Acute hospital admissions - a registry-based study of general practitioners' and out-of-hours doctors' roles as gatekeepers in Norway

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Thesis for the degree of Philosophiae Doctor (PhD)
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Scientific environment

During the work of this thesis, I have been following the PhD programme at the Department of Global Public Health and Primary Care at the Faculty of Medicine at the University of Bergen, Norway. My place of employment has been the National Centre for Emergency Primary Health Care, NORCE Norwegian Research Centre, Bergen, Norway. I have also completed training in the Norwegian Research School in General Practice.

Contents

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Summary

Access to proper health care is important for patients with acute medical conditions. In many health care systems, patients must be assessed by a primary care doctor before referral to an acute hospital admission. This is called gatekeeping. Strategies to reduce hospital workload and costs often focus on acute admissions and the general practitioners' (GPs') and out-of-hours (OOH) doctors' gatekeeper roles. Despite this decisive role, knowledge of the GPs' and OOH doctors' gatekeeper function has been poorly explored. The thesis investigated the GPs' and OOH doctors' roles as gatekeepers for acute hospital admissions in Norway and the impact of different referral practice by the primary care doctors.

This study is a registry study and was performed by linking national data on primary care doctors' claims from the Control and Payment of Reimbursement to Health Service Providers Database (KUHR) along with data from the Norwegian Patient Registry (NPR). A doctor who had sent a claim for a patient 24 hours before an acute admission was defined as the referring doctor. The diagnoses included in the primary care doctors' claims were defined as the referral diagnoses, whereas the discharge diagnoses came from the NPR. The primary care doctor's referral rates were calculated and adjusted for patient-related and local organizational factors, and the doctors were sorted into quartiles of low, medium-low, medium-high, and high referral practice.

Of all acute admissions to hospital in Norway in 2014, 36% were referred from OOH doctors, 28% were referred by GPs, and 35% were direct admissions. The prehospital paths varied between the discharge diagnoses. Subacute and local conditions were often referred by GPs, while OOH referrals were high on a variety of acute conditions including gastrointestinal disorders, chest pain, and alcohol-related disorders. Malignant neoplasms and several hyper acute critical conditions were dominated by direct admissions in our material, illustrating that the direct admission category comprised of both direct hospital-follow up and admissions directly by ambulance.

The GPs referred 1% of patients after a consultation or home visit, whereas OOH doctors referred 11%. Abdominal pain and chest pain were the most frequent referral diagnoses at 8% and 5%, respectively. After referral with an abdominal pain or chest pain diagnosis, the most frequent discharge diagnosis was the corresponding symptom-describing diagnosis. Women were less likely to be discharged with ischemic heart disease than men after a referral with chest pain.

The mean referral rate for OOH doctors varied between the referral practice quartiles from 6.5% in the low quartile to 14.9% in the high quartile. The likelihood for patients to be referred to hospital and diagnosed with the symptom-describing diagnoses of pain in throat and chest, abdominal pain, abnormal breathing, or dizziness increased from the low to the high referral practice quartiles. There was a similar but weaker association for the critical conditions of acute myocardial infarction, acute appendicitis, pulmonary embolism, and stroke. For the patients not referred, there were no differences in 30-day mortality between the quartiles.

This study shows that GPs and OOH doctors play an important role as gatekeepers for acute hospital admissions. Doctors with high referral practice refer a larger proportion of patients where no disease is revealed. Low referral practice leads to fewer admissions, but severe conditions might be overlooked. When planning the interface between primary care and hospitals, this should be taken into consideration, and strengthening the framework for decision making regarding acute hospital admissions should be emphasized.

Norsk sammendrag

For pasienter med akutte medisinske tilstander er det viktig å ha tilgang til nødvendige helsetjenester. I mange lands helsetjeneste må pasientene vurderes av en primærleger før innleggelse i sykehus, og dermed fungerer primærlegen som portvakt. Strategier for å redusere sykehusenes arbeidsbelastning og utgifter fokuserer ofte på akuttinnleggelser og fastlegers og legevaktlegers portvaktrolle. På tross av denne viktige rollen i helsetjenesten, er fastlegenes og legevaktlegenes portvaktfunksjon lite utforsket. Avhandlingen undersøker fastlegen og legevaktlegenes rolle som portvakt for akutte sykehusinnleggelser i Norge, og betydningen av ulik innleggelsespraksis hos primærlegene.

Studien er en registerstudie som ble gjennomført ved å koble nasjonale data fra primærlegers regningskort fra databasen Kontroll og utbetaling av helserefusjoner (KUHR) med data fra Norsk pasientregister (NPR). Legen som hadde sendt et regningskort 24 timer før en akutt innleggelse ble definert som henvisende lege. Innleggelsesdiagnosene ble hentet fra regningskortene fra primærlegen, mens utskrivelsesdiagnosene ble hentet fra NPR. Primærlegenes innleggelsesrater ble beregnet og justert for pasientfaktorer og lokale organisatoriske faktorer. Legene ble gruppert i kvartiler fra lav, medium-lav, medium-høy og høy innleggelsespraksis.

Av alle akuttinnleggelser i 2014 ble 36 % innlagt fra legevakt, 28 % fra fastlege, og 35 % var direkteinnleggelser. Fordelingen av innleggende instans varierte mellom ulike utskrivelsesdiagnoser. Subakutte og lokaliserte tilstander ble ofte henvist fra fastlege, mens legevaktlege henviste en stor andel av flere akutte tilstander inkludert mage og tarmproblemer, brystsmerter og alkoholrelaterte tilstander. Kreft og flere akutte hastetilstander ble ofte innlagt direkte uten fastlege eller legevaktvurdering, noe som illustrerer at denne gruppen direkte innleggelser bestod av både direkte sykehusoppfølging og direkte innleggelser fra ambulanse.

