.6 General challenges in interhospital transport of critically ill patients

To be able to transport a critically ill patient at the right level of care, the personnel must have the right competence from training and experience in both technical and non-technical skills, demanding systematic education and SOPs (57). What profession or education is best qualified to perform each unique transport is debatable.

Technical challenges

For each transport, the significance of weather, temperature, noise, and vibrations must be weighed against the possible impact on the patient, and the correct transport modus. A favourable dispatch time must be chosen. Battery capacity is a classic challenge for equipment that usually has a continuous power supply in the hospital and when brought out of the hospital is dependent on internal power supply. All the medical equipment and its flaws must be well-known by the personnel. There are mandatory regulations for securing the equipment, often demanding specific brackets, that prohibit moving different stand-alone hospital equipment into ambulances or aircraft. These are some of the technical challenges making experience and competence from inside the hospital not necessarily transferable to the prehospital environment (58). Thorough pre-transport planning should minimize risk and preparedness to solve technical problems along the way is key.

Non-technical challenges

The prehospital environment is a challenge for the personnel as well. The personnel must be able to cope with an ICU patient in addition to the out-of-hospital environment. This may involve stabilisation of the physiology and adjustments to medical treatment prior to departure, such as adding muscle relaxants and adjusting ventilatory settings. During the transport of critically ill patients, it is crucial to maintain treatment at an appropriate level, demanding the right transport modus, equipment, and personnel (48, 59). The Crew Resource Management (CRM) will be challenged by noise, lack of light, and sometimes cooperation with unknown personnel. The personnel are alone, with little or no possibility of extra assistance if needed. The prehospital personnel can always call for good advice and consult expertise at the referring or receiving hospital, but in the end, the decisions and actions are up to the transporting personnel. If the situation or the patient calls for a difficult intervention or there is a physical need for another competent person available, a phone call will not help you. Performing interhospital transport can also be hazardous for the participating personnel. There is an increased risk of accidents with ambulance vehicles and aircraft, especially when a degree of urgency is involved (60). Unexpected incidents and unforeseen complications, both technical and medical may occur (58, 61). The ability to handle unforeseen incidents and expected or even unexpected deterioration of the patient is imperative.

Medical challenges

The necessity and urgency of transport should always be weighed against the risk of transport itself (44). For the referring hospital, it is crucial to initiate the transport at the right time, taking into consideration the potential deterioration of the critically ill patient if the transport is not effectuated or delayed. There will often be a time window where the benefit of transporting the patient outweighs the risk, but this is a difficult assessment, individual to every patient and condition (62). The time of day of the transport is also important (58), knowing that transports performed after hours are associated with increased mortality and readmissions (63).

Organisational challenges

When the transport is performed by a prehospital team, the critically ill patient may occupy resources meant for emergency assignments for a longer period. This period is not solely the transport time from the referring to the receiving hospital but does also include time for stabilisation and preparation prior to the transport and time for delivery and medical report at the receiving hospital. The ideal transport modus may not always be available at the local hospital for the interhospital transport of a critically ill patient. The transport may be busy performing another transport or out of service due to weather conditions, the classic being the rotor-wing not being able to take off due to bad weather, like freezing fog or powerful wind. This is associated with increased mortality (64). The use of a checklist should be integrated into the SOPs, securing the safety of the patient as well as the personnel (5, 59, 65).

4.1.7 Status and challenges in Norway

Political

The health enterprise reform in 2002 changed the ownership of public hospitals in Norway. The ownership of local hospitals changed from the counties to newly established Regional Health Authorities (66). As a consequence, the capacity for i.e. surgery in small local hospitals was reduced (28). A downsizing of local hospitals in the periphery will necessarily lead to an increase in interhospital transports in general.

The number of transports

Interhospital transports between ICUs were for 2015 estimated to be 2700 annually within the South-Eastern Norway Health Authority, where 2/3 were performed by regular ambulances (67). The South-Eastern Norway Regional Health Authority represents approximately half of all inhabitants in Norway, where the other half is divided between the remaining three Regional Health Authorities.

Impact on local hospitals

In Norway, the need for transport may challenge the resources available at the local hospital. Sometimes this can be solved by dispatching a Mobile Intensive Care Unit (MICU) if available. This usually consists of an air ambulance or an ICU ambulance, manned with an EMT or specialised nurse and an anaesthesiologist (68). If this is not available, perhaps due to weather or concurrency conflict, and the transport is urgent, the transport may be performed ad hoc. This means setting up a transport team right there and then at the local hospital with the personnel resources available.

For a small hospital, with maybe just one resident and one consultant available, urgent transport may pose a big challenge. Either one of the physicians must accompany the patient, leaving the hospital with no anaesthesiology backup, or an alternative combination of personnel must perform the transport. Usually, the most experienced consultant will stay at the hospital and the resident will go with the patient. Alternatively, another constellation is chosen, maybe with one or two specialised nurses to accompany the critically ill patient.

Standards and guidelines

There is no consensus-based national standard for interhospital transport of critically ill patients in Norway. However, national regulations for dispatch (69) and national standards for the prehospital personnel (70) do exist. In addition, The Norwegian Society of Anaesthesiology and The Norwegian Society of Intensive Care Nursing have made National Guidelines for Intensive Care, last revised in 2014. These guidelines herald the risk for complications during interhospital transport of critically ill patients and suggest the same level of care and personnel competence during transport as it is in the ICU without further definitions or demands, independent of transport mode. The guidelines suggest that work on national guidelines is in progress (12), but this is not the case so far. A national standard for transporting critically ill patients is warranted and endorsed by the experienced professionals performing these transports in Norway (34).

To ensure a safe and standardised transport adapted to each patient, special training and education of personnel is necessary as well as a systematic approach to identify adverse events (71). With the absence of a national standard in Norway, the personnel performing the transports lack a paramount argument for medical and technical education and training and the hospitals do not have legal incentives to assure the personnel's clinical and transportation competence or experience. Hence, these

transports may be accompanied by the personnel available rather than accompanied by personnel according to the patient's needs.

The various resources and different transportation and personnel available, have made a heterogenous solution for transportation throughout Norway. The competence of the transporting personnel in general ranges from basic health care personnel (e.g. ambulance workers) to experienced anaesthesiologists when the Norwegian Emergency Health Regulations (72) are followed.

Standard Operating Procedures

The equipment for observation and treatment en route should be regulated in local SOPs. In Norway, it is up to each hospital to create its SOPs for interhospital transport of critically ill patients and to create checklists if felt necessary. It is each personnel's responsibility to be able to handle the equipment and the potential deterioration of the patient. In Norway, many hospitals do not have any SOPs or checklists for these transports (Table 1).

At Helsebiblioteket, a funded online service from the Norwegian Institute of Public Health (73), with SOPs, standards, and medical information, a local SOP from Innlandet Hospital Trust was in 2014 lifted to be a national procedure. There was no consensus to make this local SOP a national procedure or standard and it was never revised. This SOP is now deleted from the Helsebiblioteket.

The Emergency Medical Services

The ambulance service in Norway is now a well-developed service under Norwegian legislation (72). The Emergency Medical Services (EMS) resources are dispatched by Emergency Medical Communication Centres (EMCC), called "Akuttmedisinsk Kommunikasjonssentral" (AMK). The public hospitals are responsible for the organisation of the EMS. According to the Emergency Medicine Regulations, at least one of the two personnel in the ambulance is required to be a licensed Emergency Medical Technician (EMT) in addition to several other requirements (72). To support the ambulance service in time-critical medical emergencies, a system of first responders, usually recruited from the local fire department, is dispatched in the more rural areas of Norway (74).

Luftambulansetjenesten HF

A specialised service, Luftambulansetjenesten HF, performs a large and important part of interhospital transports in Norway. In 2020 this service completed 16500 assignments and around 20% were secondary transports (75). The service consists of helicopters, aeroplanes, and ICU ambulances.

According to the Emergency Medicine Regulations (72), the Air Ambulance helicopter in Norway is to be manned by a physician and an EMT with a bachelor's degree such as Paramedic or Nurse. The Air Ambulance aeroplane must be manned by a nurse with a bachelor's degree or more. This is supplemented with further personnel when needed and the physician is usually a specialist in anaesthesiology or has equivalent education and experience. In addition, the pilot(s) are medically trained as well.

In Norway, anaesthesiologists are often responsible for interhospital transport of the critically ill patient (68). The personnel are checked out and regularly trained in

different advanced medical emergencies and transports, including transports with mechanical organ support. The medical personnel are employed by the Regional Health Authority and the service is based on contracts.

Dispatch
The dispatch of prehospital resources in general is standardised by The Norwegian Index for Medical Emergencies ("Norsk indeks for medisinsk nødhjelp") (76). However, the dispatch of physician-manned transports is not standardised in this dispatch tool (77). It is therefore up to the doctor on call at the local hospital, with or without a local SOP for support, to decide when and how to transport the critically ill patient.

Ideally, the specialised services in Norway are requested and dispatched through local or regional Emergency Medical Dispatch centres (EMDs) and are valuable contributors to performing interhospital transports. At the same time, these services are a limited resource and may have concurrent assignments or weather challenges, resulting in local hospitals being forced to solve the transportation on their own.

Geography
The Norwegian geography with long distances, mountains, islands, scarcely populated areas, and few and small hospitals in many areas is an additional challenge (78). The larger hospitals are placed in the larger cities and are often specialised, some with national functions such as Haukeland Hospital in Bergen with a national burn function and Oslo University Hospital with a national function for transplantations. This may have a direct impact on the available health resources and may indirectly have an impact on the general health (48).

4.2 Research Status

For details of the literature search, see Appendix 12.1 Literature search.

4.2.1 Evolution of the research of intrahospital transports

The research and the following publications regarding interhospital transports of critically ill patients, seem to have a repetitive pattern. In general, this can be divided into steps, describing the evolution of intrahospital transport parallel to and dependent on the considerable technical and medical advancement in patient care and intensive medicine over the last decades.

1. Publications on the basic structure, like how to set up an ambulance for transport and what equipment is possible to use during transport. The publications refer to transportability, demonstrating merely that it is possible to transport critically ill patients and that these transports may be crucial.

2. Experience of adverse events and unstable patients during transports appears and a growing concern is expressed.

3. Suggestions on how to make the transports safer appear. The warrant for guidelines, checklists, and SOPs emerges. Accompanying personnel and

necessary education are discussed. At the same time, new or better equipment is introduced and validated for transport, allowing even more unstable and critically ill patients to be transported.

4. Guidelines, checklists, SOPs, and standards for the transport of critically ill patients are implemented.

5. Evaluations of the guidelines, checklists, SOPs, and standards are performed. At the same time, a persistent concern for the transport of these fragile patients shines through in many publications.

One example is the United Kingdom, where the evolution of interhospital transport of critically ill patients has developed approximately parallel in England, Scotland, Ireland, and Wales, following this pattern.

1. Transportability: In 1968 a Mobile Intensive Care Unit (MICU) is established in Belfast and reports on patients with myocardial infarction surviving transport from out-of-hospital to and between hospitals. (7) In Glasgow a population of critically ill patients transported by ambulance between hospitals is described and found safe with the recommendation of stabilisation and continuing medical treatment en route (79).

   Equipment: In the early 1980s, services in Glasgow (80), Oxford, and Edinburgh (81) describe how to set up a trolley and an ambulance to perform the transport of critically ill patients. Then an intensive care trolley compatible with “all” ambulances is introduced in 1987 (82).

2. Concern: In 1984, after 15 years of interhospital transport experience, hazards due to instability during transport from rural hospitals to more specialised units are described and discussed. Transport by helicopter is described as even more hazardous and time-consuming. The need for standardised care before and during transport is warranted in addition to better communication (83). The outcome of transported critically ill patients is described using longitudinal APACHE-score (84).

3. Personnel and education: Experienced personnel is in 1988 described as better than inexperienced personnel for the transport of critically ill patients and the need for training prior to participation in transports is declared. The anaesthesiologist is stated as the preferred specialty (85), but other professions, such as nurses, are participating (86) and warrant education (87). A course in interhospital transport of critically ill patients for all professions was first held in 1998 (88).

   Safety: The receiving units for the transports in the United Kingdom are not satisfied with the arrangements for transfer and regionalisation of transport services (89) and after an evaluation of transports, dedicated teams are suggested, and the need for standardisation emerges (90). Because of observed deterioration at the referral hospitals, due to transport delays, it is now (1990) heralded that the transport be performed as early as possible (91).

Transportability over long distances is said to be possible, conditioned in qualified personnel and appropriate equipment (92). A survey of transported patients with head injuries found the medical escort to be poor and calls for the implementation of the recommendations of the Royal College of Surgeons and the Association of Anaesthetists (93). In an editorial in Anaesthesia three years later, standards for interhospital transfers are warranted (94).

Equipment: From the beginning of the 1990s, more advanced equipment is introduced and validated, such as ventilators (95), pulse oximetry, and blood pressure-apparatus (96). Sometimes, the equipment is not accepted as adaptable for use in-flight (97).

4. In 1997 the first version of "Guidelines for the transport of the critically ill adult" is published by the Intensive Care Society in London. This is followed by several revisions, the latest in 2019 (98). In addition, guidelines based on reviews (99) and for specific patient groups (100) are available.

5. Despite existing guidelines, evaluations of interhospital transports of critically ill patients in the United Kingdom show another reality. In 2003 the quality of care during transports, with the use of junior staff and inadequate monitoring, is criticised after monitoring transports for a year (101). The centralisation and the following need for interhospital transport of critically ill patients in the United Kingdom are inevitably "driven by the economy of scale, new technologies, corporate mergers, safety, and standard concerns" (26).

4.2.2 Quality and Safety

To address the quality and safety of critical care in the ICU in general, The European Society of Intensive Care Medicine (ESICM) has developed nine indicators, including the availability of a consultant level Intensivist, an adverse event report system, standard handover procedure at discharge and the rate of unplanned endotracheal extubations (102). This is partially adaptable to interhospital transports.

To evaluate the quality of transport, one challenge is to measure the physiological patient parameters, preferably continuously, during the transport (40). This would detect possible patient deterioration and can be combined with changes during transport, such as patient loading, and even adverse events. These measurements should be standardised and made possible to sample, to ensure important information for later research (103).

4.2.3 Standards, Guidelines, and Checklists

A survey of transported patients with head injuries found the medical escort to be poor and called for implementing the recommendations of the Royal College of Surgeons and the Association of Anaesthetists already in 1991 (93). In an editorial in Anaesthesia three years later, standards for interhospital transfers are called for (94). The European Board of Anaesthesiology and the European Society of Anaesthesiology agreed in 2010 to a declaration on patient safety (104). It requires all institutions to support the WHO Safe Surgery Checklist (105) and to contribute to a national incident reporting system.

The surgical safety checklist was found to improve the outcome for surgical patients (105). Introduction of checklists for intrahospital transports of critically ill patients are found by Ash et al to significantly reduce adverse events and physiological derangement (106). The same result should be expected for interhospital transports. By introducing a checklist as a transfer instrument, Malpass et al observed compliance by transporting physicians 90% of the time (107). Berube et al were able to reduce incidents during interhospital transports by introducing a standard-of-care-programme (108). Introducing checklists for interhospital transports improve safety for the critically ill patients in general and for specific transported groups of patients as well (109).

In the United States, The Society of Critical Care Medicine published guidelines for the transport of critically ill patients in 2004 (56), and in Australia and New Zealand in 2015. The European Committee for Standardisation has published standards for Rescue Systems including road ambulances (110), helicopters, and fixed-wing air ambulances (111, 112). These standards have been adopted to corresponding standards in Norway (42). In addition, each country has the responsibility to produce its guidelines for critical care itself. As an example, England published their first version of "Guidelines for the transport of the critically ill adult" in 1997 from the Intensive Care Society in London. This is followed by several revisions, the latest being "Guidance on: The Transfer Of The Critically Ill Adult" in 2019 for the whole of Great Britain (98). There is a variation within the Scandinavian countries, where i.e. Denmark has guidelines, last revised in 2016 (113), while Sweden does not have any specific guidelines for interhospital transport (114, 115). In Norway, there is a national standard for anaesthesiology last updated in 2021 (116), and national guidelines for intensive care from 2014 (12), but no specific national guidelines for interhospital transport of critically ill patients.

In the United Kingdom in 2005 there is a call for specialists to take responsibility for guidelines, training, and equipment to make improvements of, and to avoid adverse events during, critical care transfers (117). One solution for enhancing the quality of transports is to use Specialist Retrieval Teams instead of junior doctors in regular ambulances (118). Further research on the impact of SOPs and checklists on patient outcomes is warranted (119)

In addition to systematic work with standards, guidelines and checklists, the knowledge and experience among personnel performing these transports should be addressed (120).

4.2.4 Education and Training

When untrained residents perform transports of critically ill patients, the transport can become a real challenge, due to lack of necessary experience and education (120). Other professions, such as nurses, are also participating in these transports (86) and warrant education (87). In England, a course in interhospital transport of critically ill patients for all professions was first held in 1998 (88). Now training, education, and directly supervised transfers have to be completed prior to any independent transfers (99).

Learning by simulation has shown to be useful for emergencies in complex critical care, especially when leadership is important (121) and is already implemented within

aviation (122). High-fidelity and in-situ simulation are highlighted as tools for stress coping and adequate Crew Resource Management (CRM) (123, 124).

Ad hoc transports may still not meet the standards of national guidelines, producing avoidable critical incidents during transports, probably due to the personnel's inexperience and lack of training (125). During ad hoc transports, serious adverse events are more likely to appear (118).

5. Aims of the thesis

This thesis aimed to obtain insight into the performance of interhospital transports of critically ill patients in Norway. We wanted to investigate the patient population regarding morbidity and mortality and to get insight into the quality and safety of the transports. In addition, we wanted to investigate the allocation of resources needed for this population and what it is like for the personnel to perform these transports.

5.1 Initial needs assessment (Unpublished survey)

This survey aimed to assess the actuality and necessity for research on the interhospital transport of critically ill patients in Norway. We wanted to address the preparedness for transports and of the personnel, and what solutions were chosen when transports had to be performed unprepared. Furthermore, the survey aimed to determine if there were any warrants for standardisation regarding these transports.

5.2 Aims of paper I

The aim was to obtain knowledge on how interhospital transports were executed and discover challenges and potential improvements. We wanted to collect and analyse the transport experiences from a personal perspective.

5.3 Aims of paper II

The aim was to assess the quality and safety of the transports and to investigate the type and number of self-reported incidents during interhospital transport of critically ill patients. Further, we wanted to analyse to what degree these incidents were reported in the electronic incident reporting system. Secondarily, we wanted to identify potential interventions to prevent a repetition of the incidents.

5.4 Aims of paper III

We wanted to describe the population of intensive care patients transported between hospitals in terms of morbidity and mortality and to describe the different types of transports. We aimed to compare the transport population to the general ICU population in Norway in terms of morbidity and mortality.

5.5 Needs assessment follow-up (Unpublished survey)

The aim was to compare the status of preparedness for interhospital transports from this repeated survey to the status from the first survey. We wanted to recognise if there were any changes during the research period in general and maybe discover a change in the warrant for standardisation of the interhospital transports of critically ill patients in special.

6. Methodology

To obtain a broad description of the transports they were explored from different angles and with different methodologies, thus obtaining a triangulated view (126). The methodology approaches ranged from qualitative interviews, questionnaires, incident registration, and review of records, to database analyses.

6.1 Description of study sites and study setting

All the research was performed in Norway and mainly within the South-Eastern Norway Regional Health Authority.

6.1.1 Needs assessment and follow-up (Unpublished surveys)

At the beginning of the research period, all 43 intensive care units that reported to the Norwegian Intensive Care Registry (NIR) in 2013 were included. This consisted of both local and regional (university) hospitals across Norway, thereby exploring both referring and receiving ICUs.

At the end of the entire research period, in 2022, the same questionnaire was sent out to the same 43 intensive care units that contributed in 2013.

6.1.2 The interviews (Paper I)

This investigation was performed at four different hospitals within the South-Eastern Norway Regional Health Authority. The participating hospitals were Østfold Hospital Trust, Innlandet Hospital Trust, Oslo University Hospital, and Vestfold Hospital Trust. We interviewed personnel with different education and experience, performing interhospital transports of critically ill patients. The interviewees were purposely selected and represented the personnel that typically performed interhospital transports at the different hospitals.

6.1.3 The incident study (Paper II)

We collected adverse event forms from two different ICU transport services. The first service was a newly established road ambulance and the second was a well-established road- and fixed-wing-ambulance service. Both services were physician manned in addition to a specialized nurse or a paramedic. The transports were performed within Oslo University Hospital (OUH), by road ambulance. The incidents were collected for a total of 20 months. One year later we examined the electronic incident reporting system of the South-Eastern Norway Regional Health Authority to obtain the number of reported incidents during the study period. Finally, we initiated an expert group to study and categorize the collected incidents.

6.1.4 The cohort study (Paper III)

We registered all the adult critically ill patients transported into, out of, and within Oslo University Hospital in 2013. We defined patients to be critically ill if they were transported between two intensive care units. Finally, data from The Norwegian Intensive Care Registry, The Norwegian Cause of Death Registry, the hospital Electronic Patient Journal, the Air Ambulance Journal System, and the Emergency Medical Communication Centre database were collated.

6.2 Study designs

To collect data from different perspectives, different study designs were chosen (127).

6.2.1 Needs assessment and follow-up (Unpublished surveys)

To include all Intensive Care Units in Norway, the Norwegian Intensive Care Registry was contacted directly by mail for a list of ICUs reporting patient data to the registry.

A simple questionnaire containing mostly dichotomic response alternatives was constructed (Appendix 12.2 The questionnaire for the local hospitals and Appendix 12.3 The questionnaire for the university hospitals). It was kept short, with two sides of A4, and specific to keep the time impact for the responders low to stimulate the response rate. The questionnaires sent to the local hospitals and the university hospitals were slightly different, hence only the local hospitals were responsible for the transports.

The questions were formulated in an easy-to-understand manner and were a mixture of open and closed questions with the opportunity for personal comments. The questionnaire was created based on the researcher's clinical experience with ICU transports, piloted by colleagues, and edited before the release (128).

As an indication of preparedness for interhospital transports, we asked for SOPs and checklists and for any fixed criteria for what personnel to accompany the patients. We wanted to know what solutions were chosen when transport of a critically ill patient was necessary, but the preferred transport was unavailable. We asked if they had dedicated personnel for the transports and if the personnel were approved for the equipment used during transports, to indicate personnel preparedness and training. In addition, the impact on the local hospital when performing transports ad-hoc was addressed.

We also asked for the warrant of national standardisation of these transports. If a warrant for national standards existed, the research could contribute to an understanding of the need for standardisation of these transports.

We contacted all 43 intensive care units reporting to the Norwegian Intensive Care Register by phone via the person randomly on-call that day. Information on the survey was given and then we asked for the most appropriate representative for the ICU. To qualify as a representative, the person should work in the intensive care unit and be a part of the everyday decision-making process regarding the transfer of critically ill

patients. The suggested person was then contacted by mail with written information about the survey and later contacted by phone. If the representative were unable to answer the questionnaire in due time or evaluated him-/herself as not representative, he/she was asked to point out another representative and this person was then asked to answer. This process was repeated until an appropriate representative was able to answer in due time, like a mix of purposive and convenience non-probability sampling (128).

The questionnaires were sent out through regular postal delivery. The anonymity was kept through the numbering of the ICUs and the reminder was sent out without opening the already received answers to maintain anonymity. In this first round, only one reminder was sent out. This first round resulted in 42 (98%) returned questionnaires.

Nine years later, the same inquiry was repeated for a second round. We used the same questionnaire and the same recruiting approach and included the same ICUs as in the first round, even including some of the same clinicians. A total of three reminders were sent out. This second round of questionnaires was sent out through "Questback", making it easier to maintain anonymity and to send out reminders. The second round resulted in 38 (88%) returned questionnaires.

The answers from both survey rounds were summarized and analysed (129), using IBM SPSS Statistics (IBM Corp.), version 27. We used simple descriptive statistics.

6.2.2 The interviews (Paper I)

To investigate the personnel's experiences of interhospital transports from a personal perspective, a qualitative approach was chosen (130).

Four different hospitals were chosen, each performing interhospital transports with different constellations of crews. This provided insight from participating personnel with a varied amount of experience and different formal and informal background. The number of interviewees was not set in advance, but rather to be decided by the interviewers when saturation was achieved at each site. Some of the interviewees were deliberately selected to ensure information-rich cases. However, some of the interviews were dependent on the "there and then"-availability of the interviewees, resulting in a more random selection and thereby introducing the necessity of a constant comparative method (described in paragraph 2. below).

We performed a systematic text condensation according to Malterud, consisting of four different steps, starting with the sampling of data through interviews (131). For all interviews, the same experienced main interviewer conducted most of the interview and the same assistant interviewer contributed with in-depth questioning and supplementary questions.

1. We performed 20 semi-structured interviews from an interview guide with no set alternative answers (Appendix 12.4 Interview Guide from paper I). The first part of the interview concentrated on the participants' personal experiences and

the second part explored more general topics regarding interhospital transport. If the subjects were not mentioned already, we asked for a description of a correctly performed transport and what made a transport safe to get a description of how interhospital transports should be executed and at the same time discover challenges and potential improvements.

2. A constant comparative method was applied after each interview. This method allows the interviewers to continuously evaluate the degree of saturation after each interview. Saturation is obtained when new information is not likely to be achieved with further interviews. When the two interviewers agreed on achieving saturation, the interviews at that site were terminated.

3. All interviews were then transcribed, from the recorded material, by a person familiar with medical terms.

4. A systematic text condensation, according to Malterud, was then performed. This is a four-step process, where the text from the interviews is analysed. First is the "Birds Eye Perspective", where the interviewers go through all the text and agree on a total impression from the interviews. Second, the forming of "Meaning units" derived from the text is sorted into "Code Groups" (Appendix 12.5 Meaning units from Paper I). The third step is the "Condensation" going "from Code to Meaning". Finally, the "Synthesizing", going from condensation to description and concept.

This ends up in an Analytic text, this time describing the personal and in-depth experience of the interhospital transportation of critically ill patients.

6.2.3 The incidents (Paper II)

A surrogate measure of quality and safety for patient transport can be the number and severity of incidents and adverse events occurring during the interhospital transports of critically ill patients.

To register self-reported incidents during these transports, an incident form was introduced at two different services during an 8- and 12-month long study period to collect an equivalent number of transport forms (Appendix 12.6 Incident form from paper II). The physicians and the accompanying paramedics or nurses were asked to complete the form after each transport and include all incidents they experienced, independent of potential severity.

To create a low threshold to complete, the form was constructed as simple and time-efficient as possible. (132). It consisted of a single A4 sheet with the back side kept blank for more writing space if needed. If no incidents occurred, only four boxes needed to be checked. The form was kept anonymous, and the completed form was placed in a locked container next to the local work desk. The participants didn't need to categorize the incident regarding potential severity or significance for the patient.

During the study periods, it was emphasized, both written and oral, that the research registration was an addition to the existing electronic incident reporting system and not a substitute for obligate formal registration.

In addition to collating the registration forms, we thoroughly searched the hospital's electronic incident reporting system for reported incidents from the sampling periods. This was performed more than one year after the last registered transport to be sure not to miss any registrations.

After the investigation, an expert group was established to evaluate the incidents. The expert group consisted of three representatives, one from each of the other health regions in Norway. They all had clinical experience in interhospital transport of critically ill patients, in developing SOPs for such transports, and in handling reported incidents.

The experts were asked to categorize the incidents according to the instructions in the electronic incident reporting system. If a patient was harmed or potentially harmed, the incident should be registered. The experts were asked to give their opinion of harm or potential harm for each incident. They were then asked to categorize the consequence or the potential consequence for the patient in each incident in terms of severity; none/insignificant, minor, moderate, significant, or catastrophic/lethal.

In addition, the expert group was asked to evaluate if and how the incident could have been prevented in the future. The suggestions for potential interventions were either Checklists, SOPs, Simulation-training, or Education. The incidents were also possible to categorise as Unavoidable. In addition, they were able to comment on each incident (Appendix 12.7 Instructions for the expert panel). From the expert evaluation we were able to compare the number of expected reported incidents with the number of de facto reported incidents.

6.2.4 The cohort (Paper III)

To obtain an overview of the actual ICU-patient population transported between hospitals, we defined these transports to be the transfer of a patient from one ICU to another, with the assumption that these patients are critically ill also during the transports.

To collect data from the patients transported between ICUs, into, out of, or within OUH, for a year, all nine ICUs in OUH were contacted by telephone. This was done every weekday for a year and summing up for the weekend every Monday. The social security number was acquired in addition to the exact time and reason for the transfer. This resulted in a database of 821 transports consisting of 788 unique patients.

The social security number was used to identify the medical records from the hospital's electronic patient journal (EPJ). These records were assessed and clinical data, such as diagnosis and ventilatory support, was obtained. The SOFA score was reconstructed and calculated retrospectively from the registered clinical data, thus giving an impression of morbidity.

The time of transportation, combined with the social security number and the ICUs involved, made it possible to retrieve information on the transport from the Emergency Medical Dispatch Centre`s (EMD`s) dispatch database, named Akuttmedisinsk Informasjonssystem (AMIS). This provided data on time measurements and transport modus.

From the combination of data from the telephone survey, AMIS, and the EPJ, we categorized the transports to be either urgent or non-urgent and to be secondary transports or return transfers.

By combining birth date with transport date, and the referring and receiving ICUs, we were able to get detailed transport information from the air ambulance journal system (LABAS). From LABAS, the NACA scores were collected and used as a surrogate for morbidity.

The Norwegian Intensive Care Registry (NIR) provides annual data for the Norwegian ICU population in general. These data are also used to benchmark each ICU regarding quality and patient load. Lately, the register has implemented pandemic data as well and the name is changed to The Norwegian Intensive Care and Pandemic Registry (NIPaR). The patient data are retrieved from each intensive care unit responsible for reporting data to NIR. From NIR, the SAPS II-score for the transported cohort was obtained through the patient's social security number as an indicator of morbidity.

Through the social security number, we were able to retrieve 30-days-, 90-days- and 1-year mortality from the Norwegian Cause of Death Registry.

Data from all the pooled sources was used to describe the morbidity and mortality of the patients being transported and to describe the different types of transports performed. The collated data made it possible to compare the investigated cohort to the ICU population in general.

6.3 Ethics and approval

All studies were conducted in accordance with the Declaration of Helsinki implementing the principles of informed consent, right to withdraw, confidentiality, and privacy (133).

Regional Committees for Medical and Health Research Ethics (REC) are appointed by the Ministry of Education and Research in accordance with the Norwegian law on research ethics and medical research; the Health Research Act (134). The study protocols were either approved by REC or found not to be medical or health service research and then approved by the Local Data Protection Officials; "Personvernombudet" (PVO).

The research protocol for paper I was considered by REC not to be a medical or health research project and was therefore approved by PVO in 2013 (2013/7751). The participants were informed of the study's aims and methods and the right to refuse to participate and to withdraw consent at any time during the study without reprisal. Written consent was obtained from all the participants.

The research protocol for paper II was found by REC not to be medical and health service research and was then approved by the PVO in 2013 (2013/12873). The research protocol was then expanded twice with approvals by PVO in 2015 (2016/2625) and 2018 (18/21345). The dataset in paper II was collected by coupling social security numbers and the time of the event. This key was deleted after the retrieval of data from the registries.

The research protocol for paper III was approved by REC in 2013 (2013/457). In 2019 (2103/457) and 2020 (REC ref 21678) additional data collection was approved. The patient cohort in this paper consisted of critically ill and/or comatose patients with a high fraction of mortality, so informed and written consent would be very difficult and often impossible to obtain. Nevertheless, we were allowed to collect data without written consent because the data was deidentified in the process. The cases, represented with a social security number, were converted to numbers to be deidentified and the key was kept separate and then deleted when the data collection was completed and thereby deidentifying the dataset.

The first unpublished survey was found by REC not to be a medical or health research project in 2019 (REC ref 85434) and in 2021 the second unpublished survey and the combination of the results from the first survey were also found to be outside RECś mandate (REC ref 260072). The participants were informed of the study's aims and methods and the right to refuse to participate. By answering the questionnaire, consent was considered implied. All questionnaires were deidentified by being anonymous returns.

7. Summary of results

7.1 Results from the needs assessment survey and the follow-up survey

Preparedness for the transport of critically ill patients

As surrogate measures for preparedness for interhospital transport at the ICUs, we asked for SOPs, checklists, and if the ICUs had criteria for when an anaesthesiologist should accompany the patient.

From the first survey (2013) we found that 26 (62%) of all ICUs did not have any SOPs for the transport of critically ill patients. Of the 26 hospitals without SOPs, 16 hospitals responded that SOPs were warranted. From the second survey (2022), 20 ICUs had no SOPs and out of these, 13 responded that it was still warranted. None of the hospitals without SOPs planned to make them in 2013, whereas two of the hospitals planned to make SOPs in 2022.

In the first survey, 12 of the local hospitals had a checklist that needed to be completed prior to the interhospital transport of critically ill patients. This number was the same in 2022 with checklists used by 12 of the local hospitals.

In 2013, 18 (44%) of the hospitals had fixed criteria for when an anaesthesiologist should accompany the interhospital transport. In 2022 this number increased to 27 (75%).

Table 1: Preparedness for interhospital transport of critically ill patients, results from the needs assessment survey (2013) and the follow-up survey (2022)

Year	2013			2022		
Hospital level	Local	University	All ICUs	Local	University	All ICUs
Total of ICUs reporting to NIR	30	13	43	30	13	43
Number of questionnaire responders	29 (97%)	13 (100%)	42 (98%)	27 (90%)	11 (85%)	38 (88%)
Number of ICUs that have SOPs for interhospital transport of critically ill patients	Yes: 11 (38%) No: 16 (55%) Unknown: 1	Yes: 2 (15%) No: 10 (77%) Unknown: 1	Yes: 13 (31%) No: 26 (62%) Unknown: 2	Yes: 12 (44%) No: 12 (44%) Unknown: 3	Yes: 3 (27%) No: 8 (73%) Unknown: 0	Yes: 15 (39%) No: 20 (53%) Unknown: 3
If missing SOPs: Are SOPs for interhospital transport of critically ill patients warranted?	Yes: 10 (56%) No: 7 (44%) Unknown: 0	Yes: 6 (55%) No: 5 (45%) Unknown: 0	Yes: 16 (62%) No: 12 (46%) Unknown: 0	Yes: 8 (67%) No: 4 (33%) Unknown: 0	Yes: 5 (63%) No: 3 (38%) Unknown: 0	Yes: 13 (65%) No: 7 (35%) Unknown: 0

If missing SOPs but warranted: Are there plans to make SOPs?	Yes: 0 No: 1 (6%) Unknown: 0	Yes: 0 No: 9 (90%) Unknown: 0	Yes: 0 No: 10 (38%) Unknown: 0	Yes: 2 (17%) No: 5 (42%) Unknown: 0	Yes: 0 No: 3 (38%) Unknown: 0	Yes:2 (20%) No: 8 (40%) Unknown: 0
Checklists prior to transport (only local hospitals)	Yes: 12 (41%) No: 16 (55%) Unknown: 0	-	-	Yes: 12 (44%) No: 12 (44%) Unknown: 1	-	-
The ICU have fixed criteria for anaesthesiologist to participate during transports	Yes:12 (41%) No: 16 (55%) Unknown: 0	Yes: 6 (46%) No: 7 (54%) Unknown: 0	Yes: 18 (43%) No: 23 (55%) Unknown: 0	Yes: 17 (63%) No: 8 (30%) Unknown: 0	Yes: 10 (91%) No: 1 (9%) Unknown: 0	Yes: 27(71%) No: 9 (24%) Unknown: 0

Dedicated personnel and training

From the survey in 2013, 15 local hospitals had dedicated personnel (transport teams) for the transport of critically ill patients. In 2022 this number decreased to 8 local hospitals with dedicated personnel.

As a surrogate for the training of personnel, we asked if the participating personnel were checked out regarding equipment used during transports, and in 2013 there were 22 (78%) local hospitals where the participating personnel was checked out, whereas participating personnel at 16 (64%) local hospitals were checked out in 2022.

Local team as a back-up for an external dedicated team

When requested external transport team was not available, but the transport had to be executed, 23 (89%) of the local hospitals solved this ad hoc in 2013 and 18 (75%) in 2022. The ad hoc transports were believed to affect the resources at the local hospitals by draining the personnel resources at 20 local hospitals in both years.

Table 2: Dedicated personnel, training and ad hoc transports at the local hospitals, results from the needs assessment survey (2013) and the follow-up survey (2022)

Year	2013	2022
Hospital level	Local	Local
Total of ICUs reporting to NIR	30	30
Number of questionnaire responders	29(97%)	27(90%)
Do the ICU have personnel dedicated to transport	Yes: 15 (54%) No:13(45) Unknown: 0	Yes: 8 (30%) No: 17 (57%) Unknown: 0

Are the participating personnel checked out regarding equipment used during transports	Yes: 22 (78%) No: 5 (18%) Unknown: 1	Yes: 16 (64%) No: 7 (28%) Unknown: 2
The ICU perform ad hoc transports when the requested transport is not available	Yes: 23 (89%) No: 3 (12%) Unknown: 0	Yes: 18 (75%) No: 6 (25%) Unknown: 0
Can ad-hoc transports drain local personnel resources	Yes: 20 (71%) No: 8 (29%) Unknown: 0	Yes: 20 (91%) No: 1 (5%) Unknown: 0

The need for a National Standard

In 2013, a total of 31 (74%) ICUs reported that a national standard for interhospital transports of critically ill patients was warranted. In 2022 this number decreased to a total of 22 (58%).

Table 3: The need for a National Standard in Norway, results from the needs assessment survey (2013) and the follow-up survey (2022)

Year of survey	2013			2022		
Hospital level	Local	University	Total	Local	University	Total
Total of hospitals reporting to NIR	30	13	43	30	13	43
Number of questionnaire responders	29 (97%)	13 (100%)	42 (98%)	27 (90%)	11 (85%)	38 (88%)
Is there a warrant for a National Standard for the interhospital transports of critically ill patients	Yes: 24 (83%) No: 3 (10%) Unknown: 1	Yes: 7 (54%) No: 2 (15%) Unknown: 4	Yes: 31 (74%) No: 5 (12%) Unknown: 5	Yes: 15 (55%) No: 2 (7%) Unknown: 4	Yes: 7 (64%) No: 1 (9%) Unknown: 2	Yes: 22 (58%) No: 3 (8%) Unknown: 6

7.2 Results from Paper I

Execution of transports

According to the interviewees, a limited number of hospitals had personnel designated for interhospital transports, often resulting in ad hoc solutions for the transport of critically ill patients. The ad hoc transports were believed to drain the hospital`s on-call staff.

When the personnel chosen to perform the transports lacked experience or training, they were offered to call for help by cell phone in transit if needed. This was believed to substitute the medical assistance offered in-hospital and to replace physical assistance and supervision.

The interviewees described the absence of formal checklists to facilitate the preparation of transport, ensure safety en route, and assist in patient hand-over. As an alternative, many participants described relying on a self-made “internal checklist” based on their own experiences and mistakes.

Challenges during transports

Having the responsibility for a critically ill patient out of the hospital was described as stressful. The patient's physiological status may change, minor problems may add up to larger problems, and the patient may deteriorate during transit. An additional challenge outlined was the unreliable, and sometimes even absent, measurements and values provided by the medical equipment during transport This was in great contrast to the in-hospital measurements which were described as reliable.

Interhospital transports were described as more time-consuming than anticipated, with the total time spent often exceeding the transit time by far. Time consumption often resulted from the need for stabilisation and rigging prior to transport, to create margins needed during transport.

Some interviewees expressed concern about critical information being lost during handovers. This could pose a challenge during both the retrieval and the receiving phase of the transport.

In general, adverse events were believed to be underreported, either to avoid uncomfortable situations after reporting colleagues or because the reporting process itself was time-consuming. Only a small number of interviewees shared specific incidents or dramatic adverse events.

Most interviewees described a scarcity, or even lack of, procedures and clinical guidelines in general. This was particularly apparent among inexperienced physicians, who actively sought and enquired about such information from the local ICU or hospital, usually without any success.

Potential improvements for transport

Some of the inexperienced doctors reported transporting critically ill patients early in their careers, despite having little or no experience in intensive care. They described a “learning by doing” approach as the rule, rather than learning from others´ experiences or learning from adverse events. At the beginning of their transport careers, the interviewees seldom or never received supervision, which was suggested as one potential improvement. The general lack of systematic training was described by most and was emphasized as another important area of improvement.

Transport experience from a personal perspective

The participants expressed concern regarding the safety of the transported patients. Furthermore, the participants conveyed feelings of apprehension about being on their own, and at times they felt like a hostage instead of a resource for the patient. They felt obligated to conduct the transports after pressure and anticipation from more experienced colleagues and some characterised this as being held hostage. Some interviewees reported relying on chance or luck to perform successful transports. Two of the interviewees described the transport of critically ill patients felt “safe and easy”.

There was a large degree of self-interest involved in participating in these transports, with participants describing them as entertaining and as a break from the daily in-hospital work. Some described the transports as a means of learning emergency medicine and being forced to develop decision-making skills.

7.3Results from Paper II

Self-reported incidents
A total of 455 interhospital transports were performed by the two different physician-led mobile intensive care units. At least one completed form was registered from 336 of these transports, giving a response rate of 74%. Some of the forms described the same incident and after sorting, 294 unique incidents were identified. At least one incident was reported in 75 (48%) of the 156 transports performed by the newly established road ambulance service and in 146 (49%) of the 299 transports performed by the well-established road- and fixed-wing-ambulance service. In sum, an average of 0,65 unique incidents per transport were registered. From some of the transports, several incidents were reported, with seven different incidents during one transport as the most.

The incidents happened equally distributed with 88 (30%) during patient retrieving at the referral hospital, 103 (35%) during transport, and 103 (35%) under patient handover at the receiving hospital. The incidents consisted of 44 (15%) medical, 49 (17%) missing equipment, 74 (25%) technical, and 123 (42%) administrative, communicative, or personal adverse events.