Fastlegene la inn 1 % av alle pasientene etter konsultasjon eller sykebesøk, mens legevaktlegene la inn 11 %. Magesmerter og brystsmerter var de vanligste innleggelsesdiagnosene og stod for henholdsvis 8 % og 5 %. For pasienter som ble innlagt med magesmerter- eller brystsmerter-diagnoser, var den tilsvarende symptombeskrivende diagnosen den vanligste utskrivelsesdiagnosen. Kvinner som ble innlagt med brystsmerter hadde lavere sannsynlighet for å få bli utskrevet med iskemisk hjertesykdom sammenlignet med menn.

Gjennomsnittlig innleggelsesrate for legevaktleger varierte mellom de ulike gruppene innleggelsespraksis, fra 6,5 % i laveste gruppe til 14,9 % i høyeste. Sannsynligheten for at en pasient ble innlagt og senere utskrevet med en symptombeskrivende diagnose, smerter i svelg og bryst, magesmerter, unormal pust eller svimmelhet økte fra lav til høy gruppe innleggelsespraksis. Det var en tilsvarende, men svakere sammenheng for de kritiske tilstandene akutt hjerteinfarkt, akutt blindtarmbetennelse, lungeemboli og slag. For pasientene som ikke ble innlagt var det ikke noen forskjell i 30-dagers dødelighet mellom innleggelsespraksisgruppene.

Denne studien viser at fastleger og legevaktleger har en viktig rolle som portvakt for akutte sykehusinnleggelser. Leger med høy innleggelsespraksis legger inn større andel pasienter der det ikke påvises sykdom. Lav innleggelsespraksis fører til færre innleggelser, men kritiske tilstander kan bli oversett. Ved planlegging av grenseflaten mellom akutt primærhelsetjeneste og sykehus bør dette tas hensyn til. Rammeverket for beslutningsstøtte for akutte sykehusinnleggelser bør styrkes.

List of publications

This thesis is based on the following papers:

Paper I: Blinkenberg J, Pahlavanyali S, Hetlevik Ø, Sandvik H, Hunskaar S. General practitioners' and out-of-hours doctors' role as gatekeeper in emergency admissions to somatic hospitals in Norway: registry-based observational study. *BMC Health Services Research*. Aug 14 2019;19(1):568. doi:10.1186/s12913-019-4419-0

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Paper II: Blinkenberg J, Hetlevik Ø, Sandvik H, Baste V, Hunskaar S. Reasons for acute referrals to hospital from general practitioners and out-of-hours doctors in Norway: a registry-based observational study. *BMC Health Services Research*. Jan 15 2022;22(1):78. doi:10.1186/s12913-021-07444-7

Paper III: Blinkenberg J, Hetlevik Ø, Sandvik H, Baste V, Hunskaar S. The impact of variation in out-of-hours doctors' referral practices on acute hospital admissions: a Norwegian registry-based observational study. Submitted August 2022.

The articles are referred to as **Paper I, Paper II** and **Paper III** in the thesis and are included in the appendix.

Published Papers are Open Access and therefore free to use, copy and print.

Abbreviations

AMI	Acute myocardial infarction
CI	Confidence interval
CVD	Cardiovascular disease
ED	Emergency department
EMCC	Emergency medical communication centre
GLM	Generalized linear model
GP	General practitioner
HELFO	Helseøkonomiforvaltningen
	(Norwegian Health Economics Administration)
HEMS	Helicopter emergency medical service
ICPC	International Classification of Primary Care
KUHR	Kontroll og utbetaling av helserefusjon
	(Control and Payment of Health Reimbursements)
LEMC	Local emergency medical communication centre
NBHS	Norwegian Board of Health Supervision (Helsetilsynet)
NOS	Not otherwise specified
NPR	Norwegian Patient Registry
OOH	Out-of-hours
PSPC	Private specialist with public contract

RR	Relative risk
SSB	Statistics Norway
WHO	World Health Organization
WONCA	World Organization of Family Doctors

1. Introduction

For patients with acute medical conditions, access to proper health care is important. Both general practitioners (GPs) and out-of-hours (OOH) doctors perform acute care in a primary care setting, and a major task in their service is to assess what is the right level of care for each patient. It is of major importance to clarify if the patient requires acute referral to hospital or if treatment in primary care is preferable.

This thesis is about the GPs' and OOH doctors' role in acute medical care, with an emphasis on conditions that require hospital admission. The GPs' and OOH doctors' acute referrals to hospital is a major dimensioning factor for hospital activity. During the COVID-19 pandemic, we experienced that the hospital capacity for acute care was threatened and got considerable public attention. Daily and weekly COVID-19 admission numbers were used both as an indicator of the pandemic's epidemiological development and as a measurement of pressure on hospital capacity. The number of infected patients as well as the applied referral routines for COVID-19 patients were crucial factors for hospital activity during the pandemic.

The example of COVID-19 illustrates the impact of the assessment of acute cases by primary care doctors for hospital capacity. The health care system must be prepared for changes in hospital demands. In this thesis we investigated hospital admissions several years before the pandemic.

Aspects of acute conditions

In this thesis the term *acute* reflects the sudden onset of the current condition or the need for urgent care. The term *severe* refers to conditions that are injurious to the persons health, whereas *critical* conditions refer to conditions where proper care is crucial to avoid negative health outcomes. There is a wide spectrum of severity in acute cases. For example, acute lower urinary infection has acute onset and unpleasant symptoms, but low severity. It is not a critical condition and can safely be treated in primary care. Acute myocardial infarction (AMI) has acute onset and unpleasant symptoms, but a high degree of severity. Further, AMI is a critical condition where hospital diagnostic procedures and treatment are crucial.

1.1 The Norwegian health care system

Norway had a population of 5.4 million inhabitants in 2022. The Norwegian health care system gets high scores on accessibility, patient satisfaction, and survival rates for specific diagnoses, and it is ranked as one of the best health care systems globally (1). It is also among the most expensive health care systems in Europe, and Norwegian health care expenditures accounted for 10.4% of the Gross Domestic Product in 2017, which was the fifth highest in the WHO European Region (2).

1.1.1 Organization

The Norwegian health care system is publicly funded, and all residents have access to necessary services including primary care and hospital services.

There are two organizational health care levels in Norway, primary health care and secondary care (specialized care). The municipalities are responsible for primary health care including general practitioners (GPs), organized as regular general practitioners (RGPs), and emergency primary care services called OOH services. As of 2018 there were 420 municipalities in Norway, but in 2020 the number of municipalities was reduced to 356.

The state is responsible for secondary care, including emergency medical call centres (EMCCs), ambulance services, and hospitals with emergency departments (EDs) (3). The secondary care is administered through the four Norwegian Regional Health Authorities and their local trusts.

There are also private specialists with contracts with the Regional Health Authorities, which regulate their services as part of public financed care. These specialists are called private specialists with public contracts (PSPCs) in this thesis.

Patients older than 15 years pay an out-of-pocket fee for most services, including consultations by general practitioners (GPs) and OOH doctors. The out-of-pocket fee for a GP consultation was 152–201 NKR and was 257–305 NKR for an OOH consultation in 2017–2018 (4). The maximum sum that a patient may pay per year was 2,258 NKR in 2018. Ambulance transport and hospital stays are free of charge.

Below follows a description of the Norwegian health care system with an emphasis on acute care.

1.1.2 Primary health care

1.1.2.1 Regular general practitioners (RGPs)

The RGP services are organized as patient list scheme (5), and more than 99% of the population is listed by a chosen GP (6). The mean list size in 2018 was 1,113 patients (6). The RGP provides primary care for the list patients, including chronic disease follow up and acute care during working hours (5). The acute care includes treatment of acute cases and referral to hospital admissions when required. RGPs are obliged to participate in the OOH services in the municipality where their RGP practice is localized (5).

Most Norwegian RGPs work in small group practices of 3–6 doctors. The colleagues in the group practice usually help each other in providing acute care for each other’s list patients in case of absence of the acute ill patient’s RGP. Sandvik et al. found that long-lasting RGP-patient relationships are associated with reduced need for OOH services and acute hospital admissions as well as with reduced mortality (6).

1.1.2.2 Out-of-hours (OOH) services

The municipalities are responsible for providing necessary acute primary care for all residents in the municipality through the OOH services. This includes assessing and guiding persons who request acute care, offering consultations and home visits by a doctor to diagnose and treat acute cases, and providing medical care in accidents and other acute cases via callouts (3).

The Norwegian Directorate of Health has published standardized guidelines for the organization, equipment, and staffing of OOH services, including local emergency medical communication centres (LEMCs) (7).

There is considerable variation in how the municipalities in Norway organize the OOH services and the LEMCs. In 2021 there were 168 OOH services (8). Half of the OOH services were organized as inter-municipal services, while the other half consisted of a single municipality.

The size of OOH services varies with 77 services having fewer than 10,000 residents in the area they cover, 80 OOH services covering 10,000–100,000 residents, and 11 covering more than 100,000 residents (8). The smallest are only staffed with one physician on call, which is the minimum obligation in the national regulations, while the largest have several physicians, nurses, and other care providers included in their services.

The OOH doctor makes telephone contacts, has consultations at OOH clinics, and makes home visits and callouts. A major task for the OOH doctor is the assessment of acute cases and referral of patients in need of hospital care.

As a result of GPs' obligation to participate in the OOH services, GPs perform about 60% of consultations and home visits in the OOH services (9). Also, interns are obliged to work OOH during their internship. In addition, other physicians perform OOH services without being a GP or an intern. In this thesis this diverse group is referred to as *OOH* *physicians* and consists of hospital doctors, scientific employed doctors, and other doctors participating in the OOH service in addition to their fulltime main occupation. In the biggest cities there are also large OOH clinics staffed with full time OOH physicians. In the Norwegian registries, it is only possible to identify the GPs and interns.

The OOH clinics are equipped with regular GP diagnostic and treatment facilities. Further, they are equipped for acute cases with, for example, automatic external defibrillators, advanced airway devices, and basic acute medication (10). In case of callouts and home visits, 60% of the OOH services have a dedicated and usually uniformed OOH vehicle (8).

1.1.2.3 Local emergency medical communication centres (LEMCs)

LEMCs are primary care call centres and are the primary point of contact for acute cases when there is suspicion of a non-life-threatening condition. In 2021 there were 94 LEMCs in Norway (8). LEMCs can be reached by the national OOH telephone number 116 117. At the LEMCs, registered nurses perform telephone triage and decide whether to give medical advice when appropriate, to offer a doctor consultation or home visit, or, in case of a severe accident or other severe acute case, to direct the call to the EMCC, which will make a callout for a physician and an ambulance.

In a cross-sectional study based on data from a representative sample of LEMCs, Raknes et al. studied the urgency level of contacts. They found that 72% were categorized by the nurse as *not urgent* (green), some of which could wait until the RGP's opening hours, 25% were *urgent* (yellow) and needed immediate assessment and care in the OOH services, and 3% were categorized as *life threatening conditions* (red) that should be handled by alarming both the ambulance and the OOH doctor.

1.1.3 Secondary care

1.1.3.1 Emergency medical call centres (EMCCs)

The EMCCs receive emergency calls from the public via the national medical emergency number 113 when life-threatening situations are suspected. In 2018 there were 16 EMCCs in Norway (11). The EMCCs are staffed with trained nurses or ambulance personnel who perform telephone triage (3).

The EMCCs use a triage system similar to the LEMCs. If the incident is recognized as a *life-threatening condition* (red), an ambulance is called out, often accompanied by an OOH doctor. If the case is triaged as *urgent* (yellow), the call is directed to the LEMC.

1.1.3.2 Ambulance services

In 2021 there were 530 ambulances in Norway (12). They were localized based on demographic considerations to achieve short response times for the population in case of emergencies. Each ambulance is staffed with two ambulance professionals with a minimum a specialized practical-oriented high school education (3). The ambulance service is organized as a part of the hospital services and is responsible for the transportation of patients, personnel, and equipment as well as for performing examination, prioritization, treatment, and monitoring of patients. In addition to the car ambulances, there are boat ambulances in areas with poor road infrastructure, and there are 14 helicopter emergency medical services for the most severe and critical cases.