Registration in the hospital´s electronic incident reporting systems
Of the 294 unique incidents reported during the research period, a total of three incidents were registered in the hospital´s electronic incident report system. In other words, 99% of the self-reported incidents were not registered in the mandatory reporting system.

The expert group
The three experts were highly variable in the evaluation of potential seriousness, with 62-211-266 (21-72-90%) of the events considered insignificant, 14-47-143 (5-16-94%) considered moderately serious and 9-33-86 (3-11-29%) of the events considered serious or catastrophic.

A similar inter-variability appeared when asked if the incident was “unavoidable” n-y 17-53-206 (6-18-71%) and if the incident should have been reported 28-33-250 (10-11-85%).

The experts agreed on checklists, SOPs, and training as possible ways of avoiding the reported incidents in the future.

7.4 Results from Paper III

The patients
We recorded 821 transports of 788 critically ill patients within a year, of which 534 (65%) were males, and the median age was 58. The cohort’s morbidity and mortality

were similar to national averages with a mean SAPS II score of 40 and 30-day mortality of 20 percent compared to national averages SAPS II 40.1 and 30-day mortality 19% for university hospitals. 427 (52%) of the cohort received mechanical ventilation during transport, and 229 (28%) received vasopressor infusion. No patients died during transport in the study group.

We found higher mortality after transport in patients more than 70 years old, with a 30-day mortality of 32%, 90-day mortality of 40%, and 1-year mortality of 47%.

The patients were evenly distributed with medical (45%) and surgical (55%) conditions, with surgical trauma (26%) and return of spontaneous circulation after cardiac arrest (ROSC) (10%) being the largest subgroups.

The transport categories

The transports were categorized as secondary transports in 435 (53%) of the cases and return transfers in 381 (47%) of the cases. The secondary transports were transports to a supplemental or higher level of intensive care and the return transfers were to a lower level of intensive care, mostly the referral hospital. The secondary transports were classified as either urgent or non-urgent. We found 342 (42%) of the transports to be urgent secondary transports and 93 (11%) to be non-urgent secondary transports.

The return transfers were performed mainly after completed treatment for 326 transports (86%), 11 times (3%) due to capacity challenges, and 8 times (2%) following the withdrawal of medical treatment.

Almost half of the recorded transports were performed by designated teams, usually from the Air Ambulance Department, consisting of an anaesthesiologist and a nurse or a specially educated EMT. The patients transported by these teams represent a subgroup with a tendency of a higher degree of morbidity and higher registered mortality compared to the rest of the cohort.

Patients in urgent secondary transports were accompanied by an anaesthesiologist approximately twice as often (61%) as patients in return transfers (35%).

The time spent preparing the patient for transport at the retrieval hospital was roughly the same (about half an hour) for urgent and non-urgent secondary transports and the return transfers. The time consumption may include rigging and stabilisation of the patient and hand-over brief prior to departure.

8. Discussion

8.1 Discussion of results

8.1.1 The needs assessments (A relevance perspective)

At the start of the research period, we wanted to examine the relevance and need for this research project in Norway. We were uncertain of the hospitals' preparedness for transports and if the ICU transfer personnel wanted a standardization of the transport activity. The needs assessment was therefore initiated to guide the direction of the research papers.

Preparedness for the transport of critically ill patients

The first needs assessment survey in our study supported our suspicion of lacking checklists and SOPs. We found that more than half of the ICUs did not have SOPs or checklists. Interestingly, few of these centres planned to make SOPs, checklists, or training programs for the ICU transport activity. The lack of interest or intent to develop and implement local guidelines contrast with a resent expert-opinion-based recommendation from the American College of Critical Care Medicine. This guideline encourages each hospital to have a formalized plan for intra- and interhospital transport that addresses a) pre-transport coordination and communication; b) transport personnel; c) transport equipment; d) monitoring during transport; and e) documentation (56). More recently, a systematic mixed-method review on ICU transports including 15 studies concluded that standardising these transports with education and skills training is important to build safety cultures. (135).

Dedicated personnel and training

Our study showed a decrease in the number of hospitals with dedicated personnel for transports during these nine years, with only one-third of the hospitals reported having dedicated teams in 2022. A specialized mobile ICU transfer unit in the Netherlands showed a decrease in number of adverse events compared to ICU transport by normal ambulances (12.5% vs 34%), indicating a clear safety effect with less risk and enhanced quality by using dedicated teams for ICU transports (136). The same research group also analysed adverse events during MICU transfers, identifying technical problems with the advanced intensive care medical equipment as the main root cause of the adverse events. They highlight the ability for the team to solve those technical problems as a key to reduce risks and avoid adverse events during transport (58).

The decrease in dedicated personnel observed during our 9-year study period is concerning and represents an increased risk for patients in the otherwise improving field of critical care medicine. In a questionnaire-based survey among medical heads of all ICUs in the Netherland, von Lieshout et al found that the level of escorting personnel and type of transport vehicles were considered as the most important factors by intensive care physicians in determining patient transportability, and more important than the severity of illness itself, meaning that with optimal personnel and transport facilities, even severely ill patients are considered safe to transport (137). In Groningen, Netherlands, a specialized mobile ICU transfer unit (MICU) was established in March 2009, and Wiegersma et al showed a decrease in number of adverse events compared to

ICU transport by normal ambulance (12.5% vs 34%), indicating a clear safety effect with less risk and enhanced quality by using dedicated teams for ICU transports (136).

Direction of research

The first needs assessment survey in our study indicated the necessity to investigate the quality and safety of interhospital transports. We had to evaluate the impact on the staff performing the transports and the ICUs affected, and to address the lack of SOPs and education for the transport of critically ill patients. With the second round of the survey, the lack of procedures and education of personnel was still evident, yet fewer respondents called for a national standard for interhospital transport of critically ill patients. The reduced interest in a national standard may be a result of better performance or availability of MICUs, the increase in local SOPs, or the increasing number of ICUs with criteria for the escort by an anaesthesiologist.

8.1.2 The interviews (A personnel perspective)

The scientific literature on interhospital transports has generally focused on the patient perspective, focusing on patients' outcomes and adverse events (138-140). Fewer studies report how the personnel experiences these transports (141-143). From the interviews we obtained a deeper understanding from the performing personnel's perspective and were able to explore possible reasons for adverse events. The contributing professions were EMTs, general nurses, anaesthetists, intensive care nurses, residents, and staff anaesthesiologists. They represented a wide range of experiences and different backgrounds. This is representative of the heterogeneity of the personnel accompanying these patients in Norway (144).

Execution of transports

The lack of experience and training felt by the interviewees is comparable to other services i.e. in Scotland, where Paton et al found that 20% of trainee doctors performed their first transport without any training (145). Some of the residents and ambulance workers in the interviews felt obliged to participate despite feeling not fully qualified and sometimes they even relied on chance to make the transport safe. This corresponds to Cook et al's findings by questionnaire, where 12 out of 31 trainees reported to have been asked to participate in a transport of a critically ill patient without feeling qualified and 4 out of 31 experienced a critical incident during transport (120).

Challenges during transports

Previous quantitative studies have identified common challenges during intrahospital transport, in particular with regards to equipment failure and lack of additional support in the prehospital setting (58) These same themes emerged from the interviews, where more specific training in transfer medicine, as well as rigorous and careful planning to create "margins" prior to transport were described by the most experienced providers as strategies to meet some of these challenges. Risk of information loss during handovers was also highlighted in several of the interviews, This implies that these transports are not only a technical challenge but also represent a need for non-technical skills, corresponding to the findings of Dalto et al, who identified communication errors to significantly cause adverse events in air ambulance services (146).

From Droogh et al and Ligtenberg et al we know that adverse events happen during interhospital transports (58, 147) and we found similarly high numbers of adverse events in The Incident study, discussing this in chapter 8.1.3. Therefore, our expectation prior to the interviews was numerous stories of adverse events and serious incidents to be told. Surprisingly, the participants rarely shared this, and we therefore had to ask directly for this and even then, only sparse episodes were shared.

Potential improvements for transport

A general lack of checklists, SOPs, and guidelines was described by participants. A big concern was the almost complete lack of systematic education, training, and supervision when it came to transports in general and working in the prehospital setting. Combined with a lack of systematic sharing of experience from adverse events, important lessons may be lost (148). The use of standards or guidelines (119, 149) and implemented checklists are said to improve compliance with guidelines (150, 151) and thereby potentially improve patient outcomes. Additionally, the importance of education and training in both technical and nontechnical skills is needed (152).

From the interviews, it was apparent that the organisation and preparedness for these transports were not optimal. In general, standardisation is thought to be an effective means of enhancing the quality of medical procedures (119) and this could be one method of closing the quality gap in transport medicine.

Transport experience from a personal perspective

The interviews gave insight into the personal experience of performing the transports. The participants expressed general concern for the safety of the patients during transport. The feeling of being expected to participate in the transports despite a lack of training is an important memorandum to the organisers of the transports. Similarly, participants feeling like a hostage is a strong warning of a malfunctioning system, taking a chance on behalf of the patients.

In contrast, it was interesting how many of the interviewees expressed a personal interest and even a thrill for these transports. This has not earlier been addressed. Unfortunately, self-interest can be a part of the problem, making the personnel accept participation without proper education and experience and, in that way, accept lower quality care between hospitals than in hospitals.

8.1.3 The incidents (A quality and safety perspective)

As a surrogate for quality and safety during transports (147, 153), we examined the type and number of self-reported incidents occurring during transports at two different services. Compared to earlier research (140, 147, 153, 154), this was a high but not unexpected number. Later research has shown a lower prevalence of adverse events, but with a high risk of bias due to the quality of included studies (155).

The self-reported incidents

The high number of self-reported incidents contrasted with the findings from our interviews, where very few adverse events were mentioned. One explanation could be the provided anonymity for reporting adverse events in the incident study leading to a lower threshold for registration. Another explanation may have been that the type of

incidents reported was not perceived as serious enough to be remembered as a dramatic adverse event by the interviewees. With different professional backgrounds, the attitude and awareness of incidents may vary as well (71).

The same number of incidents were reported during retrieval and delivery as during the transport. This indicates that not only the out-of-hospital transport represents a challenge but all parts of the transport, including the in-hospital part, which correlates well to similar intrahospital transport research (156, 157). The different types and distribution of incidents found in our research correlate to earlier findings with an evenly distributed diversity, from technical to medical (58), indicating the mixed hazards of interhospital transport of critically ill patients (139).

The incident reporting system

To learn from the mistakes of others, and to discover systematic errors, the incidents should be systematically reported and scrutinized (158-160). The almost complete lack of registered incidents, found from our investigation of the electronic incident reporting system, was striking. We found only 1% of the incidents reported, suggesting extensive underreporting, likely lost system learning, and probability of repeated errors. It is mandatory by law to register serious or catastrophic events (161), which was the case in some of the self-reported incidents.

An Incident Reporting System has its limitations and will not be better than the information fed into the system (132). Incidents may be under-reported due to barriers to reporting and experienced lack of meaningfulness for the reporter, thus leading to a safer appearance than reality (158). Another important barrier to reporting incidents is possible sanctions for the individual or their colleges, leading to a culture of under-reporting to avoid sanctions (162, 163).To improve reporting, the electronic incident reporting system should probably be anonymous (159). This would take away the threat of sanctions and avoid the exposure of inexperience or lack of knowledge (158, 163). This is the way it is done in aviation, securing amnesty for mistakes and mishaps in change for learning from mistakes and achieving a safety culture.

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The expert group

The incidents were grouped into categories and severity to compare to earlier findings. In addition, we wanted suggestions for possible interventions to prevent the incidents from happening. To obtain this, an expert group of experienced intrahospital transport experts was carefully chosen as suggested by Langfeldt (164).

The expert group showed surprising divergence in the evaluation of severity of the incidents. This may be a result of different experiences regarding quality and safety improvement culture, even though all three had similar backgrounds. The different services they represented are exposed to different types and numbers of transports and

the personnel can be exposed to a wide range of patient morbidity and urgency throughout their career. The awareness of incidents, incident reporting, and the understanding of the value of learning from incidents will probably vary between services and experts.

8.1.4 The cohort (A patient perspective)

The cohort

In 2014 we registered 821 critically ill patients transported to and from the ICUs at Oslo University Hospital. This number correlated to the 2015-estimate of 2700 yearly interhospital transports of critically ill patients performed within The South-Eastern Norway Regional Health Authority (67), which Oslo University Hospital is a part of.

The patients had high SOFA- (16) and SAPS II-scores (15) indicating high morbidity and high expected mortality. The patients represented a heterogeneous group with both surgical and medical diagnoses, which is comparable to the average ICU population in Norway, which is described as a "case-mix"-population (165).

From the Norwegian Intensive Care Registry, 58% of Norwegian ICU patients received ventilatory support in 2014, which then included postoperative supportive Continuous Positive Airway Support (165). In the cohort, a total of 52% were mechanically ventilated, with 55% of the urgent secondary transported patients receiving mechanical ventilation. The overall 30-day mortality in ICU patients in Norway is 18 to 22% (Personal communication, E A Buanes, PhD, head of the Norwegian Intensive Care Registry) compared to 19% in the cohort.

Patients older than 70 years old, showed higher 30-days, 90-days, and 1-year mortality. The increased mortality may be a consequence of age itself and not transport (166). Nevertheless, this fact should be taken into consideration when considering transports of elderly patients to higher-level ICUs.

In summary, the cohort showed heterogeneity, morbidity, and mortality comparable to the patients in ICUs in Norway (165). This indicates that the transported patients are intensive care patients in the same degree and in need of the same critical care en route as the patients in the ICUs.

The transport categories

We noted that secondary transports performed by air ambulance teams had higher morbidity rates. This may be attributed to a bias in patient selection, as more critical cases necessitate specialized transport teams. However, when air ambulances are unavailable, local hospitals must rely on their own resources, leading to ad hoc solutions that may pose risks to the patient due to economic and organizational constraints.

Return transfers, in contrast, are predictable and should allow for adequate planning. Despite this, they often suffer from systematic under-triage, receiving fewer resources and personnel than needed. Even though these patients still require intensive care, they are frequently transported without an anaesthesiologist, a practice that may unnecessarily increase patient risk (167). This systematic under-triage cannot be

justified by the small number who are transferred back for palliative care or after treatment withdrawal.

Unexpectedly, we found that all categories of transports required the same average preparation time of thirty minutes, regardless of patient stability or urgency. This could indicate that experienced personnel, who handle more critical cases, can prepare patients more quickly, while less experienced staff may need additional time for less critical patients. Nevertheless, any delay in admission or transfer has been linked to increased ICU morbidity and mortality, underscoring the necessity to minimize preparation time (99, 168, 169).

The transported cohort compared to the ICU population
The mortality and morbidity rates of our transported cohort mirrored those of the average patient in Norwegian ICUs. This suggests that transported patients demand the same level of stabilization, surveillance, and sometimes intervention, as those within the hospital (99). Yet, the care outside the hospital is governed by local or ad hoc guidelines rather than the stringent national standards applicable within ICUs, potentially compromising the care for this vulnerable patient population.

8.2 Discussion of methods

The overarching plan was to investigate the transports from different approaches, to obtain a broad impression and understanding. Both quantitative and qualitative approach was chosen to explore and refine the research questions. First by a simple questionnaire, then through interviews. Then, after obtaining a broad understanding of the research questions, a quantitative method was chosen to describe and compare the different types of transports for the final paper. Finally, the questionnaire was repeated.

8.2.1 Methods discussion for the needs assessments and the interviews

The needs assessments
We used a questionnaire to evaluate the actuality of the research. The importance of creating anonymity was paramount as the questionnaire contained questions trying to highlight weaknesses and shortcomings in the organisation of transport. The participants were recruited by asking each ICU to provide a representative that dealt with transports on a weekly basis. The recruitment strategy was meant to help us get a real-world view of how these transports were planned and conducted, still, we cannot be sure that some participants had other agendas, like making the organisation appear better, or worse, than reality.

The questionnaire itself was mostly dichotomic, which made the research summary easier but may have led to missing out on important nuances. Some of the questions contained the possibility to make further remarks, but this was rarely done by the participants. To avoid missing data out of preconception, the survey could have been conducted as focus group interviews. Overall, we thought it was more important to allow for anonymity and ask for information from all the ICUs involved.

The interviews

During the interviews, the participants and the interviewers interacted with each other both verbally and non-verbally. On one side, leading questions and unspoken anticipation from the interviewers may have represented interviewer bias. The interviewees, on the other side, may have been biased in their loyalty to their working place or they may have answered what they believed the interviewers wanted to hear.

The interviewees may not have been representative for the workplace, but by interviewing several participants until believed saturation, this is to a certain extent avoided. We chose not to use focus groups to avoid inter-collegial influence and to avoid possible hierarchic impact amongst the participants.

8.2.2 Methods discussion for the incidents- and the cohort research

The incidents

This investigation was dependent on the participants to report the incidents. To achieve useful data, the participants had to understand the study and the importance of conscientiously reporting the incidents to avoid missing data. The number of registered incidents in the mandatory incident report system indicated that we achieved a good culture of registration. This may be due to our approach, including anonymity, low threshold, time-effectiveness, and convenience during registration, but may also be partly explained by the Hawthorne effect, making the participants more dedicated to reporting during the investigation.

There was unavoidably some degree of underreporting. To address this, all the transports could have been accompanied by an observer, which would have been much more resource demanding. It could have been an alternative to videotape the transports, but then the patients´ anonymity and the personnel's integrity would be a challenge.

By appointing the expert group to evaluate the registered incidents, a qualitative aspect was introduced. This was done to get a better understanding and description of the seriousness of the incidents. By having three experts independently review the incidents we hoped to reduce some of the subjectivity of the assessment. However, the large variation in assessments between the experts underlined the complexity of these evaluations.

The cohort

The main challenges in the cohort investigation were the missing data and the difficulties in data-linkage trying to merge data from different databases. The missing data resulted in the need to obtain additional data from other resources as a supplement, which made the research more time- and resource-demanding. On the other hand, adding data from several sources, likely contributed to more precise results with the new data confirming the already collected data. An example of this was the mortality data, where we were missing data for half of the cases in the intensive care registry, but these data could be collected from The Norwegian Cause of Death Registry.

8.2.3 Validity and transferability

Validity in a scientific context refers to the extent to which a research study measures what it intends to measure, reflects the truth, and can be generalized to the real world. It

is a crucial aspect of the quality of research and its findings. Validity of often further dived into external and internal validity. Internal validity refers to the degree to which the causal relationships established in the study can be trusted, whereas external validity is about the generalizability of the findings. Can these findings be replicated in other environments, with other participants, and at different times?

The qualitative methodology chosen to elucidate the experiences and insights from personnel involved in transport of critically ill provided rich data to explore the main challenges they face during transport. Adhering to the rigorous methodology recommended for qualitative research is important for the internal validity of our findings, but the external validity may be questioned. Challenges may vary between regions and countries, but it is likely there will still be important lessons to lean that will be applicable to a wider readership. Similarly, the attempt to create a low threshold system for reporting adverse events secured a much higher number of events reported compared to replying on the systems in place to report adverse events. This improves the internal validity of our findings, although the findings may not be directly applicable to other systems.

Lastly, our studies primarily focused on personnel and transport cases from the South-Eastern Region Health Authority in Norway, encompassing over three million people—more than the remaining three Health Authorities in Norway put together (170). While our findings may broadly reflect interhospital transport dynamics across a large part of Norway, there are important regional differences that may challenge the external validity.

We did, however, find that adverse events during transport comparable to findings from other countries, supporting the external validity of our results.

8.3 Strengths and limitations

8.3.1 Strengths

Both qualitative and quantitative research methods were used to obtain different perspectives. This resulted in a triangulated approach to the research field and may contribute to a broader understanding of the execution and performance of interhospital transports.

Interhospital transport of critically ill patients in Norway is a neglected research area. The needs assessment survey in the beginning and the needs assessment follow up-survey after nine years, have confirmed this and shown the persistent challenge of these transports. This makes the research an important contribution to the knowledge in this area.

The personal experiences from these transports have not earlier been examined in Norway and by performing in-depth interviews, new knowledge of the personnel's challenges and their personal experiences have been described. This qualitative research, together with the needs assessment survey, made the fundament for the following quantitative research by creating hypotheses for further research and revealing possible weaknesses in the management of interhospital transported patients.

With the self-reported incidents, we were able to compare the number of actual incidents with the number of registered incidents in the hospital's electronic incident report system. From this, we showed a large discrepancy between actual incidents and reported incidents that were not known.

By collecting data from several sources, we have been able to describe the cohort of critically ill patients transported between intensive care units to be just as critically ill as the cohort of patients at the hospitals´ intensive care units. This strongly supports the need for standardisation to ensure that quality of critical care is a continuum during transport as well.

Throughout the research, there has been great interest among pre-hospital colleagues with enthusiastic participation and useful inputs all the way. The research brought public interest through an interview after the second publication (171) and the necessity and the warrant for national guidelines or standards for the interhospital transport of critically ill patients were highlighted.

8.3.2 Limitations

During the interviews, there was always a danger of interviewees communicating what they thought we wanted to hear, or what they thought to be socially acceptable. We considered this to be less likely as the interviewees spontaneously brought up contradictions and paradoxes, indicating a personal level of reflection. In addition, the experiences were often presented with examples of solutions, supporting our perception of a true personal description.