The ambulance service cooperates with the EMCCs, LEMCs, and OOH doctors. For some well-defined severe and hyper-acute critical cases there are regional procedures for the ambulance to go directly to the hospital without involving the local OOH doctor. Examples of such conditions are stroke, AMI with ST elevation, severe traumas, and women in labour. The EMCCs perform the fleet management of the ambulance services.

1.1.3.3 Hospitals

In Norway there are 51 hospitals with emergency departments receiving acute cases. Due to demographic factors, there is a considerable variation in size and activity in these hospitals. The largest hospitals serve around 600,000 inhabitants, whereas the smallest serve approximately 30,000. There are around 800,000 hospital stays in Norway every year, and in the years 2015–2018 two thirds of all admissions were acute (13).

1.1.4 Prehospital paths for acute hospital admissions

Secondary health care in Norway is generally referral based. This also goes for acute referrals to hospital (14, 15). The referral agent is usually a GP or an OOH doctor, but it might also be a nursing home doctor. In addition, hospital doctors who follow up patients with severe chronic illness can make arrangements for admitting the patient, if necessary, either as an outpatient follow up or by direct contact from the patient. In acute severe cases the ambulance services might bring the patient directly to hospital according to regional procedures or by agreement with the EMCC. In Norway there is no formal system for self-referring to hospital.

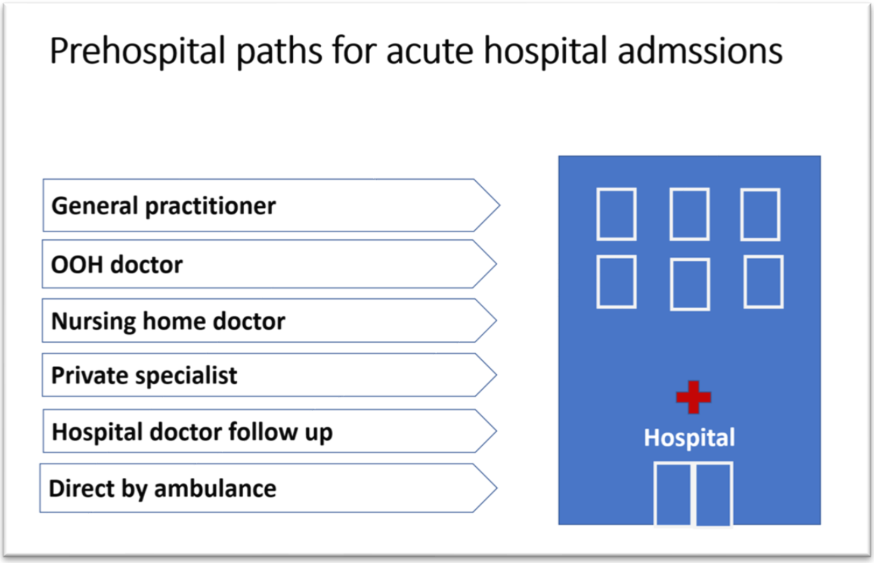

Figure 1. Prehospital paths for acute hospital admissions illustrating the referring agent.

In a small study including 255 patients from a medical department in eastern Norway, Grondahl et al. found that 26% of the admitted patients came from GPs, 31% came from OOH services, 18% came from secondary care (hospitals or outpatient clinics), 6% came from other institutions (e.g. nursing homes), and 18% were direct admissions (14).

According to regional ambulance procedures, it is expected that the most acute cases where the time from onset to treatment is crucial will go directly to hospital by ambulance. In a Norwegian study from 2009–2010 it was found that most patients with stroke contacted EMCCs and were admitted by the ambulance services, but 36% first contacted the GP or OOH services (16). In a prospective observational study from the Netherlands of 202 patients with acute coronary syndrome and 243 with stroke, almost half of the patients first contacted the GP (17).

The national numbers and distribution of prehospital paths for acute hospital admissions in Norway has not been available. Despite substantial attention and efforts to reduce time to hospital for the critical conditions of stroke, AMI, severe traumas, and sepsis, the prehospital paths for these and other acute conditions are not described at a national level, and the roles of GPs and OOH doctors regarding different clinical conditions are not fully clarified.

1.2 Medical care at different levels

1.2.1 Ecology of medical care

Most cases of minor acute illness are managed with self-care, but it is of major importance for the public to have access to proper acute medical care when needed. Most acute patients can be treated safely and adequately in primary care, whereas some need hospital care.

White et al. described the prevalence of illnesses and injuries and the utilization of primary care and hospital services in 1961 in the famous and much referred to paper "The ecology of medical care" (18). The paper estimated that during one month for every 1000 adults at risk 750 reported one or more illnesses or injuries, 250 consulted a physician, and 9 were admitted to hospital. Similar analyses have been performed more recently, and the results published by Green et al. in 2001 and Johansen et al. in 2016 show remarkably stable use of health services, including hospital admissions at just below 10/1000 (19, 20).

THE ECOLOGY OF MEDICAL CARE

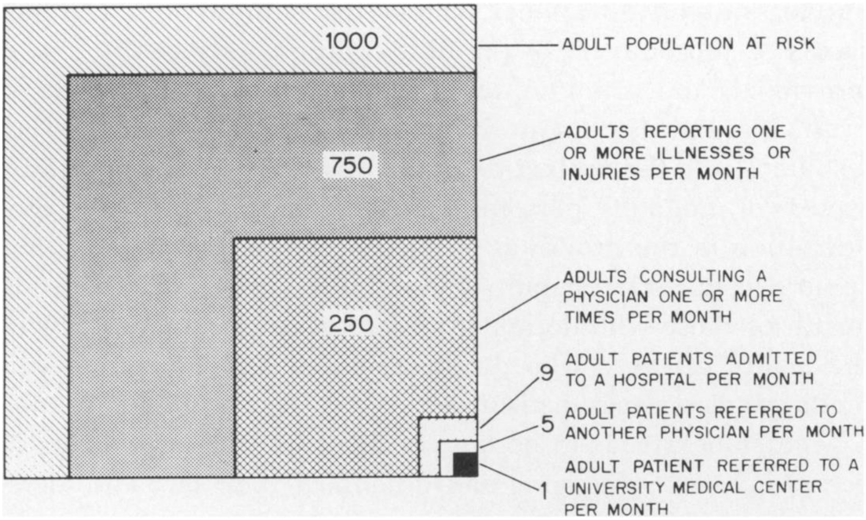

FIGURE 1. Monthly prevalence estimates of illness in the community and the roles of physicians, hospitals, and university medical centers in the provision of medical care (adults sixteen years of age and over).

Figure 2. Illustration Figure 1 from the article by White et al. Ecology of medical care (18). (Source: Screenshot from the journal, open access.)

Even if only the most severe cases of acute illness require hospital admission, acute cases dominate hospital activity and costs (13). According to The Norwegian Directorate of Health's public online statistics 72% of the hospital stays in the first quartile of 2022 were acute admissions.

1.2.2 Gatekeeping and referral practice

The goal for primary care doctors in acute care is to deliver high quality services for conditions of different degrees of urgency and severity. The majority of acute cases in primary care need examination and treatment that can safely be performed outside hospital. Nevertheless, the most severe cases need hospital admission.

One could use the term “door opener” with regard to the primary care doctor’s role as a facilitator of hospital care. In the literature the term “gatekeeper” is more common, but it has led to considerable debate (21). Gatekeeping emphasizes the guarding of the gate, focusing on not letting too many in rather than providing the best health service to all patients and opening the gate to the patients in need of hospital care.

In a health care setting, the term “gatekeeping” means that the patients are required to visit a primary care physician who will authorize access to secondary care, hospital care, and further tests (22-24). In many health care systems gatekeeping is used to improve acute care and reduce utilization of secondary care and thereby reduce hospital workload and public expenditures on health care (22, 23).

The gatekeeping system was introduced in the United Kingdom early in the twentieth century (25). Several studies have investigated the effect of gatekeeping, and a systematic review by Sirpa et al. capturing literature up to September 2017 including 25 studies found an association between gatekeeping and better quality of care, particularly for preventive care and appropriate referrals to specialty care and tests (23). Gatekeeping results in lower utilization of specialty health services, including fewer hospitalizations, but also more primary care visits because all patients going to specialty care must visit a primary care doctor in advance. Further, Sirpa et al. found lower patient satisfaction in a gatekeeping system compared to direct access (23). One study from 2011 reported poorer outcome for patients with cancer in a gatekeeping systems, possible due to diagnostic delay (26).

Internationally there has been a debate on the primary care doctors’ gatekeeper role (27). The evidence of the general impact of gatekeeping in a health care system is not clear, partly because of heterogenicity in health care systems and in the studies exploring gatekeeping. Therefore, there has been a call for more research on health outcomes in health systems with different gatekeeping arrangements and different degrees of gatekeeping (23, 27). Knowledge at patient and consultation level to reveal likelihood for referral for specific complaints and subsequent clinical outcome has been stressed (28).

Researchers have shown large differences in referral practice between primary care doctors for referrals to secondary health services, including acute hospital admissions (29-33). A British study of OOH doctors including a population of 167,000 persons from 2001–2004 showed an almost fivefold difference in referral rate from the lowest to highest quartile of referrers (31). A recently published study of variation in referral rates to a hospital ED between general practices showed a 2.53-fold variation between the highest and lowest quartiles (28). Studies exploring GPs' and OOH doctors' referral rates for acute admissions to hospital have not been performed in the Norwegian health care setting, and internationally the impact of different referral practice has been poorly explored.

1.2.1.1 The patient perspective

From a patient perspective it is essential that acute critical conditions are recognized when the health services are contacted. Minor conditions can easily be handled with self-care, sometimes supported by advice from health care professionals (34, 35). Midtbø et al. found that 26% of all contacts to Norwegian LEMCs were handled by nurse counselling, while other cases might require consultation by a GP or OOH doctor.

Many acute medical conditions require immediate examination and treatment to obtain good health outcomes, avoid complications, and save lives. Examples of such critical conditions are acute coronary syndrome (36), sepsis (37), traumas (38), stroke (39), pulmonary embolism (40), and acute appendicitis (41).

Proper acute care promotes public trust in the health services, and access to quality essential health care services is included in the United Nations Sustainable Development Goal number 3.8 (42).

1.2.1.2 Health care utilization- effects of different degrees of gatekeeping

Health care across the world is facing increasing pressure due to more elderly and multimorbid patients and increased therapeutic possibilities (43). Countries have different models of health care organization regarding access to acute hospital care. In some countries patients have direct access to hospital services and can show up directly in a hospital ED (44). However, direct access burdens the hospital's ED and may lead to crowding of unselected patients and a higher proportion of non-acute patients in the ED. It has been shown that ED crowding leads to poorer patient outcome and higher costs (24, 45, 46). Poor access to primary care has been identified as a cause of ED crowding (44, 47, 48), and gatekeeping by primary care has been suggested as a solution to ED crowding (43, 44).

In a health care system with gatekeeping, it is important for patient safety that the gatekeepers identify and refer patients with critical conditions. Low referral practice with few referrals as a proportion of total contacts will reduce hospital workload and costs, but the risk of overlooking critical conditions has been suggested by Svedahl et al. in a recently published Norwegian study (32). On the other hand, a high referral practice will lead to high patient numbers at hospital and increased hospital costs and workload.