The incident reporting will probably be dependent on each contributor`s background, experience, and culture, resulting in a large diversity in what is believed to be incidents and how serious the incidents are. This heterogeneity may produce a personal bias amongst the participants and became even more apparent in the expert group`s evaluation of the incidents.

There was a lot of missing data in the cohort study, particularly from the Norwegian Intensive Care Registry and the Emergency Medical Communication Centre`s dispatch database. We tried to substitute this with data from other sources, such as mortality-data from the Norwegian Cause of Death Registry, but the amount of missing data is still an important limitation to our research. The SOFA score was constructed in retrospect. This made the survey more complicated and probably the results less accurate.

The research projects were conducted for several years. This may have resulted in outdated results, influencing the actuality of the research findings and thereby the conclusion in the thesis. To address this, the “needs assessment survey” performed initially, was repeated at the end of the project to unveil possible changes in the execution of transports at the ICU level and possible changes in SOPs and personnel participation. We found that little was changed during the time of research and consider the results to be up to date.

9. Conclusions

The out-of-hospital environment during interhospital transports was described as challenging and potentially hazardous and different from the in-hospital environment and the in-hospital availability of resources. The interhospital transports were experienced as time-consuming and logistically challenging. In addition, they were described as potentially unsafe for both patients and personnel. The personnel who worked out of the hospital believed this special environment was not fully understood by personnel who only worked inside the hospital.

Self-reported adverse events occurred in half of all registered transports, indicating a potential for quality and safety improvement. During some of the transports, more than one adverse event happened, making an average of one adverse event in two-thirds of the transports. However, only one percent were registered in the hospital`s electronic incident reporting system, thus indicating a significant degree of under-reporting. The adverse events were a mixture of technical, medical, and organisational, and with different degrees of severity.

Proposed interventions to prevent future adverse events were distributed by the group of experts between the use of checklists and SOPs, training, and some simulation. The group of experts diverged in the suggestions for prevention of the adverse events and even in the number of unavoidable adverse events.

The population of intensive care patients transported between intensive care units in Norway had similar morbidity as the general intensive care population. The patients were evenly classified as surgical or medical. Approximately half of the transported ICU patients were mechanically ventilated during transport. The mortality rates were equal to the mortality rates in the Norwegian ICUs, with a 30-day mortality of around twenty percent.

At the beginning of the research period, we found that more than half of the ICUs reporting to the Norwegian Intensive Care Register lacked SOPs for interhospital transport of critically ill patients, and less than half of the ICUs used checklists prior to transport. At the end of the whole research period, most ICUs still lacked checklists and SOPs, indicating a persistent low degree of preparedness for these transports. When interhospital transports had to be performed ad hoc, it still represented a challenge for the local hospitals` utilisation of personnel resources.

10. Future perspectives and implications

10.1 The near future in general

Several fields of research that need to be assessed in the field of critically ill patient transport have been suggested, such as safety, education and training, outcomes, and clinical care issues (172).

To study and evaluate the quality and safety of the transports, different scoring systems have been used, with traditional scoring systems from the intensive care society, like SOFA- and APACHE-scoring systems. A group in the Netherlands and Germany have recently developed and validated a new scoring system based on the ABCDE principles well known to clinicians, called the QUIT-EMR, have been suggested (173). This may be the beginning of a more standardised research tool addressing quality and safety during transport.

The performing personnel`s experience and education vary, and it is suggested that the transports should be performed by trained retrieval teams (118). Nevertheless, despite guidelines, paramedics sometimes perform transports alone, and the level of critical care may exceed their education and experience (174). Criteria to select the correct personnel for each patient should be investigated.

The preparation and arrangement prior to transport may be a time-consuming part of the total transport (175) and measures to make this part of the transport more safe and efficient should be looked into. The importance of documentation and communication during transport has already been shown to facilitate continuous care and achieve a better outcome (176).

An interhospital transfer may have a large impact on the family members of the critically ill patient as well and this should be addressed in the total picture of intensive care (177).

10.2 The near future in Norway

The quality and safety during interhospital transport of critically ill patients in Norway have now been addressed. The results imply several areas for improvement.

The value of learning from incidents and adverse events must be managed correctly and applied to the systematic teaching of personnel. This requires an easy-to-use incident reporting system, maybe even anonymous, to obtain a low threshold of reporting. The incidents should then be systematically and professionally interpreted to increase the learning value and facilitate systematic improvements.

Systematic collection of data from transports of critically ill patients should be mandatory. This can be used for benchmarking and quality improvement. In addition, these data can be used for research. A national registry, maybe in combination with already existing registries, can be a solution, but this demands consensus and implementation nationally.

A national guideline or standard for these transports should be established. To be implemented, this should be done with broad national consensus and based on existing evidence. It is important to keep such guideline or standard continuously updated as new evidence-based knowledge emerges. Revisions in compliance with other guidelines and standards should be implemented when available.

10.3 New possible impacts in the future

According to the Danish politician Karl Kristian Steincke; "Prediction is difficult, especially about the future". However, several areas may impact on the transport of the critically patients in the future.

Technical
There has been a revolutionary development of medico-technical equipment, with the use of ultrasound, video-laryngoscopes, capnography, and more advanced ventilators during the transport of intubated patients (178-180). The necessity of new equipment and the potential impact on patient outcomes should always be scrutinized. Invention of new and yet not known technical equipment may facilitate better patient observations and even new treatment options prior to and during transport and maybe even at the local hospital, avoiding the transport in its entirety.

Artificial Intelligence
As summarised by Bohr et al, the technical development and the use of Big Data, Artificial intelligence (AI) and machine learning is believed to have a large impact on healthcare in general (181). The ability to recognise patterns for prognostication, prediction of demand and resource availability shows promising results in critical care (182) and in prehospital emergency care (183). AI may be used to predict and even avoid adverse events. In Korea a deep learning-based prediction model have been shown to predict adverse events in ICU patients and then facilitate life-saving strategy prior to the event, even during transport (184). Artificial Intelligence in health care, according to a 2022-report from the European Community, is however not without risk, i.e. raising a concern for patient harm, privacy issues and security (185).

Robotics
New ways of transporting critically ill patients between hospitals are being developed, such as autonomous vehicles. One example is the research partnership between The Norwegian Air Ambulance Foundation and Airbus on eVTOL (electrical Vertical Take-Off and Landing)-vehicle being a drone capable of transporting patients. Drones have already successfully been used in emergency medicine, such as delivering Automated External Defibrillators (AEDs) in Sweden (186) or emergency blood products in Rwanda (187). Nevertheless, there are no current registered trials at "clinicaltrials.com" concerning robotics and interhospital transport of critically ill patients.

Environmental considerations
Prehospital services in general are contributors to pollution and environmental impact. With The United Nations Sustainable Development Goals (188) and the Norwegian Government's Climate plan (189) as a frame of reference, the Norwegian healthcare system have united committed to environmental goals (190). To be climate neutral before 2045, the CO2-production is to be reduced by 40% within 2030, including fossil-

free activity by 2030. This will naturally affect the prehospital services and the interhospital transport of critically ill patients directly.

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12. Appendices

12.1 Literature search

Set	Search Statement	Annotations
1.	Critical Care/	
2.	Intensive Care Units/	
3.	ICU.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	
4.	"Intensive care*".mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	
5.	"critical care*".mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	
6.	Patient Transfer/	
7.	transport.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	
8.	transfer.mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms]	
9.	1 or 2 or 3 or 4 or 5	
10.	6 or 7 or 8	
11.	9 and 10	
12.	limit 11 to english language	
13.	limit 12 to humans	

14.	limit 13 to (adaptive clinical trial or case reports or classical article or clinical study or clinical trial, all or clinical trial or comparative study or consensus development conference or consensus development conference, nih or controlled clinical trial or equivalence trial or evaluation study or guideline or historical article or introductory journal article or journal article or meta analysis or multicenter study or observational study or practice guideline or pragmatic clinical trial or randomized controlled trial or "review" or "systematic review" or validation study)	
15.	limit 14 to pharmacologic actions	
16.	14 not 15	
17.	limit 16 to ("all infant (birth to 23 months)" or "newborn infant (birth to 1 month)" or "infant (1 to 23 months)" or "preschool child (2 to 5 years)" or "child (6 to 12 years)")	
18.	16 not 17	

12.2 The questionnaire for the local hospitals (in Norwegian)

Spørreundersøkelse om intensivtransport mellom sykehus
Vennligst svar på BEGGE sider av arket!

1. Finnes det prosedyrer, basert på pasientens kliniske tilstand, for valg av transportnivå? (med transportnivå mener vi både transportmodus og eventuelt ekstra personale som følger pasienten)
☐ Ja ☐ Nei ☐ Vet ikke

Hvis nei: Er det behov for prosedyrer? ☐ Ja ☐ Nei

Er det planer om prosedyrer? ☐ Ja ☐ Nei Eventuelt innen når?.....

2. Er det alltid en spesialist i anestesiologi som tar den endelige avgjørelsen om intensivtransport av pasienten?
☐ Ja ☐ Nei ☐ Vet ikke
Annen spesialist…….

3. Har dere faste kriterier som utløser at det skal være med:
Anestesiolog: ☐ Ja ☐ Nei ☐ Vet ikke
Kommentar…….

Annen lege: ☐ Ja ☐ Nei ☐ Vet ikke
Kommentar…….

Sykepleier: ☐ Ja ☐ Nei ☐ Vet ikke
Kommentar…….

4. Har dere dedikert personale til denne type oppdrag (intensivtransport)?
☐ Ja ☐ Nei ☐ Vet ikke

Kommentar: …….

5. Er det aktuelle personalet alltid sjekket ut på utstyret som brukes ved intensivtransport?
☐ Ja ☐ Nei ☐ Vet ikke

Kommentar: …….

6. Har dere dedikert utstyr til transport av intensivpasient?
☐ Ja ☐ Nei ☐ Vet ikke

Kommentar: …….

7. Har dere en sjekkliste som brukes før intensivtransport? (med sjekkliste mener vi f.eks en huskeliste for hva som skal være med og hva som skal kontrolleres før transporten starter)
☐ Ja ☐ Nei ☐ Vet ikke

Kommentar: …….

8. Hvilke alternativer har dere hvis dere har behov for intensivtransport, men ikke får ønsket ekstern hjelp (f.eks pga samtidighetskonflikt eller ikke flyvær)?

a. Bruker egen dedikert ambulanse med eget dedikert personale: ☐ Ja ☐ Nei

b. Venter til dere får hjelp av ekstern part, selv om dette tar tid: ☐ Ja ☐ Nei

c. Løser dette ad hoc, avhengig av hast og alvorlighetsgrad: ☐ Ja ☐ Nei

d. Annet……

Kan dette gå utover lokal beredskap? ☐ Ja ☐ Nei ☐ Vet ikke

Kan dette forverre pasientens tilstand? ☐ Ja ☐ Nei ☐ Vet ikke

Kommentar: …….

9. Hvilke utfordringer står ditt sykehus som oftest overfor ved planlegging av intensivtransport? (Ranger etter viktighetsgrad, der 1 oppleves viktigst og 5 minst viktig)

☐ Det finnes ikke tilstrekkelig / tilrettelagt utstyr for å kunne gjennomføre transporten

☐ Det finnes ikke dedikert og trenet fagpersonell for transport av intensivpasient

☐ Hvis egne fagpersoner følger, blir lokal beredskap på sykehuset for lav

☐ Mottakende sykehus avviser overføringen

☐ Bestilt ekstern transport avviser oppdraget

☐ Annet: Skriv ned ……

10. Er det ønskelig med en nasjonal standard for transport av intensivpasienter?

☐ Ja ☐ Nei ☐ Vet ikke

Kommentar: …….

11. Er det ønskelig med en sentral organisering i det regionale helseforetaket for alle disse transportene?

☐ Ja ☐ Nei ☐ Vet ikke

Kommentar: …….

12. Hva er avstanden til nærmeste universitetssykehus?

Antall kilometer: …….

Vennligst postlegg skjemaet i vedlagte konvolutt så snart som mulig.
Tusen takk for hjelpen!

12.3 The questionnaire for the university hospitals (in Norwegian)

Spørreundersøkelse om intensivtransport mellom sykehus
Vennligst svar på BEGGE sider av arket!

1. Har dere prosedyrer, basert på pasientens kliniske tilstand, for hvilket behandlingsnivå **dere krever** av lokalsykehusene under intensivtransport (med behandlingsnivå mener vi transportmodus og hvem som eventuelt skal følge pasienten)?
☐ Ja ☐ Nei ☐ Vet ikke

Hvis nei: Er det behov for prosedyrer? ☐ Ja ☐ Nei

Er det planer om prosedyrer? ☐ Ja ☐ Nei Eventuelt innen når?.....

2. Har dere faste kriterier som utløser krav om at det skal være med:

Anestesiolog: ☐ Ja ☐ Nei ☐ Vet ikke
Kommentar…….

Annen lege: ☐ Ja ☐ Nei ☐ Vet ikke
Kommentar…….

Sykepleier: ☐ Ja ☐ Nei ☐ Vet ikke
Kommentar…….

3. Er transport av intensivpasienter **til** ditt sykehus tilfredsstillende mtp hvilket **personale** som følger? (følger det for eksempel "Norsk Standard for Anestesi" eller nasjonal/internasjonal consensus)
☐ Alltid
☐ Ofte
☐ Sjelden
☐ Aldri
☐ Vet ikke
Kommentar……

4. Oppleves intensivtransportene **til** ditt sykehus som **forsvarlig?** (følger det for eksempel "Norsk Standard for Anestesi" eller nasjonal/internasjonal consensus)
☐ Alltid
☐ Ofte
☐ Sjelden
☐ Aldri
☐ Vet ikke
Kommentar……

5. Er transport av intensivpasienter **fra** ditt sykehus tilfredsstillende mtp hvilket personale som følger?
☐ Alltid
☐ Ofte
☐ Sjelden
☐ Aldri
☐ Vet ikke
Kommentar……

6. Oppleves intensivtransportene **fra** ditt sykehus som **forsvarlig**?

☐ Alltid
☐ Ofte
☐ Sjelden
☐ Aldri
☐ Vet ikke
Kommentar……

7. Har du opplevd at pasientens kliniske situasjon er blitt **betydelig forverret** som en **direkte** konsekvens av at transporten ikke har vært forsvarlig?

☐ Alltid
☐ Ofte
☐ Sjelden
☐ Aldri
☐ Vet ikke
Kommentar……

8. Er det gjennomgående forskjeller ved intensivtransporten avhengig av hvilket sykehus som står for transporten?

☐ Ja ☐ Nei ☐ Vet ikke

Kommentar……

9. Hvilke faktorer gjør det oftest vanskelig å arrangere forsvarlig intensivtransport når pasienten skrives ut **fra** din intensivavdeling? (Faktorer som gjør at transport blir utsatt eller man velger andre løsninger, for eksempel til annet sykehus)

Ranger etter viktighetsgrad, der 1 oppleves viktigst og 5 minst viktig

☐ Mottagende sykehus har ikke plass

☐ Mottagende sykehus kan ikke yte forsvarlig intensivbehandling

☐ Mottagende sykehus kan ikke stille med **egen** transport

☐ Mottagende sykehus kan ikke skaffe ønsket **ekstern** intensivtransport

☐ Annet: …….

10. Er det ønskelig med en nasjonal standard for transport av intensivpasienter?

☐ Ja ☐ Nei ☐ Vet ikke

Kommentar..……
.

11. Er det ønskelig med en sentral organisering i det regionale helseforetaket for disse transportene?

☐ Ja ☐ Nei ☐ Vet ikke

Kommentar……

Vennligst postlegg skjemaet i vedlagte konvolutt så snart som mulig.

Tusen takk for hjelpen!

12.4 The interview guide from paper I

Theme / structure for interview
EMT
Nurse
MD (resident / anesthesiologist)

Introduction / preparation (less than half a page)
Written information is sent in advance
Let the candidate **read** the content: **ask if something is unclear.**

Clarify the following:

- **You can stop at any time;**
- **Anonymity (get a respondent number);**
- **You have the right to have the interview deleted (you cannot change parts of the interview).**

The interview
Formalities
What is **your formal or highest level of education**?
For how long have you been working in this profession?
Where do you work **now**? (for the tape)
How **old** are you?

This is what we are going to talk about:
In this conversation, we want **to hear about your experiences and your thoughts regarding the transport** of intensive care patients between hospitals.
By **intensive care patients, we mean patients who are being transported from, to or between** intensive care departments because they need intensive care monitoring and treatment (for example, intubation or vasoactive treatment) healthcare that they cannot get in a normal hospital ward.

Two types of intensive care transport:
To make it easier, we **put patient transports into two different categories: planned transports, where we have some time to arrange, plan and order** the transportation and choose the best qualified health professionals, and **ad hoc transports, which must be arranged very quickly and during duty hours** because the patient needs a quick transport in order to receive better help at another hospital.

A. Special transports:

1. Have you ever attended these transports? One or several?
   Do you remember a transport like this? Or
2. **Did any of these transports leave a special impression on you?**
   Do you remember the transport…?
   Would you call it a planned transport or an ad hoc transport
3. Can you **tell more about this transport, the way you remember** it?

   Were you **the only accompanying personnel?** (The treatment rooms?)

How did you **experience the interaction?**

Can you tell me some more about it?
(Could you choose how the transport was carried out?)

What do you **feel about the transport**?

Do I **understand you correctly** when you say that…?

How did the transport go?

Did you feel **that it was safe?**

B. General transports:

1. Have **any transports felt unsafe?** (Unsafe for the patient?)

2. Have you ever experienced **failure or situations** that could lead to **consequences for the patient?**

   Can you **say something about what happened?**
   (Try to explain how it proceeded and the consequence for the patient.)

   How was **the communication?**

   Deficiencies with the car? Medical or technical?

   Do you feel **that you have had enough knowledge and education** during the transports?

3. What **do you think is necessary** in order to provide proper assistance during intensive care transports?
   Can you say something general about the transports? Something about the **preparations, equipment and personnel.**

   Scoring of the patient
   Mandatory personnel
   Mandatory checkout

4. Do you have any **experience with these transports from anywhere else** in Norway or abroad?

   The final part
   Do you think **this interview went well?**
   Is **there anything you feel you didn´t get the chance to say** or something **you want to add** before we finish this interview?