With high referral practice, one expects that more of the patients referred will have no critical conditions revealed at hospital (43). These referrals are often called unnecessary referrals or avoidable admissions, and several initiatives have been undertaken to identify and reduce unnecessary referrals by reducing referral rates from the gatekeeper (14, 49, 50). Lillebo et al. found in 2013 that according to the referring physician 21% of acute hospital admissions from OOH service could have been avoided if eligible alternatives were available, and Grondahl et al. found that 7% of acute admissions to a medical hospital department could have been avoided (14, 49). In a Norwegian study from a medical department from 1999, Eriksen et al. found that 24% of the admissions were inappropriate, but these admissions accounted for only 12% of the hospital costs (51). In England there has been an economic incentive for GPs to reduce referrals to secondary care, but the safety of this has been questioned (50). Further research using OOH data linked with hospital admission data to determine the impact of variation in OOH referral rates has been requested (52).

1.2.1.3 The gatekeeper perspective

In a health care system where primary care doctors perform gatekeeping for secondary health services, the gatekeeper's major dilemma is to identify the patients in need of secondary care without overlooking critical cases while at the same time not overloading the hospital capacity (22, 27). This is a professional challenge for the doctor and might be a considerable personal burden. In a qualitative study of GPs' management of cardiorespiratory consultations in an OOH-setting from the Netherlands, researchers revealed that GPs found these consultations challenging and difficult, leading to high number of referrals (53). Tension and uncertainty, as well as defensive behavior, were the key themes.

In a scoping review on ED physicians' clinical reasoning published by Pelaccia et al. in 2020, they found that clinicians relied on knowledge based on their clinical experience when making decisions, and experts relied on their intuition to a greater extent than novices (54). When it comes to assessing the need for acute admissions to hospital, clinical reasoning is influenced by the clinician's fear of litigation and malpractice (22, 54).

Gatekeeping is recognized as a tool for reducing ED crowding (43, 44). The doctors with high referral practice working in a health care system already under pressure increase ED crowding and hospital workload. For health care administrators, the hospital costs are a major concern, and both hospital workload and costs call for a thorough assessment by the gatekeeper when referring patients to hospital care.

Patient safety has been given increased attention, and this is reflected in health care regulations (55, 56). In Norway the processing of patient complaints by the Norwegian Board of Health Supervision (NBHS) focuses on uncovering errors made by health care workers. Examples of reactions from the NBHS after uncovered errors are a formal warning, limited authorization as a health care worker, or withdrawal of authorization. Withdrawal or limited authorization is usually due to drug abuse on duty or providing unregulated prescriptions. Poor medical assessment may result in a formal warning.

Medical errors in OOH services regarding assessment of acute illness for referral, sometimes with tragic outcome, are often published in the press (57-59). The public are concerned about patient safety, and the attention and description in the press may indicate low-quality health care and ignorant health care workers. To be disclosed as an incompetent doctor in the press is a frightening perspective for health care workers attending acute care patients (54).

Often the gatekeeper's decision to refer an acute case is based on limited information and under time pressure. Assessment of acute conditions is a difficult task with a higher risk of unfavourable outcome and errors compared to other health care services (56, 60).

Primary care doctors performing gatekeeping functions for acute hospital referrals may be concerned about the risk of errors leading to poor outcome for the patient as well as formal reactions from the NBHS or negative attention from the press. Al together, this may lead to defensive medicine and higher referral rates (54). On the other hand, pressure from hospitals or other incentives to reduce referral rates may lead to low referral rates (50).

1.3 Diagnoses

Using diagnoses is a way for health care workers to categorize complaints, diseases, and injuries and is a useful tool in medical work and communication.

1.3.1 Diagnostic classification systems

The WHO publishes the International Classification of Diseases (ICD), which has been used for comparable statistics, mortality, and morbidity studies for more than a century. ICD defines symptoms, diseases, and injuries by a code containing one letter indicating an organ system and a number indicating the specific condition. The number of digits in the code indicates the level of detail in the diagnosis classification. As an example, AMI is coded I21, and I21.0, I21.1, I21.2, I21.3, I21.4, and I21.9 signify different localizations of the myocardial infarction. The ICD system is well suited for hospital services and secondary care. In Norway, the International Statistical Classification of Diseases and Related Health Problems version 10 (ICD-10) is used when secondary care reports activity to the National Patient Registry (NPR) and the Norwegian Cause of Death Registry.

Primary care requires a diagnostic framework suited for the nature of primary care services and the primary care epidemiology. The World Organization of Family Doctors (WONCA) took the initiative to develop the International Classification of Primary Care (ICPC) in 1972 and owns the rights to the classification (61). The ICPC system classifies symptoms, diseases, and injuries into conditions according to a code. Each code contains a letter reflecting the organ system and a two-digit number giving the specific condition. AMI is coded as K75, where K represents the circulatory system and 75 the specific condition. A few ICPC-2 conditions have three digits.

The second version – ICPC-2 – was published in 1998. In Norway we use ICPC-2 in primary care, and GPs and OOH doctors are obliged to use at least one ICPC-2 diagnosis when sending a claim to The Norwegian Health Economics Administration (HELFO) and when prescribing a sick leave (62).

1.3.2 Diagnoses in acute care

In Norway, musculoskeletal, respiratory, skin, digestive, and unspecific disorders are the most frequent reasons for encountering OOH services (63). The most frequent diagnoses given at an OOH consultation in Norway before the COVID-19 pandemic were Upper respiratory infection acute (R74), Abdominal pain/cramps general (D01), and Laceration/cut (S18) (9). In Denmark, injury and poisoning is the most frequent diagnosis chapter for short hospital contacts and hospital admissions from both EMCCs and LEMCs (64).

In Norway there is no link between information on the referral contact leading to hospital admission and the hospital data. Therefore, information on primary care diagnosis codes for the contacts resulting in acute referral to hospital has not been available, nor have hospital diagnoses after referrals from different referral agents. This information is important for the understanding of GPs' and OOH doctors' role in acute referrals to hospital.

1.3.3 Critical diagnoses

Many acute medical conditions require immediate diagnosis and treatment at hospital to obtain good health outcome, avoid complications, and save lives. Examples of such conditions are acute coronary syndrome (36), sepsis (37), stroke (39), pulmonary embolism (40), acute appendicitis (41), and severe traumas (38). The Norwegian clinical handbook for OOH services recommends acute admission when these conditions are suspected (38). National registries on stroke, heart infarction, traumas, and cardiac arrests have been established the recent years, but the primary care involvement in these conditions is poorly investigated.

1.4 Norwegian health registries

1.4.1 National health registries

In Norway, the nationwide health registries facilitate large-scale health services research (65). It is mandatory for public health services to supply information to these national registries, which include personal identification number, administrative data, type of contact with health care, procedures performed, and diagnoses.

The NPR contains information on all public hospital and PSPC activity and in Norway from 2008. The Control and Payment of Reimbursement to Health Service Providers database (KUHR) contains information on all patients who have visited GPs or OOH doctors from 2006.

The registry data in the KUHR are produced by the primary care physicians, whereas the NPR data are produced partly by clinicians and administrators in secondary health care. The data were originally delivered for administrative and financial purposes, but these national health registries are well suited for epidemiological studies on patient utilization of health care both in primary care and secondary care (6, 32). By linkage of the registries, patient trajectories across care levels may be studied (65).

1.4.2 Access to registry data and data management

The registries contain sensitive data at the personal level including diagnoses and treatments. Therefore, there are strict regulations on access to health registry data with considerable administrative procedures to get access to the data (66). Although there have been initiatives to simplify the administrative procedures, there has been little progress in reducing the administrative burden in getting access to health registries. This goes for administrative workload and time spent waiting for access (67).

When all required permissions are given, the register owner is ready to deliver data to the researcher. This implies a thorough description of the required dataset. Nevertheless, there are numerous possible pitfalls in this process, some obvious to the researcher and some more hidden. Important issues are the completeness of the delivered material, the data format, and the included variables. This requires substantial processing, including quality control of the data set. To protect personal sensitive data the registry administrator prepares the data separated from the researcher.

Data management with large data sets is complicated and using large-scale third-party data for performing specialized procedures is both a strength of the project as well as a risk for hidden errors.

2. Aim of the present study

The aim of this study was to investigate GPs' and OOH physicians' roles as gatekeepers for acute hospital admissions in Norway and to investigate the impact of different referral practices.

The aim was fulfilled by three substudies, each resulting in a published or submitted paper:

Substudy I: To study the prehospital paths for acute admissions to somatic hospitals in Norway and to investigate the variation in GP's and OOH physician's roles as gatekeepers, with respect to geographic centrality, time of day, and different clinical conditions (**Paper I**).

Substudy II: To investigate the spectrum of reasons for acute referral to hospital from GPs and OOH doctors in Norway, including referral rates for the most frequent ICPC-2 diagnoses, and the relation between common referral symptoms/diagnoses and the discharge diagnoses from hospital (**Paper II**).

Substudy III: To investigate the variation in OOH doctors' referral practice for acute referrals to hospital and the impact of the variation on referrals where no disease is revealed at hospital and referrals where critical conditions are diagnosed (**Paper III**).

3. Materials and methods

The registry data collected and prepared for this study are also the source for several other studies under the main project called *Health Care Utilization in Norway*. In addition to the current study exploring referrals to acute hospital admissions and GPs' and OOH doctors' roles as gatekeepers, the overall health care utilization project has covered other topics. A study on continuity of care found strong associations between long-lasting RGP-patient relationship and lower use of OOH services, fewer acute hospital admissions, and lower mortality (6). That publication has achieved considerable attention and impact on the scientific and public debate on primary care organization, especially in England (68). Also, continuity of care among patients with chronic diseases has been investigated, and we found the continuity of care for these patients to be high in Norway (69). Furthermore, there is an ongoing study exploring GPs' and OOH doctors' roles in prehospital severe trauma care.

3.1 Study setting and data sources

This study was performed using registry data from all inhabitants in Norway from 2013 to 2018. The Norwegian population was 5,051,275 at the start of 2013 and 5,328,212 at the end of 2018 (70).

Three data sources were used:

- The KUHR, which contains information about GP and OOH activity in Norway.
- The NPR, which contains information on all secondary health care activity in Norway.
- Statistics Norway (SSB), which provides information on demographic data on all residents.

3.1.1 Control and Payment of Reimbursement to Health Service Providers Database (KUHR)

HELFO administers the KUHR and receives compensation claims from all GPs and OOH physicians. Every contact with a GP or OOH physician results in a claim to the KUHR, and each claim contains the patient's personal identification number, the patient's age and sex, the time and date of the contact, the type of contact (e.g. telephone contact, consultation, or home visit), and one or more ICPC-2 diagnosis codes (61, 62). In addition, the claim contains information about the provider, including the provider's identification number, age, and sex and the municipality where the service is performed.

In the KUHR, the claims contain codes specifying the type of contact, including consultations (2ad, 2ak, 2ae, 2fk), home visits (11ad, 11ak), short or simple contacts (1ad, 1ak), or telephone contacts (1bd, 1bk, 1f, 1g). The type of primary care service is also defined in the KUHR and is categorized into GP or OOH contacts. Contacts by interns during regular daytime hours are defined as GP activity but can still be identified as intern contacts in the data. The KUHR contains no information on physician activity in nursing homes.

The data in the KUHR are collected for reimbursement purposes but are widely used in primary care research (65). The Norwegian Directorate of Health owns both the KUHR and HELFO. From 2017, the KUHR has been part of the Norwegian Registry for Primary Health Care.

3.1.2 Norwegian Patient Registry (NPR)

The Norwegian Directorate of Health owns and administers the NPR (13, 66). The NPR contains information on all persons who have been in contact with and have received treatment in Norwegian secondary health care, including hospital care and PSPCs. The record for each contact includes the patient's personal identification number, the date, time, and type of contact (e.g., outpatient consultation or hospital stay including length of stay), the degree of urgency, and one or more ICD-10 diagnostic codes. Up to 2017 the NPR also included data regarding the OOH activity of the second largest city in Norway (Bergen). Admissions to psychiatric institutions were not included in this study.