12.5 Meaning units from paper I

Meaning units sorted into topics

Meaning units	Number mentioned relevant to the topic	(Number of interviewees mentioning meaning unit)					
Code group	**Organization and education**						
Subgroup	Hospital organization and draining of personnel resources						
No 15							
Meaning units							
Resource	AL	L 1(1)	AS 3(2)	IS	IA 1(1)	A 2(1)	
Readiness	AL	L 1(1)	AS 1(1)	IS	IA	A 1(1)	
Enough staff	AL	L 1(1)	AS	IS	IA	A	
Personnel	AL	L 1(1)	AS	IS	IA	A	12
Subgroup	Clinical guidelines and checklist						
No 9							
Meaning units							
Procedures	AL 2(2)		L 5(3)	AS	IS 5(3)	IA	A 6(2)
Systems	AL 19(3)		L 12(5)	AS 3(1)	IS 1(1)	IA 3(1)	A 2(2)
Recipe	AL 1(1)		L	AS	IS	IA	A
No 1							
Meaning units							
Checklist	AL 7(2)		L 6(2)	AS	IS 3(2)	IA 1(1)	A 76
Subgroup	Inner checklist						
No 18							
Meaning units							
Checklist (inner)	AL 2(1)	L 6(4)	AS 2(2)	IS	IA	A	
Control	AL 7(2)	L 6(3)	AS 3(2)	IS 4(3)	IA	A 5(3)	
Thorough	AL 2(1)	L	AS	IS	IA	A	
Ensure	AL 1(1)	L	AS	IS 1(1)	IA 2(1)	A	
Want	AL	L 1(1)	AS 3(1)	IS 1(1)	IA	A 2(2)	48
Subgroup	Training and preparedness for intensive care transports						
No 25							
Meaning units							
Learning	AL 7(3)	L 31(6)	AS 4(3)	IS 4(2)	IA 11(2)	A	
Education	AL	L	AS 2(2)	IS 1(1)	IA	A	
Be introduced	AL 1(1)	L 1(1)	AS	IS	IA	A 1(1)	
Advise	AL 3(1)	L 1(1)	AS	IS 4(3)	IA	A	71
Subgroup	Learning by doing and learning from others						
No 31							
No 36							
Meaning units							
Experience	AL 6(3)	L 16(5)	AS 6(3)	IS 8(3)	IA 2(1)	A 2(1)	
Newcomer	AL 2(1)	L 8(3)	AS 1(1)	IS	IA 2(1)	A	
More than before	AL	L 2(2)	AS	IS	IA	A	
Share events	AL	L 1(1)	AS	IS 1(1)	IA	A	
Truly felt	AL 1(1)	L	AS	IS	IA	A	58
Pass on experience	AL	L 1(1)	AS	IS	IA	A	
Cases	AL	L	AS 1(1)	IS	IA	A	
Share experience	AL 1(1)	L 2(2)	AS	IS	IA	A	

Tips	AL 6(1)	L 5(2)	AS	IS	IA	A	16

Code group **The out-of-hospital environment**

Subgroup Concern for the out-of-hospital transport of critically ill patients in general

No 32

Meaning units

Fit	AL	L 1(1)	AS	IS	IA	A	
Secure	AL	L 6(5)	AS 8(2)	IS 7(2)	IA	A 1(1)	
Watch	AL 3(2)	L	AS	IS 1(1)	IA	A 1(1)	
Alone	AL 6(2)	L 12(5)	AS 5(2)	IS 3(2)	IA 3(1)	A	
Hope	AL	L	AS 1(1)	IS 1(1)	IA	A 1(1)	
Catastrophic	AL	L	AS 1(1)	IS	IA	A	
Unrest	AL 1(1)	L	AS	IS	IA 2(1)	A	
Afraid	AL 5(2)	L	AS 1(1)	IS	IA 2(1)	A	
Danger	AL 1(1)	L	AS	IS	IA	A	
Scary	AL 1(1)	L	AS 1(1)	IS	IA	A 1(1)	
Paranoid	AL 4(1)	L	AS	IS	IA	A	
Fail all the time	AL 1(1)	L	AS	IS	IA	A	81

Subgroup Time consuming

No 13

Meaning units

Time	AL 8(2)	L 12(4)	AS 2(1)	IS 9(3)	IA 8(2)	A 9(1)	
Hour	AL	L	AS 2(1)	IS 3(2)	IA 1(1)	A 9(2)	63

Subgroup Creating margins

No 27

Meaning units

Margin	AL 12(3)		L	AS	IS	IA	A
Bastards in the system	AL 2(1)		L	AS	IS	IA	A 14

No 19

Meaning units

Quality	AL 6 (2)	L 6 (3)	AS	IS	IA	A	
Proper	AL 3(1)	L 4 (1)	AS	IS 2(1)	IA	A	
Expected level	AL	L 1(1)	AS	IS	IA	A	
Worst case	AL 1(1)	L	AS	IS	IA	A	
Gamble	AL 2(1)	L	AS	IS	IA	A 1(1)	
Trust	AL 3(2)	L 1(1)	AS	IS 1(1)	IA 1(1)	A 1(1)	
Risk	AL 4(3)	L	AS	IS 2(1)	IA	A 1(1)	39

No 8

Meaning units

Work out of hospital	AL	L	AS 2(1)	IS	IA 2(2)	A 1(1)	
In the ambulance	AL 1(1)	L 4(4)	AS 5(3)	IS 7(2)	IA	A 1(1)	
Underway	AL 7(2)	L 9(3)	AS 3(1)	IS 5(3)	IA 3(1)	A 2(2)	52

Subgroup Comparing out-of-hospital work to in-hospital work

No 8

No 14

Meaning units

(Un)stable	AL 5(2)	L 24(6)	AS 8(3)	IS 9(3)	IA 5(1)	A 7(2)	
Transportable	AL	L	AS 2(2)	IS	IA	A	
Medical history	AL	L 1(1)	AS	IS	IA	A 1(1)	
Brief	AL 7(2)	L 1(1)	AS 5(2)	IS 2(1)	IA 3(2)	A 3(2)	
Dialogue	AL 1(1)	L 1(1)	AS	IS	IA	A	85

No 31

Meaning units							
Ventilator	AL 31(3)	L 10(4)	AS 7(2)	IS 12(3)	IA 10(2)	A 3(1)	
Equipment	AL 31(2)	L 4(1)	AS 11(3)	IS 11(3)	IA 19(2)	A 17(3)	
Machines	AL 7(2)	L	AS	IS	IA	A	
Battery	AL 10(2)	L 3(1)	AS 1(1)	IS 2(2)	IA	A 3(1)	
Charging	AL 14(2)	L 2(2)	AS	IS 1(1)	IA	A 1(1)	204

No 32

Subgroup Patient information report

No 13

Meaning units *Time / Hour*

Code group **Personal attitudes**

Subgroup Self interest

No 20

Meaning units							
Personal	AL	L 1(1)	AS	IS	IA	A	
Enjoy	AL	L 2(2)	AS	IS 6(2)	IA	A	
Thrilling	AL	L 3(2)	AS	IS	IA 1(1)	A	
Allowed to	AL 3(1)	L	AS	IS	IA 2(1)	A	
Fun	AL 1(1)	L	AS	IS 3(2)	IA	A 2(2)	
Want to	AL	L 1(1)	AS	IS	IA 1(1)	A	
All right	AL	L 2(1)	AS 1(1)	IS 1(1)	IA 4(2)	A	
Exciting	AL 1(1)	L	AS	IS 1(1)	IA 2(2)	A	
Thrive	AL	L	AS 1(1)	IS	IA	A	38

Subgroup Lack of worry

No 38

Meaning units							
Not felt unsafe	AL	L	AS 2(1)	IS 2(1)	IA	A	
Safe	AL	L 4(4)	AS 3(1)	IS	IA	A 1(1)	
Simple missions	AL	L	AS 1(1)	IS	IA	A	13

Subgroup Relying on chance

No 42

Meaning units							
Passed easily	AL	L 3(3)	AS	IS	IA 1(1)	A	
Hope	AL	L 1(1)	AS 1(1)	IS 1(1)	IA 1(1)	A 1(1)	
Lucky	AL	L 3(2)	AS 3(1)	IS 4(2)	IA	A 4(2)	23

Subgroup Being a hostage

No 33

Meaning units							
Hostage	AL 1(1)	L	AS	IS	IA	A	
Shared responsibility	AL 4(2)	L 4(3)	AS 3(3)	IS 4(2)	IA 1(1)	A 3(3)	
Consultant opinion	AL	L 1(1)	AS	IS	IA	A	
Emergency law	AL 1(1)	L	AS	IS	IA	A	
Prehospitally unexperienced	AL 1(1)	L	AS	IS	IA	A	
Take charge	AL	L 1(1)	AS	IS	IA	A	24

Code group **System attitudes**

Subgroup To call for help and collegial assistance

No 39

Meaning units							
Call	AL 3(3)	L 3(3)	AS 2(2)	IS 2(1)	IA 1(1)	A 1(1)	14

Subgroup Being forced out of the comfort zone

No 43

Meaning units													
Cowboy	AL	1(1)	L	2(2)	AS	1(1)	IS		IA		A		
Jump in	AL		L	1(1)	AS		IS		IA		A		
Sort of hit and miss	AL		L	1(1)	AS		IS		IA		A		
Alone	AL	3(2)	L	6(4)	AS	3(2)	IS	3(2)	IA	1(1)	A	1(1)	
Stressful (and scary)	AL		L	4(1)	AS		IS		IA	1(1)	A		
In the beginning...I didn`t know	AL		L	1(1)	AS		IS		IA		A		
How could you	AL		L	1(1)	AS		IS		IA		A		
Pressured	AL	1(1)	L	2(1)	AS		IS		IA		A		
Too early	AL		L	2(1)	AS		IS		IA		A		
Why shouldn´t we	AL		L	1(1)	AS		IS		IA		A		
Someone has to	AL		L		AS		IS	1(1)	IA		A		37

Subgroup Patient safety awareness

No 19

Meaning units													
Quality	AL	5(2)	L	3(2)	AS		IS	1 1)	IA	1(1)	A		
Proper	AL	2(1)	L	4(1)	AS		IS	1(1)	IA		A		
Arrogance	AL		L	1(1)	AS		IS		IA		A		
Worst case	AL	1(1)	L		AS		IS		IA		A		
Gamble	AL	1(1)	L		AS		IS		IA		A	1(1)	
Trust	AL	2(2)	L	1(1)	AS		IS	1(1)	IA		A		
Risk	AL	5(3)	L		AS		IS	1(1)	IA		A		31

Subgroup Reporting an adverse event

No 34

Meaning units													
Adverse event	AL	6(2)	L		AS	3(1)	IS		IA	1(1)	A		
(Potentially) serious	AL	3(2)	L		AS		IS		IA		A		
Tell	AL	1(1)	L		AS		IS		IA		A		
Report	AL	4(2)	L		AS		IS		IA		A		18

Total 1017

12.6 Incident form from paper II

Registration of incidents during transport of critically ill patients

☐**Paramedic/EMT** ☐**Anaesthesiologist** ☐**Transportnumber**_____

Important information
This form is confidential and anonymous. It is important that **absolutely all** incidents are included, independent of possible consequences to the patient, and that this form is filled out for every transport of critically ill patients, regardless of whether incidents occur. You may use keywords and the template of your choice. **Please write legibly!**

Template suggestion (every box)
- What happened
- Potential consequences for patient
- Certain consequences for patient
- What limited the consequences
- How the incident can be avoided

During loading ☐ No incident
Incident:

During transport ☐ No incident
Incident:

During handover ☐ No incident
Incident:

Unnecessary time use
During what part of the transport (loading/transport/handover):

Time of delay (in minutes):

Main cause of delay:

Questions and comments about this form and registration can be addressed to "personal mail". Thank you!

12.7 Instructions for the expert panel (in Norwegian)

Instruks og CRF:

Her er de tre punktene vi ønsker at du skal vurdere og registrere i SPSS/EXCEL. Er det behov for mer informasjon om hendelsen enn det som stikkordsmessig er ført i datafilen, er det mulig å hente fram den egenrapporterte hendelsen fra tekstfilen du har fått tilsendt på minnepinne.

1. Avviksregistreringen:

Ifølge instruksen for OUS i avvikssystemet Achilles skal følgende registreres:

Uønskede hendelser og forhold som har skadet, kunne ha skadet eller kan skade pasienter.
Gjelder pasientnær diagnostikk, behandling og pleie, samt pasientsikkerhetsrisiko ved håndtering av medisinsk og pasientadministrativ informasjon (på papir eller i kliniske IKT-systemer).
For eksempel:

- *Medisinsk utstyr (elektromedisinsk utstyr, engangsutstyr / medisinske forbruksvarer)*
- *Samhandling / henvisning / venteliste / forsinket behandling*
- *Legemidler og blodprodukter – ordinering, bestilling, utregning, administrasjon og bivirkninger.*
- *Kliniske IT-systemer / journaldokumentasjon*
- *Feil / manglende pasientidentifikasjon*
- *Leiringsskader*
- *Feil / mangelfull behandling*
- *Sykehusinfeksjoner og risiko for smitteoverføring mellom pasienter*

Det første vi ønsker er at du vurderer om hendelsen skal registreres i avvikssystemet eller ikke.

Skal denne hendelsen registreres i avvikssystemet?
0 = Vet ikke
1 = Ja
2 = Nei

2. Risikovurdering

Ved registrering blir man bedt om skjønnsmessig å vurdere både faktisk konsekvens for pasienten og potensiell konsekvens hvis hendelsen skjer igjen (med samme eller annen pasient). For systemarbeidet er det den potensielle konsekvensen vi er interessert i.

Potensiell konsekvens
Hva er forventede utfall dersom hendelsen skjer om igjen (med en annen pasient)?

Ingen/ubetydelig konsekvens
- *ingen observerbar skade på pasient / nesten-uhell*

Mindre alvorlig konsekvens
- *forbigående negativ helseeffekt / skade som ikke krever omfattende behandling*

Moderat skade
- *skader som krever behandlingstiltak*

Betydelig skade
- *betydelig økt utrednings- eller behandlingsintensitet*
- *skader som medfører reoperasjon eller overflytning til intensiv overvåkning*
- *forlenget sykehusopphold*
- *varig funksjonstap*

Unaturlig dødsfall / katastrofal skade
- *plutselig og uventet død som kan ha årsak i behandling / mangel på behandling*

Det andre vi ønsker er at du skjønnsmessig graderer den potensielle konsekvensen av den beskrevne hendelsen.

0 = Ingen/ubetydelig konsekvens
1 = Mindre alvorlig konsekvens
2 = Moderat skade
3 = Betydelig skade
4 = Unaturlig dødsfall / katastrofal skade

3. Forslag til løsning

Det er selvsagt ønskelig å forebygge og å unngå systemfeil og enkelthendelser, men hva skal til for å oppnå dette?

Det tredje vi ønsker at du vurderer er om hendelsen kunne vært unngått eller håndtert bedre ved innføring av sjekkliste, ny/endret prosedyre, gjennomføring av simuleringstrening eller opplæring:

0 = Ikke mulig å unngå/forebygge
1 = Sjekkliste
2 = Prosedyre
3 = Simuleringstrening
4 = Opplæring

13. Reprint of papers

13.1 Paper I

Eiding et al. Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine (2019) 27:27
https://doi.org/10.1186/s13049-019-0604-8

Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine

ORIGINAL RESEARCH Open Access

Interhospital transport of critically ill patients: experiences and challenges, a qualitative study

Helge Eiding[1,2*], Ulf E. Kongsgaard[1,3] and Anne-Cathrine Braarud[1]

Abstract

Background: No consensus based national standard for interhospital transports of critically ill patients exists in Norway. The local hospitals are responsible for funding, organizing and performing these transports, resulting in potentially different level of care for the critically ill patients depending on local hospital resources and not the level of severity in the patient's condition. The aim of this study was to examine how these transports are executed and to discover challenges during transports and potentials of improvement.

Methods: A qualitative study with 20 semi-structured interviews of doctors, nurses and ambulance personnel representing a wide range in experience and formal education, reflecting the different compositions of crews performing interhospital transports was conducted. A systematic text condensation of the interviews was performed to describe personal experiences and values.

Results: Few interviewees reported special adverse events when asked. Instead they chose to describe more general characteristics of the working environment, their own positive emotions or fears and the strengths and weaknesses of the organizational system. The prehospital working environment was described as different from the in-hospital environment. The personnel experienced being on their own during transports, lack of procedures and checklists and often no systematic education or demanded preparedness for participating. The resident doctors described pressure from elderly colleagues to participate in the transports. At the same time, all interviewees reported a self-interest in participating in these transports.

Conclusions: Safe interhospital transports of the critically ill patients are challenged by the characteristics of the out of hospital environment. The transports are described as potentially unsafe for both patients and personnel. Systematic education is warranted, highlighting the use of checklists and special educational programs in prehospital critical care medicine. The strong personal interest to participate in these transports may serve as a barrier against changing todays system.
To ensure the right level of competence and safety for each unique patient, it is imperative to standardize the interhospital transports on a national level, built on consensus from experienced prehospital personnel.

Trial registration: The trial is approved and registered by the local representative for the Norwegian Data Protection Authority as trial 13–7751.

Keywords: Inter hospital, Patient safety, Patient transfer, Ambulance transport, Critically ill, Intensive care, Standard care

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Background

There is an increasing need for interhospital transport of critically ill patients. This demand is a consequence of the specialization and regionalization that is intended to improve outcomes within intensive care [1, 2].

Interhospital transport of critically ill patients may be needed if additional technical or medical care is not available at the patient's location. Norwegian standards on how to perform anesthesia [3] and in-hospital critical care [4] exist, but there are no national standards for interhospital transport. According to The Norwegian Patient Safety Program [5], the hospital trusts are responsible for establishing and implementing guidelines and standards for patient care. The hospital trusts are responsible for both organizing and funding interhospital transports according to the Specialized Health Services Act [6].

Furthermore, there are no defined national requirements regarding the medical or technical equipment or on the education or clinical experience of personnel accompanying the transport of critically ill patients. There are four main compositions of crews performing these transports in Norway; regular ambulances with emergency medical technicians (EMT), temporary staffed ambulances with either additional nurses or residents in anesthesiology and specialized transport units with experienced anesthesiologists [7]. In Norway it is in general the anesthesiologist who staff the specialized transport units, making it rare for other specialists to participate.

Knowing that these transports are expensive, logistically challenging, and high-risk in regard to adverse events [8], the issues of organization, patient safety and quality of interhospital transport must be addressed [9]. Thus, to learn more about how these intensive care transports are performed and experienced by the crew members, in-depth interviews with healthcare personnel who perform interhospital transports of critically ill patients on a regular basis was conducted.

Methods

A total of 20 unique interviews were conducted from June 2013 to September 2014. For a description of study subject, see Table 1.

Inclusion criteria

Emergency medical technicians, nurses, residents and staff anesthesiologists who had experience transporting patients in need of intensive care between hospitals were eligible for inclusion. Personnel from four different hospital trusts run by the South-Eastern Norway Regional Health Authority was included to cover the four main different compositions of crews and accompanying personnel in intensive care transports. The local heads of the Ambulance Service, Department of Anesthesiology and Air Ambulance Department were asked to find available interview subjects and set up appointments for the interviews.

Table 1 Description of study subjects

Occupation	Label	N	F	Age	Experience in years
EMT	A	3	0	38–52	11–20
Nurse					
General	IA	2	2	36–42	16–18
Anesthetist	AS	3	2	57–58	20–32
Intensive care	IS	3	3	41–53	9–13
MD					
Resident, anesthesiology	L	6	3	31–40	0.5–3.5
Staff anesthesiologist	AL	3	1	45–58	20–24
Total		20	11	31–58	0.5–32

N; numbers, F; female, EMT; Emergency Medical Technicians

Research ethics

The study was approved by the local representative for the Norwegian Data Protection Authority. In addition, approval from the local representatives of the included organizations (EMTs, nurses and physicians) and the local leaders of each hospital trust was obtained.

All study subjects received written and verbal information about the major objective of the study, i.e., to "collect personal experience from interhospital transports of critically ill patients". The right to withdraw from the study at any point during or after the interview was emphasized. All study subjects signed a written consent for participation prior to the interview.

All the invited study subjects agreed to participate when they were asked and no one have in retrospect asked to be withdrawn from the study.

Data collection instrument

After defining the major objectives of the study to the interviewees, a semistructured interview guide, divided into two main parts, was used. All interviews started with the first part regarding the participant's earlier experience of any specific patient transport leaving a particular impression; "The special transport". The interviews were then shifted towards the second part containing more general topics in order to explore different aspects of the interhospital transport of critically ill patients; "Transports in general". Several alternative sub-questions were set up (Additional file 1: Interview guide). As the interview was semistructured, there were no set alternative answers.

Data collection

The interviews took place during regular working hours in the ambulance or in hospital quarters at each local

hospital trust to ensure that the surroundings were safe and well known. The same two interviewers performed all the interviews and had separate and predetermined roles, thus ensuring uniformity among all the interviews. Both interviewers were specialists in anesthesiology and had several years of clinical experience in prehospital services, including transporting critically ill patients. One interviewer was serving as the Medical Director of the Oslo University Hospital Ambulance Service, and the other was working as an anesthesiologist both in and out of the hospital. It was emphasized that the interviewers did not work on commission from the local hospital leaders.

All interviews were recorded, and two separate recorders were used to ensure backup. The interview was always conducted by the same interviewer. The second interviewer contributed by asking supplementary questions for clarification or more in-depth questioning.

After each separate interview, the interviewers compared the information achieved from the interview with already existing data from previous interviews using a constant comparative method [10]. The interviewers then terminated further interviews at each study site when they felt saturation was achieved, i.e. when no additional disclosure of new topics or perspectives were discovered during the interviews.

All the interviews were transcribed verbatim into written accounts by personnel familiar with medical writing who proclaimed confidentiality. The transcripts were then stored in a secure server.

Data analysis

The data analysis was performed according to Malterud's "Systematic text condensation" [11] as follows:

Total impression in the bird eye perspective

Both interviewers separately read all interviews to obtain a general sense of the interviews and to intuitively identify temporary themes that drew the attention of the reader. These temporary themes may well be separate from the main themes of the interview guide.

Identifying and sorting meaning units – From themes to codes

The written interviews were then read with the aim of identifying "meaning units", with a meaning unit covering one or more of the identified temporary themes from step one. This could be text fragments (quotations) containing some information about their personal experience from the interhospital transport of critically ill patients. The meaning units that related to the temporary themes or represented different aspects of the same theme were then organized into code groups. The codes were developed and adjusted several times, ending up with four code groups. The quotations were labeled with letters representing different professions (Table 1) and numbers representing each unique contributor.

Condensation – From code to meaning

The interviewers then collectively discussed and sorted all 108 of the identified meaning units into subgroups. All subgroups should mediate the essence from several stories, not only a chain of separate descriptions. (Additional file 2: Meaning units sorted into topics). Eighteen subgroups of meaning units were identified (Table 2).

Synthesizing – From condensation to description and concepts

The meaning units were synthesized into analytic text, choosing quotes to represent or complement the analytical text describing the interhospital transport of critically ill patients.

Results

Organization and education

Hospital organization and draining of personnel resources

Several interviewees reported suboptimal in-house staffing when a patient needed transport, thus draining the hospital of medical personnel. One of the interviewees

Table 2 Code groups and subgroups

Code group	Organization and education
Subgroups	Hospital organization and draining of resources
	Clinical guidelines and checklist
	Inner checklist
	Training and preparedness for intensive care transports
	Learning by doing and learning from others
Code group	The out-of-hospital environment
Subgroups	Concern for the out-of-hospital transport of critically ill patients in general
	Comparing out-of-hospital work to in-hospital work
	Time consuming
	Patient information report
	Creating margins
Code group	Personal attitudes
Subgroups	Self-interest
	Lack of worry
	Relying on chance
	Being a hostage
Code group	System attitudes
Subgroups	To call for help and collegial assistance
	Being forced out of the comfort zone
	Patient safety awareness
	Reporting on adverse events

reported a discrepancy between planned staffing and actual staffing pertaining to out-of-hospital transports. Another interviewee described a lack of physical resources, such as emergency ambulances.

> … of course, officially we have someone who is on call for transport, but it's not always we have the staff for this … (AS1 p15).

Clinical guidelines and checklists

Some interviewees reported a lack of clinical guidelines for interhospital patient transport; others reported having problems finding these guidelines in the local patient safety system. The different professions had various opinions of the importance of clinical guidelines and checklists. The doctors described an interest in guidelines but revealed difficulties in finding these when needed. Other interviewees reported that guidelines existed but that they were neither fully implemented nor mandatory. None of the interviewees mentioned checklists spontaneously. When asked directly about checklists, many interviewees felt that checklists were mostly lacking or they did not know whether they existed. Some interviewees did not see the importance of having checklists.

> … no, we don't have a system in place … so it depends on the person … (AL2 p4I).

> … checklists would of course be a big support … then I would've perhaps felt safer at an earlier stage … (IS3 p11).

Inner checklist

Several nurses and doctors claimed to use their own "checklists", which they described as a "personal mental list" that they remembered. These personal checklists were not written or shared between personnel.

> … there is no actual checklist, we should definitely have this, but we don't. I have my own order of things, I kind of have my own checklist, in my head … (L2 p5).

> … the safety routines you have, they are sort of in your spine … you don't always feel like you are in control … (AS3 p17).

Training and preparedness for intensive care transports

All professions agreed on the necessity of specific training, both medical and technical, for performing these transports. Many interviewees felt they were expected to participate in the interhospital transport of critically ill patients despite lack of training. Several interviewees described the possibility of supervision as a one-time-only experience. Many of the doctors were concerned with lack of practice and called for more competence and experience to be able to recognize and handle potentially dangerous situations during transport. Several of the interviewees disclosed having performed intensive care transports alone without having had any experience performing intensive care treatment.

> … one of the criteria for success is that the doctors shouldn't just come along as a support without them knowing the equipment … I think it would be much better if you knew the equipment yourself as well … especially when things start to fall apart … (AL1 p10).

> … not truly … not like proper scheduled training, it was more like an experienced nurse that kind of said it would be a good idea, to take this or that along with you. That was kind of the training, not the way you would think training would be … (IS3 p5).

Learning by doing and learning from others

After a number of transports, personnel are expected to gain experience on their own, which is described by many as "learning by doing". They described themselves as better qualified and able to complete a safer transport after having had their own experiences. Some of the interviewees had suggestions on how the education should be implemented as a whole. They emphasized the importance of learning from adverse events experienced by colleagues. Some interviewees gave examples of good arenas for learning from others, such as short courses and meetings. One doctor suggested simulation and a more systematic education.

> … what's important is passing on your experience to others you know, not everyone has to make the same mistake to discover that something was stupid … (AL1 p9).

The out-of-hospital environment

Concerns for the out-of-hospital transport of critically ill patients in general

All participants described many factors of insecurity that potentially add to a stressful workload during these transports. They all felt they were on their own regarding decision-making or emphasized the load of working on your own. Many of the interviewees expressed that during the mission, they wished for the transport to be over as

soon as possible. One of the junior doctors described how working alone away from the safety of the hospital makes both themselves and the patient vulnerable.

> … many of these patients are literally dying all the time … (IA2 p15).

Comparing out-of-hospital work to in-hospital work

Regardless of their education or experience, all the participants emphasized the striking difference between working in and out of the hospital. The out-of-hospital challenges were described as diverse, from many small hindrances sometimes adding up to the extreme stress of feeling completely alone with a deteriorating critically ill patient. They described that patients were more unstable when transported. The patients' physiology often deteriorated during transport, making even a short transport with a stable patient potentially challenging. The parameters of medical equipment were described as less precise and sometimes not even possible to collect during transport. For these reasons, the out-of-hospital monitoring often had to be more extensive than in-hospital monitoring.

> … they (the hospital staff) don't quite understand the fact that you have much less resources, you don't have any backup … you can't take a break, you have to sort out basic things like the oxygen supply and things like that … they think it is the same thing (out-of-hospital and in-hospital) but it is two very different places … (AL3 p6).

Time consuming

Interhospital ambulance transports were described as time consuming. Several interviewees emphasized the discrepancy between the time spent on the road and the total time of the mission. They described this by how time consuming it is to prepare and stabilize the patient, collect patient information, and adjust medication and medical equipment prior to transport. One of the interview subjects even described having to compromise between the use of time and how many safety measures would be necessary.

Patient information report

Several of the doctors were worried that vital information regarding the patients was lost during handovers both pre- and post-transport. Sometimes, this loss of information was due to a lack of attention from the receiving personnel. Some interviewees felt that the hospital personnel wanted to be relieved of the patient responsibility as soon as possible, thus under-communicating vital information and not understanding the importance of this information for out-of-hospital personnel.

> … I do notice … that when you handover and people don't listen to you, it feels as though the message shrinks, and you may forget to say things you thought were important … (AL2 p5).

Creating margins

The experienced anesthesiologists spontaneously emphasized the importance of "creating margins" to secure safe patient transport. This topic was not mentioned by any other working group. "Creating margins" included everything from details such as securing intravenous lines and pharmacological relaxation of the patient to stabilizing and even changing the treatment of the patient prior to transport. They explained "creating margins" as working systematically to reduce or even eliminate the risks during transport. One of the respondents repeatedly used the expression "ensure" in order to explain the way of working outside of the hospital. Another respondent compared the preparations for adverse events during transports to athletes' preparations prior to a competition.

> … the transport medicine, partly the emergency medicine, but especially the transport medicine, is about being systematic and creating margins … (AL1 p17).

Personal attitudes

Self-interest

Most of the participants expressed some degree of positive self-interest in participating in prehospital work in general and especially in the interhospital transport of critically ill patients. Transporting these patients was often explained as a good way to learn emergency medicine. Several of the doctors experienced being forced to step up to the challenge and thereby learn decision-making. Some subjects described the out-of-hospital experience as a kind of entertainment and something covering the need for a "break" from everyday work.

> … it is kind of like a fearful joy, because, it is actually kind of fun in a way … (L3 p2).

> … when people suddenly show trust toward you … I do enjoy that … (IA2 p6).

Lack of worry

Several of the nurses spontaneously described these transports as easy to perform and felt no reason to

worry. Two of the nurses felt very safe in believing the patients to be well-prepared and stabilized prior to each transport. They described these transports as being "safe and easy".

> … the intensive care transfers are actually often the safest ones, because the patients there are properly prepared, even though they are very ill, they still, in a way, have all the right monitoring and they have secured airways … (AS3 p5).

Relying on chance

Some of the personnel considered themselves to be lucky when adverse events and patient deterioration were avoided during transports, while others expressed the hope of avoiding challenging clinical situations in future transports.

> … now, I have actually been very lucky, as in the fact that the patients I have transferred have been stable, and it has sort of all gone well … (IS1 p5).

Being a hostage

One staff anesthesiologist expressed the feeling of being a hostage during transport; another regarded his level of competence to be a risk of substandard treatment of the patient and, at the same time, inadequate care of himself as a colleague, being expected to participate in these transports.

> … we all felt that it was unsafe (intensive care transfers as a junior doctor), we all sat there and held the tube, hadn't even been inside an ambulance before … and the consultants didn't want to go, so I remember that we were the ones who were sent, we didn't even know how to intubate, so you kind of became a hostage, like a substitute for a bad fixation of the tube, that was kind of what is was like … when I think about it now I think it was truly badly done … they (the consultants) didn't dare, they knew it could be dangerous you know … and we were slightly too stupid to understand it … (AL3 p21).

System attitudes

To call for help and collegial assistance

Most of the interviewees explained how inexperienced personnel are offered the opportunity to call a colleague when in need during transports to compensate for their lack of skills and knowledge. This offer was described as a safety measure for both doctors and nurses during transports. Some of the inexperienced doctors described it as comforting to know they could call someone to discuss ongoing treatment or patient deterioration.

> … you should talk to others, you should "call a friend" if you are in need, it is possible to call others both in the hospital where you are picking up but also definitely at the receiving hospital, you could also call others who are experienced with patient transports … (AL1 p15).

Being forced out of the comfort zone

All the residents gave the impression of being under pressure. They felt they were expected to work outside of the hospital even though they felt incompetent due to a lack of experience and education.

> … I do remember, in the beginning I felt forced … and I did say that I was not comfortable with this, and that I truly didn't want to do this, but few seemed to truly understand … (L1 p19).

> … so I do think it is a stress factor just being at call actually, the fact that you could get sent out, and be completely on your own … (L2 p12).

Patient safety awareness

All the interviewees discussed patient safety when asked about the topic specifically. The experienced anesthesiologists were particularly concerned with this and shared many self-experienced stories concerning patient safety in general. One of the subjects used the resemblance to aviation safety when evaluating patient safety. Formalized education, medical treatment protocols, learning from others and checklists were also mentioned as parts of a patient safety system.

> … the aviation industry stopped measuring their quality by the number of accidents ages ago because they (accidents) are very rare … so we cannot use the fact that someone died during transport or not … luckily, not many die during the transport, and that is a good thing, but that doesn't mean that the rest of it is any good … (AL1 p31).

Reporting on adverse events

The interviewees were not asked specific questions about reporting adverse events, but several still mentioned the topic. Lack of oxygen supply and battery capacity during transport was pointed out as well-known events for the novice personnel, but no specific

transports where this had occurred was actually brought up. Some interviewees had experienced that adverse events were not necessarily reported and proposed several explanations for this. Some participants described reporting adverse events as uncomfortable, while others described reporting these events as time consuming.

> … a lot of things do happen that should have been reported as an adverse event, but it does take time to actually sit down and write in Synergy (registration system for adverse events) …

> some people may even think this is uncomfortable to do as well, especially if colleagues are involved … (AS1 p19).

Discussion

To learn more about personal experiences, episodes, values and interaction, Malterud recommends the use of qualitative methods [12]. In-depth interviews were chosen, being a method recommended for revealing personal experiences and ethical values. The interviewers had personal field experience from prehospital patient transports and from former use of in depth interviews in research. They both had a theoretical background that supported their choice of topics for the interviews. To enhance the reliability and validity of the interviews, the conceptual framework, communication process and analysis of the text was addressed and thoroughly discussed in the planning of the study.

Knowing that the interhospital transport of critically ill patients is organized in mainly four different ways, individuals from four specific hospital trusts were eligible for interviews. In qualitative research a limited number of informants can be chosen. The strategic sample size of this study was not decided in forehand but decided to be achieved when the interviews presented a diversity in information, contradictions and paradoxes that could enlighten the research topics. To ensure this, stepwise recruitment and analysis of the richness of information gained decided the number and type of interviewee objects. The participants had a wide range of experience and represented all working organizations (EMTs, nurses and physicians), thus ensuring a maximum variation sampling. In the resident group, a larger number of interviewees were chosen to cover a variation in personal experience with transports. [13]

There is no official registration of the number of transports performed by each personnel, hence, as a surrogate, the experience in years represents the interviewees experience of interhospital transports.

In our experience, the interviewees were distinct, and the participants individually brought up topics and themes that provided an accurate description of their experiences. All respondents spontaneously presented both contradictions and paradoxes, indicating reflections at a personal level. Their experiences were often paired with suggestions on how the system could provide better patient safety and a safer working environment. We believe these spontaneous themes and experiences give a true description of the different organizational systems for intensive care transports and not just a socially acceptable description of how the service should be organized.

According to the interview guide, the interviewees were initially asked to share an experience from a transport that made a special impression, followed by their impression of transports in general. We were anticipating stories containing adverse events and even dramatic outcomes [14], but surprisingly few of the interviewees gave any details of adverse events except general comments on running out of battery or oxygen.

The interviewees presented working environments with a striking lack of educational systems, procedures and checklists for the transport of critically ill patients. All participants described having a great self-interest in participating in these transports. The residents emphasized this despite worries about own personal suitability for the work and lack of specific education. Expectations from the consultants on duty were sensed as a pressure to participate, especially by the interns. The combination of self-interest and sensed expectations can potentially facilitate an unsafe environment for both the personnel and this vulnerable patient group.

The out-of-hospital treatment of critically ill patients should be of the same quality and safety level as in-hospital treatment [15], but there is no consensus on a standard for the transfer of intensive care patients in Norway. These transports are performed under different routines, with different equipment, with few if any checklists and by different professions with variable experience from different hospital trusts run by the South-Eastern Norway Regional Health Authority.

Many of these transports were described as challenging for the local hospital resources on call, often resulting in the least experienced personnel being forced to participate in these transports, only offered the opportunity to call a senior doctor during transports as a safety measure. In reality we believe this safety measure only to be a method of verbal moral support, demanding the inexperienced personnel en route to understand when to call for help and when to sort out events alone. This may contribute to a false sense of safety for the personnel and thus lower the threshold of participation in the transport of complicated or unstable patients. The inexperienced crew member even described the feeling of being a hostage during these transports due to their felt lack of competence and the feeling of being on their own.

The fact that none of the interviewees discussed checklists until they were asked directly is surprising, knowing that the use of checklists influences important working processes in surgery by reducing complication rates and the length of hospital stay [16], and during transports, is associated with a reduction of adverse events [15]. The creation of personal inner checklists based on self-experienced adverse events and needs derived from prior transports, in our opinion shows that the performance as a whole was left to chance during these transports.

Transporting the critically ill patient is more time consuming than just the transport itself, often demanding stabilization and even a change of treatment prior to leaving the hospital. This point was emphasized only by the experienced doctors, describing the importance of "creating margins" for the patient by spending more time initially to facilitate a safer transport. [17]

The out-of-hospital environment was described as very different from the in-hospital environment by most of the participant. The more experienced personnel emphasized not being able to trust the equipment for surveillance and being alone or deprived of resources while caring for unstable patients out-of-hospital. The in-hospital colleagues are often perceived as ignorant of the out-of-hospital challenges, independent of, and even despite of, their in-hospital skills [18]. This ignorance may result in the underreporting of challenges in patient treatment during the handover and thereby increase the potential challenges during transports.

The interviews revealed how participants with increasing experience became increasingly more aware of safety issues and the necessity to prevent adverse events. The different levels of reported concern for performing inter-hospital transports of critically ill patients may be a Dunning-Kruger-effect [19], which suggests that those with little experience, as a result of ignorance, accept the risk of transport on behalf of the patient. This Dunning-Kruger-effect, combined with the large degree of self-interest in performing these transports focusing not on the patient but on fail-and-learn based self-education, might explain the willingness to accept the system as it is.

The participants also identified hindrances in reporting adverse events, such as time consuming systems and the fear of revealing the events to colleagues thus resulting in the underreporting of adverse events.

The skills of working with critically ill patients outside of the hospital must be systematically learned, as in all medical disciplines, including knowledge of how to create margins to transport the patient safely. We find that this provides a potential for structured education and learning from others instead of requiring that all personnel have to experience all the pitfalls of out-of-hospital transports on their own.

Having a national standard could guide the level of competence needed depending on the patient's condition, similar to in-hospital critical care, and thereby define the level of education needed for the personnel who accompany critically ill patients. [18]

Conclusion

Interhospital transport of critically ill patients was described as time consuming, draining of local hospital resources, logistically challenging and potentially unsafe for the patients.

Most of the personnel warranted systematic education and wanted to learn from more experienced personnel in general and from previous adverse events in particular. Patient safety issues, the use of checklists and special educational programs were highlighted as areas for improvement.

The interviews revealed how the out-of-hospital environment demands special considerations concerning education and system planning. The strong personal interest in participating in the transport of critically ill patients may serve as a barrier against the changes of today's system.

The time for standardizing the transport of critically ill patients is ripe. This standardization should be on a national level and include directions for improving the education and competence of accompanying health personnel, procedures and checklists, and tools for safe handover and decision-making both before and during transport. The national transport standard should be built on a consensus from experienced personnel to ensure an appropriate level of demanded competence for each unique patient, thereby securing patient safety.

Additional files

Additional file 1: Interview guide. (DOCX 16 kb)

Additional file 2: Meaning units sorted into topics. (DOCX 26 kb)

Acknowledgements

We are grateful to all the interviewees participating in this study.

Funding

This study was supported by The Norwegian Air Ambulance Foundation.

Availability of data and materials

The datasets used and analyzed during the current study are available from the corresponding author on request.

Authors' contributions

All authors contributed to the concept of the study. All authors contributed to the analysis of data, the design of the study and writing the manuscript. All authors read and approved the final manuscript.

Ethics approval and consent to participate

Prior to initiation, the study was approved by the local representative for the Norwegian Data Protection Authority (13–7751), the local representatives of the included organizations and the local leaders of each hospital trust. All participants received written and verbal information about the study and the right to withdraw from the study at any point during or after the interview. All study subjects signed a written consent for participation prior to the interview.

Consent for publication

Not applicable.

Competing interests
The authors declare that they have no competing interests.

Publisher's Note

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Received: 28 September 2018 Accepted: 19 February 2019
Published online: 04 March 2019

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13.2 Paper II

OPEN

Potentially Severe Incidents During Interhospital Transport of Critically Ill Patients, Frequently Occurring But Rarely Reported: A Prospective Study

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Objectives: The out-of-hospital environment can pose significant challenges to the quality and safety of interhospital transport of critically ill patients. Because we lack knowledge of the occurrence of incidents, their potential consequences, and whether they are actually reported, this study was initiated.

Methods: Two different services in Norway were asked to self-report incidents after every interhospital transport of critically ill patients. Sampling lasted for 12 and 8 months, respectively. An expert group evaluated each incident for severity and demand for reporting into the hospital's electronic incident reporting system. One year later, the hospital's reporting system was scrutinized to determine the number of incidents actually reported.

Results: A total of 455 transports of critically ill patients were performed, resulting in 294 unique incidents reported: medical (15%), technical (25%), missing equipment (17%), and personal failures and communication difficulties (42%). Only 3 (1%) of the 294 unique incidents were actually reported in the hospital's electronic incident reporting system. The experts were inconsistent in which incidents should have been reported and to what degree checklists, standard operating procedures, simulation, and training could have prevented the incidents.

Conclusions: This study of interhospital transports of critically ill patients reveals a very high number of incidents. Despite this fact, these incidents are severely underreported in the hospital's electronic incident reporting system. This suggests that learning is lost and errors with predominant probability are repeated. These results emphasize the existing challenges in regard to the quality and safety of interhospital transport of critically ill patients.

Key Words: interhospital, interfacility, incidents, adverse events, critically ill, transport, reporting systems, patient safety, ambulance transport, intensive care, standard care

(*J Patient Saf* 2020;00: 00–00)

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H.E. received funding from The Norwegian Air Ambulance Foundation. For the remaining authors, no conflicts of interest were declared.

Ethics approval: The study was approved by the local representative for the Norwegian Data Protection Authority (protocol number 2013/12873 and 2016/2625) and by the local representatives of the participants and local leaders.

Supplemental digital contents are available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's Web site (www.journalpatientsafety.com).

The need for interhospital transport of critically ill patients is increasing as a consequence of specialization and regionalization designed to improve intensive care outcomes.[1,2] The critically ill patients are either transported to receive a higher level of treatment or transported back to a lower level of treatment, but are still in need of critical care.

Safe interhospital transport of critically ill patients can be challenging given the characteristics of the out-of-hospital environment. These transports are performed under different routines, using different equipment, with few (if any) checklists and by different professionals.[3] Transports have been described as logistically challenging and potentially unsafe for both patients and personnel.[4] However, out-of-hospital treatment for critically ill patients should be of the same levels of quality and safety as inhospital treatment.[5]

The quality of medical services is partially evaluated based on the number and severity of reported incidents. It is therefore imperative that these reports be as complete as possible—not only to describe the risks but also to help prevent future incidents—in pursuit of the goal of continuing improvements in patient safety.[6]

The international literature on prehospital and interhospital services concerning adverse event reporting is sparse. However, in an article analyzing extracorporeal membrane oxygenation patients' medical transport records, the authors identified adverse events during 31.7% of transports. In 34 of 514 transports, 2 or more adverse events occurred during the same trip.[7] In another article, incidents were reported in 16.7% of interhospital transports, but this included nurse-led transports as well, indicating a lower portion of critically ill patients.[8]

Within prehospital services in Norway, information on the prevalence of incidents and compliance regarding their reporting is lacking. Based on our clinical experiences and compared with other services, we expected that such incidents both occur[9] and may be underreported.

The primary aim of this study therefore was to investigate the number and type of self-reported incidents during interhospital transport of critically ill patients between geographically separated hospitals, and the proportion of these that were reported in the hospital's electronic incident reporting system. Second, we wanted to evaluate the registered incidents in regard to potential severity and suggest possible interventions in general to avoid the incidents in the future.

METHODS

Incident Self-Reporting and Hospital System Reporting

Part 1 of this study was to collect prospectively self-reported incidents that occurred during interhospital transport of critically ill patients by either of 2 designated services: service A or service B. An interhospital transport of a critically ill patient was defined as a

transport between 2 geographically separated hospitals with the required assistance of an anesthesiologist during transport.

Service A is a prehospital physician-staffed service at Oslo University Hospital performing interhospital transport of critically ill patients in addition to primary emergency missions. When a critically ill patient is transported, this service staff includes either an emergency medical technician (EMT) or paramedic in addition to the anesthesiologist. The unit is available on a short-notice, emergency basis at any time of day to supplement the usual ambulance staff for transport of critically ill patients. The service is operating in a dedicated emergency vehicle with no room for a stretcher, and the personnel must therefore enter a regular ambulance or an intensive care ambulance to complete a patient transport. Most of these transports are performed among the 4 hospitals making up Oslo University Hospital. Service A started to transport critically ill patients September 2013, thus being novel to these transports.

The personnel manning the service were asked to complete a study incident form after every interhospital transport of a critically ill patient from September 2013 to August 2014.

Service B is a well-established interhospital transport service at Oslo University Hospital that is staffed with an intensive care or anesthetic nurse and an anesthesiologist. These transports are also performed at any time of day via airplane and/or a dedicated intensive care ambulance. This service performs a large number of interhospital transports and retrievals every year covering the entire country. To limit data collection to true intensive care transports, study forms were only collected when an anesthesiologist attended the transport.

To collect an equivalent number of transport forms from service B to compare with service A, the service B survey lasted 8 months, from March 2016 to October 2016. We performed no collection of transport forms from service A during this latter period.

Occasionally, if time is critical or there is a concurrency conflict, the transports primarily dedicated to either service A or B can be transferred to the local helicopter emergency medical service, representing a close cooperation between these prehospital services.

The participants were asked to report all incidents, independent of their opinion of the potential significance of the incident. It was emphasized that the survey was in addition to the mandatory electronic incident reporting system and that every incident had to be reported as usual, independent of the survey.

With the aim of obtaining a high response rate from personnel who work in a demanding service, the study data collection form was designed to require minimal effort. This very simple, single-page, semiopen template had space on the reverse side for more information, as needed (Appendices 1, 2, http://links.lww.com/JPS/A354; http://links.lww.com/JPS/A355). If no incidents occurred, the only effort required was to check 4 boxes. Service personnel were instructed (verbally and in writing) to complete and deliver the form after each transport, including those without any incidents. Forms were delivered anonymously to a locked box adjacent to the local work desk. To maintain participant anonymity, increase response rates, and allow us to calculate the response rate, only the transport number was recorded. Reminders were sent to staff at both services via mail and delivered verbally at both staff meetings and services throughout the study period.

Maintaining an electronic incident reporting system is required within all prehospital and inhospital services at Oslo University Hospital; using this system to report incidents with potentially moderately serious, serious or catastrophic consequences is mandatory. All personnel working at Oslo University Hospital, both inside and outside hospital, are able and obliged to file incidents in this system.

One year after the data collection was complete, the hospital's electronic incident reporting system was scrutinized to determine the proportion of incidents that had been reported. Both services and all incidents reported to all the different unit leaders were searched and then double-checked in case any reports had been inaccurately addressed. Only incidents reported from interhospital transport of critically ill patients during the sampling periods were investigated.

Expert Group Evaluation

Part 2 of the study was an evaluation of the self-reported incidents. To assess the potential severity of each incident, we established a group of senior prehospital physician experts to evaluate the materials. We also asked this group to consider which incidents should have been reported in the hospital's electronic incident reporting system and suggest an intervention to avoid the incident in the future. Each expert uniquely evaluated and scored all forms blinded to each other's results.

The expert group consisted of 3 anesthesiologists, each represented 1 of the 3 other health regions in Norway, all with more than 10 years of clinical and administrative prehospital health care experience, including interhospital transport of critically ill patients. All experts had at least 4 years of experience in developing standard operating procedures (SOPs) for these transports and responsibility for follow-up on reported incidents within their local prehospital service. The experts were blinded to one another's identities.

Data forms were manually entered into statistical software for analysis (SPSS Statistics for Windows, version 21.0; IBM Corp., Armonk, New York); these encrypted files were sent to the expert group members for evaluation, along with scans of the forms themselves, so they could consider the written descriptions. To guide their evaluations and reduce personal bias, the expert group members were also sent instructions for the Oslo University Hospital electronic incident reporting system. They were asked to evaluate the potential consequences of each incident and whether it should have been reported in the hospital's mandatory reporting system. To maintain full anonymity for the patients in this study, there were no options to evaluate the true impact of the incidents from the patients' records. Finally, they were asked to suggest whether each incident could be avoided in the future by the use of checklists, SOPs, or education, and whether they considered the incident unavoidable.

Data Analysis

Only descriptive analyses were performed, using SPSS (IBM Corp.).

RESULTS

Self-Reported Incidents

The 2 services performed a combined 455 interhospital transports of critically ill patients during the study period. At least one of the participating personnel completed the data sheet for 336 of these transports, representing a 74% response rate. Service A performed 156 transports from September 2013 to August 2014, whereas service B performed 299 transports from March 2016 to October 2016.

For services A and B, at least one participating professional reported on 84% of 156 and 69% of 299 total transports, respectively. The anesthesiologists reported on 69% and 54% and the EMTs on 66% and 64% of total transports in services A and B, respectively. In service B, the specialized nurses reported on 64% of transports. There were an additional 21 transports included in service B transports for which data were reported by the rescue personnel at the local helicopter emergency medical service. These

latter transports were performed in the same matter as the other service B transports and thus included in the results.

Service A reported incidents during 48% of their transports, with up to 7 unique incidents reported during a single transport. Service B reported incidents during 49% of their transports, with up to 4 unique incidents during a single transport. If the same incident during one transport was reported by both doctor and paramedic/specialized nurse, it was merged into one incident to avoid double registration of the same incident. A total of 634 registered incidents, consisting of 294 unique incidents, were reported, representing an average of 0.65 unique incidents per transport.

The registrations were evenly distributed between "during loading" (30%), "during transport" (35%), and "during handover" (35%), with some of the incidents occurring in more than one phase of the transport. The category for "unnecessary time use" was rarely completed, usually with just a repetition of already registered incident and with no estimated time loss.

The self-reported incidents were a mixture of medical (15%), technical (25%), missing equipment (17%), and administrative and personal failures and communication difficulties (42%; Table 1). One example of missing equipment is forgotten capnometer/capnograph occurring in 6 different transports. A capnograph/capnometer is mandatory for intubated patients according to the Norwegian standard of anesthesia.[10]

Incidents Reported in the Hospital's Electronic Incident Reporting System

Surprisingly, few incidents were reported in the hospital's electronic incident reporting system. Although 455 interhospital transports of critically ill patients were performed between the 2 services during the study periods, only 3 incidents were reported in the system, indicating a missing rate of 99% of the incidents.

Expert Group Evaluations

The expert group varied in their evaluations of the potential harm from the self-reported incidents; 21% to 90% were considered insignificant or less serious, 5% to 49% were characterized as moderately serious, and 3% to 29% were categorized as serious or catastrophic (Table 2).

Incidents classified by the expert group as potentially serious or catastrophic included dislocation of oral or tracheal tube, ventilator malfunction, and pauses in inotropic infusions due to pump failure.

The expert group advised that 28 (10%), 33 (11%), and 250 (85%) of the registered incidents should have been reported in the hospital's electronic incident reporting system (Table 2).

The expert group's suggestions for how to avoid these incidents in the future were distributed among "checklists," "SOPs," "simulation," and "training," but there was discrepancy in the importance of the suggested solutions. Checklists, SOPs, and training were quite evenly distributed, but simulation was rarely considered relevant in avoiding incidents in the future (Table 3).

TABLE 1. Incidents for Service A (Anesthesiologist and Paramedic/EMT by Car or Ambulance) and Service B (Anesthesiologist and Specialized Nurse by Plane or Ambulance) Categorized by Most Common Events

Service	Medical	Technical Failure	Equipment Not Available	Administrative
A	19 (13%)	33 (23%)	19 (13%)	72 (50%)
B	25 (17%)	41 (28%)	30 (20%)	51 (35%)
Total	44 (15%)	74 (25%)	49 (17%)	123 (42%)

TABLE 2. Expert Group's Evaluation of Incidents' Potential Consequences and Number That Should Have Been Reported in the Hospital's Electronic Incident Reporting System

Expert No.	Potential Consequence of Incidents: Insignificant or Less Serious	Moderately Serious	Serious or Catastrophic	No. Incidents That Should Have Been Reported
1	211 (72%)	47 (16%)	33 (11%)	28 (10%)
2	62 (21%)	143 (49%)	86 (29%)	250 (85%)
3	266 (90%)	14 (5%)	9 (3%)	33 (11%)

One-third of the incidents were classified as "unavoidable" by the expert group members, varying from 6% (expert 2) to 72% (expert 3).

DISCUSSIONS

The 2 participating services self-reported 294 unique incidents; surprisingly, only 3 were reported in the hospital's electronic incident reporting system during this period. The expert group diverged in their evaluation of the potential consequences of these incidents, but nevertheless, the experts suggested that 10% (expert 1) to 85% (expert 2) of the incidents should have been reported, implicating a major underreporting of potentially moderately serious, serious, or catastrophic incidents.

Even minor errors can be leading of more significant ones, and by recognizing that untoward events occur, learning from them, and working toward preventing them, patient safety can be improved.[11] This is, however, dependent on the incidents to be reported; therefore, system safety depends on feedback for optimal functioning. When incidents are underreported, important incentives for improvement are lost, and safety procedures remain static or worsen.

International consensus regarding the importance of reporting incidents exists.[12] Such procedures have been regulated under Norwegian law since 2001, and the reporting of serious or catastrophic events to the National Board of Health Supervision is mandatory.[13] When considered necessary, these events are then investigated by the National Board of Health Supervision, which determines whether the incident requires sanctioning. The Health Service as a system, as well as the individual health personnel, may be sanctioned. However, the main objective is to learn from such incidents to improve quality and patient safety. All hospitals in Norway are obliged to have an incident reporting system, although their usefulness is questionable because of known underreporting.[14,15]

The present study was initially conducted for 1 year, after which, an additional 8 months was added. During the sampling period, personnel may have focused more on these incidents, potentially even introducing actions to minimize them, which would cause the Hawthorne effect[16] and result in fewer actual incidents. An example of this is that the capnograph/capnometer was added to the equipment bag in service A during the study period, possibly leading to a lack of forgotten capnograph/meter incidents during the latter study period.

Service A was the first and, originally, only group to participate. After discovering a large volume of self-reported incidents, we added service B. Thus, service B personnel who were aware that service A was previously enrolled may have understood that there were reasons to expand the study to a second service. This may

TABLE 3. Experts' Suggestions for Avoiding Future Incidents

Expert No.	Suggested Solution				
	Checklists	SOP	Simulation	Training	Unavoidable
1	19% (55)	39% (114)	6% (17)	18% (51)	18% (53)
2	34% (99)	16% (47)	10% (29)	34% (97)	6% (17)
3	6% (18)	8% (24)	0% (0)	14% (41)	71% (206)
Combined from all experts	20% (172)	21% (185)	5% (46)	22% (189)	32% (276)

have influenced the responses in service B, potentially resulting in underreporting to make their service appear safer.

The study may also have served as an immediate posttransport debriefing, satisfying participants that the incidents were resolved, after which, they forgot about them, leading to underreporting in the hospital's system. Alternatively, the medical and technical challenges during transport may have been so impactful that incidents were overlooked. Although this issue could theoretically be resolved by including dedicated study observers on each transport, this was considered too excessive. Regardless, according to Oslo University Hospital's SOPs, reporting these incidents is mandatory.

Incident underreporting may also be due to a local or general culture in emergency medicine in which personnel expect incidents to occur and are therefore prepared for them. When an expected incident occurs, personnel may not consider it to be an incident at all because it was easily handled (i.e., as a result of competence) and therefore not report it.

A person-centered reason for underreporting incidents may be the sense that one is accusing one's colleagues, and thus, they could avoid reporting even serious incidents. Another reason could be a culture of not reporting incidents, either because of a perception that service leaders do not have incidents or because personnel avoid admitting reporting that would make them or their colleagues vulnerable. We tried to avoid similar resistance to self-reporting by ensuring the participants' anonymity.

There may be other reasons why incidents are not reported in the electronic incident reporting system.[17] One such reason might be the electronic incident reporting system itself, which is time-consuming and cumbersome, as it requires logging in, registering the patient's 11-digit identification number, describing the incident, suggesting potential consequences, grading severity, and suggesting solutions. This reporting system may also be more difficult to access for prehospital personnel than it is for hospital staff. In the study, we avoided this by using a low-effort self-report data form; to some extent, this may also explain the large discrepancy between self-reported incidents and those reported in the hospital's system. Nevertheless, when incidents go unreported in the electronic incident report system, there is no other system available, and thus, it is left to individual staff to share their experiences with colleagues or use other means of changing procedures, if possible.

Lessons can be learned from other safety-focused professions, such as aviation, which use amnesty-based and/or low-effort systems for their personnel to report incidents. Our expert group's suggested solutions for avoiding future incidents correspond with some of these (e.g., checklists, SOPs, and training).[18] This, however, requires that incidents be reported so that the organization can learn from them. Incident reporting should be a blameless system, focused on systems rather than individuals, to facilitate patient safety.[19,20]

The large proportion of unavoidable incidents implicates not only the need to prevent the incidents but also the importance of knowledge in how to deal with them. This calls for targeted training and simulation of the personnel before their participation in these transports. In that way, the personnel will be prepared to handle the unavoidable incidents.

The study results are based on 2 services, one (service A) initiated concurrent with the study and the (service B) previously well established. Nevertheless, they both experienced many incidents, surprisingly, few of which were reported in the electronic incident reporting system, suggesting an overall culture of underreporting. There is no change in the degree of reporting, demonstrating that no improvement in culture was seen over the years between the study periods. The high degree of underreporting is unfortunately described for other services as well.[21] This may give a false impression of a safe system and veil potentials of improvement.

Our expert group diverged in their evaluations of the potential harm from the self-reported incidents, which incidents should be reported and how they might be prevented, particularly in regard to the number of unavoidable incidents. This surprising discrepancy is difficult to explain completely but is previously described for other experienced reviewers.[22] Although these experts had similar professional backgrounds, diverse personal experiences may play a part. Different local cultures regarding incident reporting may also have been a factor.

Limitations

Our study depended on voluntarily self-reporting of incidents; thus, one of its limitations was likely to have been underreporting.[14] The percentage of missing forms (26%) may have been due to a concurrency conflict; both services receive emergency assignments and are quite busy with multiple daily assignments. On-call services are vulnerable to time conflicts, resulting in down-prioritizing participation in a research project. Other reasons of nonparticipation may have been lack of information or disagreement with the study itself. We tried to avoid this by thorough information of the study and guarantees of anonymity and acceptance among local representatives and leaders at the participating organizations.

Incidents might also have been either overreported or underreported with a personal agenda to show that transports are either more or less safe than reality. Both services had 2 participants in each transport who were eligible to fill out a self-report form. The forms were posted anonymously so that the participants were blinded to the reports of others. This may have reduced individual agendas to either overreport or underreport incidents.

None of the experts had any particular background in patient safety research. Because we chose to use the experts' individual review as evaluation methodology, they primarily had to have experience from the service. A better alternative might have been a multidisciplinary panel of our experts together with experts in patient safety work gathered to discuss each form aiming for a consensus decision on each incident. This methodology, which was considered, was, however, too expensive to arrange within the resources of the project.

CONCLUSIONS

A large number of incidents do occur during interhospital transport of critically ill patients in Norway. Many of these incidents are potentially dangerous or catastrophic, and reporting them in the hospitals electronic incident system is therefore mandatory. Despite this, hardly any incidents from 2 different services were reported in the hospital's electronic incident reporting system.

This large degree of underreporting implicates that important lessons may be missed, system errors with predominant probability are repeated, and service quality may be overrated; hence, transports seem to be safer than they actually are.

The interhospital transport of critically ill patients is a well-established procedure and should be subjected to the same level of inquiry as the inhospital treatment for these patients to secure quality and patient safety. This includes an improved failure culture instead of a "failures happen" culture. It is imperative to learn from reported incidents to obtain a systematic improvement of these transports.

These results emphasize some of the existing challenges in regard to the quality and safety of the interhospital transport of critically ill patients.

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13.3 Paper III

Received: 6 March 2021 | Revised: 20 September 2021 | Accepted: 15 October 2021

DOI: 10.1111/aas.14005

acta Anaesthesiologica Scandinavica

RESEARCH ARTICLE

Interhospital transport of critically ill patients: A prospective observational study of patient and transport characteristics

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Funding information
This study was supported by The Norwegian Air Ambulance Foundation.

Abstract

Background: The cohort of critically ill patients transported between Intensive Care Units (ICUs) in Norway has not been studied previously. The aim of this study was to describe the characteristics of patients and transports for different types of interhospital transfers and explore whether there were differences in morbidity and mortality between the different transfer categories and the general Norwegian ICU population.

Methods: All transports of critically ill adult patients transferred between two geographically different Intensive Care Units during a one-year period were registered. Patient and transport data were obtained from The Norwegian Intensive Care Registry, The Norwegian Cause of Death Registry, the hospital Electronic Patient Journal, the Air Ambulance Journal System, and the Emergency Medical Communication Centre database.

Results: 821 transports of 788 surgical and medical patients were enrolled. Simplified Acute Physiology Scores (SAPSII) were 43, 36 and 38 for urgent secondary transport, non-urgent secondary transport and return transfers, respectively. These were comparable to nationwide SAPSII scores that were 40 for university hospitals and 34 for local hospitals during the same time period. The return transfers had a median SOFA-score of 4.7 and 53% were mechanically ventilated. Only 33% of return transfers were performed by established teams.

Conclusion: Intensive care patients transferred between ICUs are as critically ill as the rest of the ICU population, with a similar morbidity and mortality. The return transfers of ICU-patients appear under-triaged compared to secondary transports in terms of allocated resources.

KEYWORDS
cohort study, critically ill, ICU, intensive care, intensive care unit, inter facility, inter hospital, patient transfer, transport

Editorial Comment

This prospective observational study from the Oslo Region in Norway describes the cohort degree of illness as well as considerable variation in secondary transportation practices of patients

treated in the intensive care unit. Return (to home hospital) transfers appear to be conducted with less resources allocated to them despite the high morbidity and mortality of these patients.

1 | INTRODUCTION

The development of highly specialized treatment options has led to a greater need for patient transfer between hospitals.[1] As more patients are offered specialized treatment, there may be added risks to patient safety during transport to and from higher levels of care.[2]

Critical care transfers between hospitals involve the potentially high-risk transport of unstable patients who require lifesaving interventions.[3] Health-care resources are limited, and the challenge is to ensure that patients are treated at the correct health-care level at all times.[4] Delays in transferring a critically ill patient to specialized treatment may have direct negative health consequences for that individual,[5] whereas keeping a patient in a specialized unit longer than necessary might delay treatment for someone else. These competing risks must be weighed continuously against the risk of transport itself.

Intensive care unit (ICU) transports are more time consuming and resource demanding compared with regular transports[6] and consume limited pre-admission and in-hospital resources. The goal of these transfers should be to provide high-quality care during transport to ensure a continuum of care throughout the intensive care period and to avoid unnecessary risk and delays in patient recovery.[7] To balance the quality of care and safety against cost and utilization of limited resources, more needs to be known about the specific aspects of interhospital transports.

There are three distinct categories of intensive care transports: (1) urgent and (2) non-urgent secondary transport of a patient in need of specialized treatment and (3) return transfer (repatriation) from hospitals that offer specialized treatment back to the referring hospital or hospital nearer the patient's home. These types of transports differ from that used for the primary transport of a patient to hospital from an out-of-hospital situation.

We hypothesized that patients in the three categories of intensive care transports would have different characteristics; if so, this would suggest that transports should operate at different risk levels according to the type of transfer. The aim of this study was to describe the characteristics of patients and transport used for the three interhospital transport categories. We explored whether there are differences in morbidity and mortality between these categories and compared these with existing data for in-hospital ICU patients.

2 | METHODS

2.1 | Study design and recruitment

This was a prospective observational cohort study of all consecutive adult interhospital transfers of ICU patients to and from the ICUs at Oslo University Hospital (OUH) for 1 year from 4 January 2014 to 2 January 2015. Patients younger than 18 years were excluded. The study was approved by the Regional Committees for Medical Research Ethics South East Norway (REK number 2013/457).

2.2 | Setting

OUH is the main tertiary referral hospital in south-eastern Norway, which covers a population of 3 million, and is the local hospital for most inhabitants of the city of Oslo (~600,000 people). The ICUs in OUH have an occupancy rate of more than 95%, and a correspondingly high volume of transports to and from these ICUs are executed. Within the South-Eastern Region Health Authority, acute transports between ICUs are generally managed by one of four air ambulance units, and return transfers or repatriations are generally handled by local referring hospitals.

There is no unique national standard for interhospital transports in Norway, and the organizational and economic aspects are the responsibility of the local referring hospital. Hence, there is substantial variation in the type of transport and accompanying personnel according to the patient's morbidity and resources available. The air ambulance teams usually include an anaesthesiologist accompanied by a nurse. The members of the air ambulance team follow a national standard for competence and training for air ambulance personnel.

2.3 | Data collection

To ensure the capture of all transports of critically ill patients, all nine ICUs within OUH were contacted each weekday by telephone; the information obtained on Mondays included patients transported during weekends. All patients transported were registered and were included on a daily basis, and the reason for transfer was noted.

The Simplified Acute Physiology Score II (SAPS II) and mortality data were retrieved from the Norwegian Intensive Care Registry and the Norwegian Cause of Death Registry, respectively. The SAPS II is a classification system of disease severity for ICU patients 24 h after ICU admission; the SAPS II is scored from 0 to 163 and is used to predict the risk of mortality expressed as a percentage from 0% to 100%.[8] The SAPS II was used to assess the severity of illness of each patient before ICU transport. The SAPS II was recorded on the day of the transport and represents the SAPS II at the receiving hospital, which was 24 h after the initial ICU admission.

The medical records from the hospital electronic patient journal (EPJ), Emergency Medical Communication Centre database (AMIS), and the air ambulance journal system (LABAS) were reviewed and used to collect patient and clinical data. Clinical data from the EPJ included the diagnoses, need for ventilatory support or vasopressor

support, and morbidity and severity data. Patient morbidity before transport was evaluated using the Sequential Organ Failure Assessment (SOFA) score, which was calculated from values obtained at the time of transport and therefore was reconstructed retrospectively. The SOFA score assesses organ failure based on a score for each of the respiratory, cardiovascular, hepatic, coagulation, renal, and neurological systems,[9,10] and is used to predict the clinical outcomes of critically ill patients.[11,12]

Operational data from the transports, such as timelines, transport category, means of transportation, and type of personnel involved, were collected from the AMIS and LABAS. In addition, the National Advisory Committee for Aeronautics (NACA) score was collected for patients transported by an air ambulance team and was available for 355 of 821 (43%) patients. The NACA score is a numeric scale ranging from 0 (no injury or disease) to 7 (death) and is based on a verbalized categorization of severity.[13] The patient's initial NACA score is associated with the subjective workload for the participating personnel[14] and patient's short-term survival.[15,16]

2.4 | Data analysis

Intensive care transfers were categorized into three groups: (1) urgent secondary transport of a patient in need of specialized treatment; (2) non-urgent secondary transport of a patient in need of specialized treatment; and (3) return transfer (or repatriation) from the hospital that offered specialized treatment back to the referring hospital or hospital nearer the patient's home.

Transport teams were categorized into the air ambulance team transport, which was managed by a specialized and trained crew from the National Air Ambulance Services of Norway, including a nurse and an anaesthesiologist, and non-air ambulance team transport, which generally included ambulance personnel accompanied by a physician or nurse from the referring hospital. The patient and transport characteristics for these groups were compared.

2.5 | Statistical analysis

Continuous variables are reported as means with 95% confidence intervals, and categorical variables are reported as numbers and percentages. Statistical analyses were performed using IBM SPSS Statistics (IBM Corp.), version 27. The STROBE guidelines (Strengthening the Reporting of Observational Studies in Epidemiology statement) for reporting of observational studies were followed.[17]

3 | RESULTS

During the 1-year study period, 821 transports of 788 patients were included in the study. Two patients were excluded because of an incorrectly registered social security number. A high percentage (760 or 96%) of patients were transported once, 24 (3%) patients were transported twice, three patients were transported three times, and one patient was transported four times. The patient characteristics are shown in Table 1.

3.1 | Characteristics of transported ICU patients

Of the 821 transports, 453 (55%) were considered surgical and 366 (45%) were considered medical admissions. Of all registered transports, 211 (26%) were for trauma, 16 (2%) were for burns, and 82 (10%) were for cardiac arrest with return of spontaneous circulation (ROSC). Cases involving burns or cardiac arrest with ROSC had the highest SOFA scores (Table 2).

In total, 427 (52%) of the patients were mechanically ventilated and 229 (28%) received vasopressor infusions. The SAPS II was registered in 403 (49%) of all patients, and the mean SAPS II was 40 (Table 1). Age, gender, 30-day mortality, and surgical vs. medical diagnosis did not differ significantly between groups. However, compared with patients without a registered SAPS II, those with a registered SAPS II had a higher SOFA score (6.6 vs. 4.8; $p < .001$) and were more often mechanically ventilated (257 or 64% vs. 170 or 41%; $p < .001$).

No patients died during transfer, but the 30-day mortality was 20% (159/803). In patients older than 70 years, 30-day mortality was 32%, 90-day mortality was 40%, and 1-year mortality was 47% (Figure 1). The mortality data for the main diagnostic categories are shown in Table 2.

3.2 | Transport categories

Return transfers accounted for 381 (47%) and secondary transports 435 (53%); 93 (21%) of the secondary transports were non-urgent. The main reasons for return transfer were that the patient had completed treatment at the tertiary referral hospital ICU for 326 (88%) out of 371, capacity challenges for 11 (3%), and withdrawal of curative treatment for eight (2%) patients.

3.3 | Transport teams and personnel

Of all transports, 358 (44%) were performed by air ambulance teams (Table 1). Overall, the air ambulance teams transported patients with more severe conditions than non-air ambulance teams (Table 3). For the return transfers, 133 (35%) were accompanied by an anaesthesiologist, compared to 207 (61%) of the urgent secondary transports (Table 4). The patients whose transport was accompanied by an anaesthesiologist had a median SOFA score of 6.6, NACA score of 4.7, and SAPS II of 42.

3.4 | Duration of transport

The total patient care time and time of transportation were similar for the two different types of transport teams (Table 5).

TABLE 1 Transfer categories and patient characteristics

	All transports	Urgent secondary transport	Non-urgent secondary transport	Return transfer	Registered SAPS II-score	Not registered SAPS II-score
Number	821 (100)	342 (42)	93 (21)	381 (47)	403 (49)	418 (51)
Age	58 (56, 59)	56 (54, 58)	55 (52, 59)	60 (58, 61)	57	58
Male	534 (65)	204 (60)	66 (71)	259 (68)	262 (65)	269 (64)
Primary diagnosis surgical	453 (55)	216 (63)	40 (43)	194 (51)	222 (55)	231 (56)
Primary diagnosis medical	366 (45)	125 (37)	53 (57)	186 (49)	181 (45)	185 (44)
Air ambulance team transfer	358 (44)	198 (58)	34 (37)	126 (33)	192 (58)	166 (54)
SOFA	5.7 (5.4, 6.0)	6.9 (6.4, 7.4)	5.6 (4.7, 6.6)	4.7 (4.3, 5.1)	6.6	4.8
NACA[a]	4.9 (4.8, 5.0)	5.1 (5.0, 5.2)	5.0 (4.7, 5.3)	4.6 (4.5, 4.8)	4.9	4.9
SAPS II[b]	40 (38, 42)	43 (40, 46)	36 (32, 39)	38 (36, 41)	40	–
Mechanically ventilated	427 (52)	189 (55)	43 (46)	203 (53)	257 (64)	170 (41)
Vasopressor infusion	229 (28)	145 (42)	23 (25)	64 (17)	134 (33)	95 (23)
30-day mortality	159 (20)	69 (20)	16 (16)	74 (20)	88 (22)	71 (18)

Note: Categorical variables are reported as actual numbers (percentage) and continuous variables are reported as means (95% confidence intervals). We were unable to determine transfer category for 5 transports. NACA, National Advisory Committee for Aeronautics injury severity score, SAPS II, Simplified Acute Physiology Score; SOFA, sequential organ failure assessment score.

[a]All transports missing 466, Urgent secondary transport missing 94, Non-urgent secondary transport missing 36, Return transfer missing 247.

[b]All transports missing 413, Urgent secondary transport missing 169, Non-urgent secondary transport missing 42, Return transfer missing 202.

TABLE 2 Diagnostic subgroups with SOFA and mortality

	Number	% of all transports	SOFA[a]	30-day mortality	90-day mortality	One-year mortality
Surgical non-trauma	226	28%	5.4 (4.8, 5.9)	54 (24%)	68 (30%)	86 (39%)
Surgical trauma	211	26%	4.2 (3.7, 4.7)	27 (13%)	30 (14%)	33 (16%)
Burns	16	2%	7.2 (5.3, 9.1)	7 (44%)	7 (44%)	8 (50%)
Medical	284	35%	6.5 (5.9, 7.1)	47 (17%)	58 (21%)	76 (28%)
ROSC/Cardiac Arrest	82	10%	7.3 (6.5, 8.0)	24 (30%)	29 (36%)	34 (42%)
Total[b]	819	100%	5,7 (5.4, 6.0)	159 (19%)	192 (24%)	237 (30%)

Note: Categorical variables are reported as actual numbers (percentage) and continuous variables are reported as means (95% confidence intervals). SOFA, sequential organ failure assessment score.

[a]Unable to determine SOFA-score for 3 transports.

[b]Diagnosis missing for 2 transports, mortality-data missing for 17 (30- and 90-day) and 19 (one-year) transports.

3.5 | Characteristics of ICU patients

The ICU patients display a 30-day mortality of 18%–22% (personal communication, E A Buanes, PhD, head of the Norwegian Intensive Care Registry) and a mean SAPS II score ranging from 34.1 to 40.1 dependent on ICU level. The nationwide ICU SAPS II and 30-day mortality rates from the Norwegian Intensive Care Registry are summarized in Table 6.

4 | DISCUSSION

In this cohort, critically ill patients transported between ICUs had similar morbidity and mortality rates as those treated in in-hospital ICUs. However, many transports were executed by non-air ambulance teams without an anaesthesiologist. This was also the case for return transfers, despite the assumably longer time available to plan and organize transport.

The reasons for ICU admission were evenly distributed between surgical and medical reasons, but patient morbidity was higher in the medical group. Local hospitals are expected to treat medical patients, who have a higher morbidity, and this may contribute to the initiation of transfers at a later stage of the disease when morbidity is higher. One exception may be cardiac arrest patients, who are centralized to a higher level of care directly and are repatriated after the acute phase.[18] In addition, the lower morbidity rate in the surgical group may have reflected the more centralized treatment of trauma and surgical patients, which required interhospital transport because of the injury itself and not necessarily because of the patients' overall morbidity. In Norway, critically ill patients with burn injury are treated primarily at local hospitals, and those with severe burns are centralized to one dedicated ICU that covers the whole

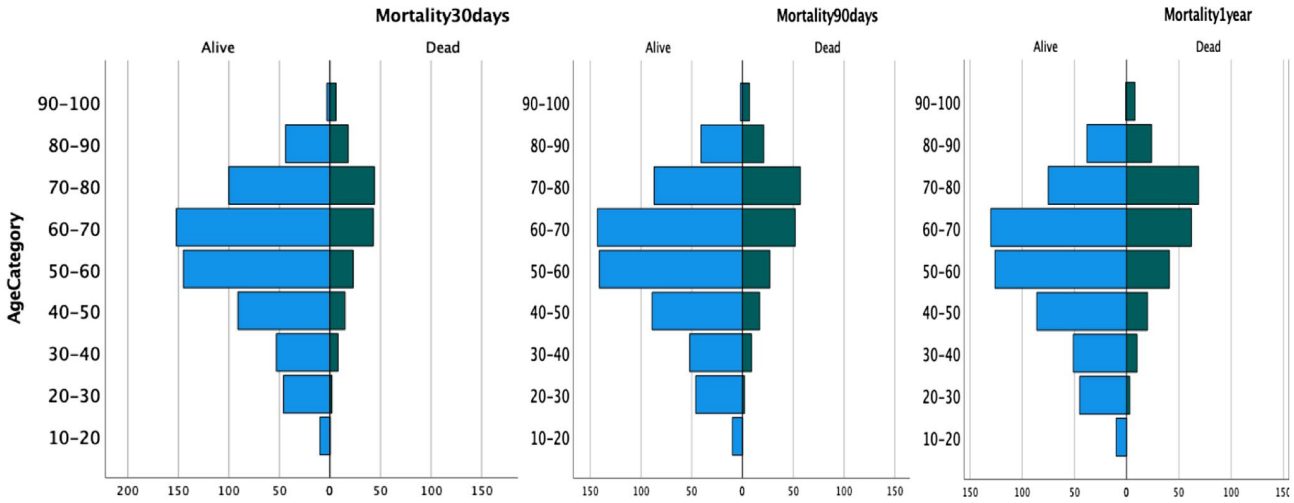

FIGURE 1 30days-, 90days- and one-year-mortality for the different age categories. Blue bars represent survival and green bars represents mortality after 30 days, 90 days and 1 year, respectively. Number of patients along x-axis and age category along y-axis. Missing mortality-data for 17 (30- and 90-day) and 21 (1-year) patients

TABLE 3 Patient characteristics for air ambulance team versus non-air ambulance team transfer

	Air ambulance teams ($n = 358$)	Non-air ambulance teams ($n = 463$)
SOFA-score	7.5 (7.1, 8.0)	4.3 (3.9, 4.6)
NACA-score[a]	4.9 (4.8, 5.0)	—
SAPS II-score	42 (39, 45)	38 (36, 40)
Mechanically ventilated	264 (74)	171 (37)
Vasopressor infusion	152 (42)	80 (17)
Secondary/return ratio	232/126	203/255

Note: Categorical variables are reported as actual numbers (percentage) and continuous variables are reported as means (95% confidence intervals). NACA, National Advisory Committee for Aeronautics injury severity score; SAPS II, Simplified Acute Physiology Score; SOFA, sequential organ failure assessment score.

[a]Air ambulance team missing 24, not registered for non-air ambulance teams.

country; this may explain the high SOFA score for this subgroup of surgical patients.

The SAPS II and the 30-day mortality rate for the transported patients (Table 1) were similar to those for the total ICU population (Table 6) in Norway during the study period.[19] This indicates the need for the same level of inter-hospital and in-hospital care, and the importance of the correct utilization of resources. The study was not designed to evaluate differences in mortality between groups, but the observed 30-day mortality and the SAPS II are similar to those reported earlier.[20]

Most of the secondary transports, especially urgent transports, were performed by air ambulance teams, and patients involved in these transports had higher SOFA and NACA scores compared with those involved in return transfers. Although 55% of the patients in the urgent secondary transport group were mechanically ventilated, 42% of these transports were performed by non-air ambulance teams, a finding that may reflect the under-triage of resources used for transporting the sickest patient population. The non-urgent secondary transports had a slightly lower mortality: 37% of these were air ambulance team transports and only 41% of these were staffed with an anaesthesiologist. This study was not designed to assess the quality of transports, but one would assume that the non-urgency would enable hospitals to ensure correct utilization of resources for this group of patients. However, given the mean SOFA score of 5.6 and that half of the patients were receiving mechanical ventilation, one would expect more than one-third of transports to be performed by air ambulance teams. This may represent an under-triage despite the lack of urgency.

Air ambulance team transport accounted for only one-third of the return transfers, and almost two-thirds of the return transfers were not accompanied by an anaesthesiologist. The lower SOFA scores may indicate less need for specialized personnel, yet half of the return transfer patients were mechanically ventilated, and 39% of the mechanically ventilated patients were transported by non-air ambulance teams.

It may be tradition to receive return transfers at the ICU for patients discharged from a tertiary referral ICU. In these cases, low mortality rates and SOFA and NACA scores are expected. However, these were surprisingly high in our study. Whether this represents the practice of premature discharge to a lower level of care is unclear and warrants further evaluation.

To maintain the same quality of treatment and safety for patients during transport as in hospital, one would expect the personnel accompanying the patient during transport to be equivalent to the personnel in the ICUs. Many of these transports involve an

TABLE 4 Participating personnel

	All transports	Urgent secondary transport	Non-urgent secondary transport	Return transfer
Nurse	34 (4)	17 (5)	6 (7)	11 (3)
Anaesthesiologist	336 (41)	189 (55)	29 (31)	118 (31)
Nurse and anaesthesiologist	42 (5)	18 (5)	9 (10)	15 (4)
No extra personnel registered	402 (49)	117 (34)	49 (53)	236 (62)

Note: Categorical variables are reported as actual numbers (percentage). We were unable to determine transfer category for 5 transports.

TABLE 5 Time measurements for the different subgroups of interhospital transports

	All transports	Urgent secondary transport	Non-urgent secondary transport	Return transfer
Preparation	33 (31, 34)	29 (27, 32)	29 (26, 33)	38 (34, 41)
Transportation	52 (49, 56)	48 (43, 53)	53 (41, 65)	57 (52, 63)
Total care time	85 (81, 89)	77 (71, 82)	84 (71, 98)	94 (88, 101)

Note: All variables in minutes. Continuous variables are reported as means (95% confidence intervals).

Preparation = Time spent to prepare the patient for transport; from arrival at the patient to departure from the referral Intensive Care Unit.

Transportation = Time spent for transport; from departure at the referral Intensive Care Unit to arrival at the receiving Intensive Care Unit.

Total care time = The total patient care time, from arrival at the patient to patient delivered at the receiving Intensive Care Unit.

We were unable to determine transfer category for 5 transports.

TABLE 6 Nationwide ICU SAPS II score and 30-day mortality (2014)[19]

Level of ICU	University hospital	Regional hospital	Local hospital
SAPS II score	40.1	39.2	34.1
30-day mortality %[a]	19	22	18

Note: Categorical variables are reported as actual numbers (percentage) and continuous variables are reported as means.

[a]Personal communication, E A Buanes, PhD, head of the Norwegian Intensive Care Registry.

anaesthesiologist and were performed by established transport units, but a notable proportion of transports were not, despite the high morbidity and mortality rates in the patient groups, which suggests an overall under-triage. This was especially true for the return transfers, which involved a low proportion of anaesthesiologists, despite the high proportion of mechanically ventilated patients and the high mortality rate. Local hospitals are responsible for return transfers, and the procedures and availability of qualified transport personnel vary between hospitals. Our findings suggest that lower-level ICUs under-triage patients when performing return transfers.

For the subgroup of patients more than 70 years of age, the 30-day, 90-day, and 1-year-mortality rates were high, and only half of these patients were alive after 1 year regardless of the form of transport. The small number of patients transferred because of withdrawal of life-sustaining therapy does not explain this. The high mortality rate indicates a subgroup of patients with a severe medical condition. This should be considered when transferring older critically ill patients.

The utilization of resources for interhospital transport can be investigated in different ways. One focuses on the total time spent for a resource to complete a transfer, and another on the type of personnel engaged in these transfers. The total patient care time is affected by variations in travelled distance, traffic, and weather. An interesting time interval, independent of the variations, was the 'preparation for transport' time. This reflected the time spent preparing the patient before transport and may include actions such as fitting the stretcher, loading the patient, obtaining medical reports, and sometimes changing treatment to obtain a more stable patient. This mean duration of preparation for transport was about 30 min and was surprisingly similar for all the registered forms of transport (Table 3). This was true regardless of whether the transport was secondary, urgent, non-urgent, or a return transfer, and independent of the type of personnel. This finding suggests the same need to arrange and stabilize the patient independent of the transport distance and the patient's morbidity.

4.1 | Limitations

Despite the use of a rigorous process to capture all ICU transports, some transports may not have been included in the cohort. The analyses were based partly on data collected from electronic emergency medical service records and our mandatory national prospective

Norwegian Intensive Care Registry. Missing data in these registries limited our analysis; for example, only half of all the transported patients had SAPS II reported to the Norwegian Intensive Care Registry. The low capture of SAPS II data probably reflects the lack of routine registration procedures. However, our data suggest a skewness in registration in which patients with higher morbidity are more often registered and may therefore represent a selection bias. The NACA score is required to be registered by the air ambulance team and no one else, and may also represent a selection bias, especially for the secondary transfers, which had a higher level of morbidity.

The reconstruction of the SOFA scores was based on data retrieved from medical records and transport journals, and was therefore performed retrospectively. For the patients maintained in a medical coma for safe transport, the Glasgow Coma Scale score was set to 3. This may lead to an overestimation of the SOFA score for the neurological system. Nevertheless, a patient transported in a coma, either related to morbidity or medically induced, arguably represents a more demanding transport and increased patient risk.

We were able to obtain only one SOFA score and one SAPS II for each patient. To predict outcomes, one would need to calculate a change in score[21] and include more observations. We used the scoring systems to describe the severity of the clinical conditions of these patients.

5 | CONCLUSION

Intensive care patients transported between ICUs are as critically ill as the rest of the ICU population and have similar morbidity and mortality rates. The return transfer of ICU patients has the same 30-day mortality rate but appears to be under-triaged in terms of allocated resources during transport compared with secondary transports and in-hospital care.

ACKNOWLEDGEMENTS

We wish to thank Trond Thoresen for retrieving and processing data from the Emergency Medical Communication Centre database and Eirik Alnes Buanes at the Norwegian Intensive Care Registry for retrieving data.

CONFLICT OF INTEREST

The authors have no conflicts of interest.

ETHICAL APPROVAL

This study was approved by the local representative of the Regional Committees for Medical Research Ethics South East Norway (REK number 2013/457).

AUTHOR CONTRIBUTIONS

All authors have contributed to the analysis and interpretation of data and have been involved in drafting the manuscript and revising it critically. The authors have all given final approval of the last version and agreed to be accountable for all aspects of the work.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

How to cite this article: Eiding H, Kongsgaard UE, Olasveengen TM, Heyerdahl F. Interhospital transport of critically ill patients: A prospective observational study of patient and transport characteristics. *Acta Anaesthesiol Scand*. 2021;00:1–8. doi:10.1111/aas.14005