3.1.3 Statistics Norway (SSB)

The SSB provides demographic data on all residents in Norway, including date of birth, sex, home address, and date of death. Information on municipality population and centrality is available from the SSB. Centrality is a description of a municipality's geographical position in relation to workplaces and public services, and the SSB sets a value from 0 to 1000 for each municipality (71). This value allows the municipalities to be categorized into 6 groups where centrality group 1 represents the most central municipalities and group 6 represents the least central (rural).

3.2 Study design

The study was designed as a registry-based observational study. The different data sets for substudies I-III will be described separately.

3.2.1 Linkage procedures and identification of referral doctor

The SSB identified the population living in Norway from 01.01.2012 to 31.12.2018. All residents were given a serial number in addition to their personal ID number, and these numbers were sent to the NPR and KUHR. The NPR and KUHR replaced the personal ID numbers in their registries with the serial number before delivery of the data to the researchers. The SSB delivered demographic data where the personal ID number was replaced with the serial number. Thus, data from all registries could be combined without revealing the patient's identity.

All GP and OOH contacts are recorded in the KUHR, and all acute hospital admissions are recorded in the NPR. However, neither the NPR nor the KUHR includes information on the referring agent (institution or person) for secondary care. Therefore, we made the assumption that if a patient visited a GP or an OOH physician less than 24 hours before the starting time of an acute hospital stay this contact was related to the admission, and this was defined as the referring contact. To account for documentation delays in primary care, contacts within 12 hours after the time of admission were also included.

Definition of primary care doctors

There are several terms describing the different categories of primary care physicians. In this thesis they are defined as follows:

GP: A doctor sending claims to the KUHR registry categorized as GP activity.

OOH doctor: A doctor sending claims to the KUHR registry categorized as OOH activity. An OOH doctor can be a GP or an intern at daytime.

Intern (**Paper III** only): A doctor sending claims as an intern to the KUHR registry during the actual calendar year.

OOH physician (**Paper III** only): A doctor only sending claims to the KUHR registry categorized as OOH activity during the actual calendar year. (Not sending claims as a GP or an intern.)

3.2.2 Dataset for substudy I

In substudy I the focus was on the prehospital paths for acute hospital admissions. The dataset was constructed by extracting all acute hospital admissions in 2014 and linking them to a previous KUHR contact as described above in section 3.2.1. As shown in Figure 1, the patient's serial number and the time of the contact and admission were crucial for the linkage. Not all acute hospital admissions had a corresponding KUHR contact.

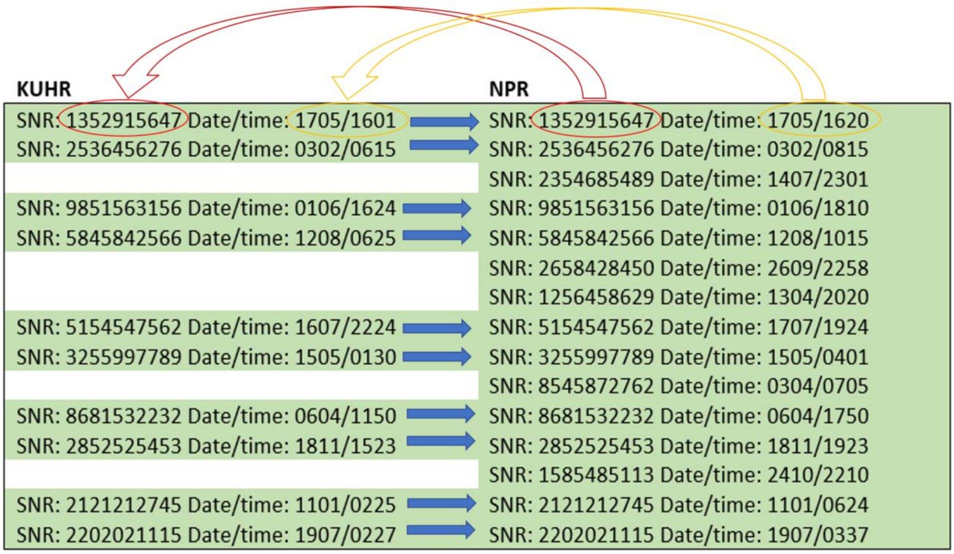

Figure 3. Model illustrating the architecture of the dataset used in substudy I, showing each patient's serial number (SNR) and date and time (date/time) for the contact, both of which were used for the linkage of the primary care contact in the KUHR and the acute hospital admission in the NPR.

Definition of variables

Prehospital contact. A prehospital contact by a GP or an OOH doctor was defined by a KUHR claim containing the codes for consultation (2ad, 2ae, 2ak, 2fk), home visit (11ad, 11ak), short or simple contact (1ad, 1ak) or telephone contact (1bd, 1bk, 1f, 1g). In substudy I the aim was to study GP's and OOH doctor's roles as gatekeepers to acute hospital admissions. Therefore, we included both consultations, home visits, simple contacts and telephone contacts as primary care contacts.

Prehospital path. The KUHR defines the type of service as a GP or OOH service, allowing the prehospital contacts to define the prehospital path. If we found no corresponding GP or OOH contact, the admission was classified as a direct admission.

Discharge diagnosis. We used the ICD-10 for discharge diagnoses given in the NPR to describe the current condition. The first three characters were used to describe the specific conditions, whereas only the first character was used to analyse diagnosis chapters. For patients with more than one discharge diagnosis, we used the primary diagnosis. By using the NPR discharge diagnosis, we could also describe the actual condition for patients who had not seen a GP or OOH doctor.

In Norway, women in labour contact the hospital directly for admission to the maternity ward. Therefore, direct admissions for birth-related conditions (ICD-10: Outcome of delivery (Z37), Liveborn infant (Z38), and Conditions in the perinatal period (P)) were excluded.

3.2.3 Dataset for substudy II

In substudy II the aim was to investigate the reasons for referral after GP and OOH contacts. KUHR data from 2017 were linked to the corresponding acute hospital admission in the NPR as described above in section 3.2.1. Figure 4 shows that only a small proportion of the KUHR contacts were followed by an acute hospital admission.

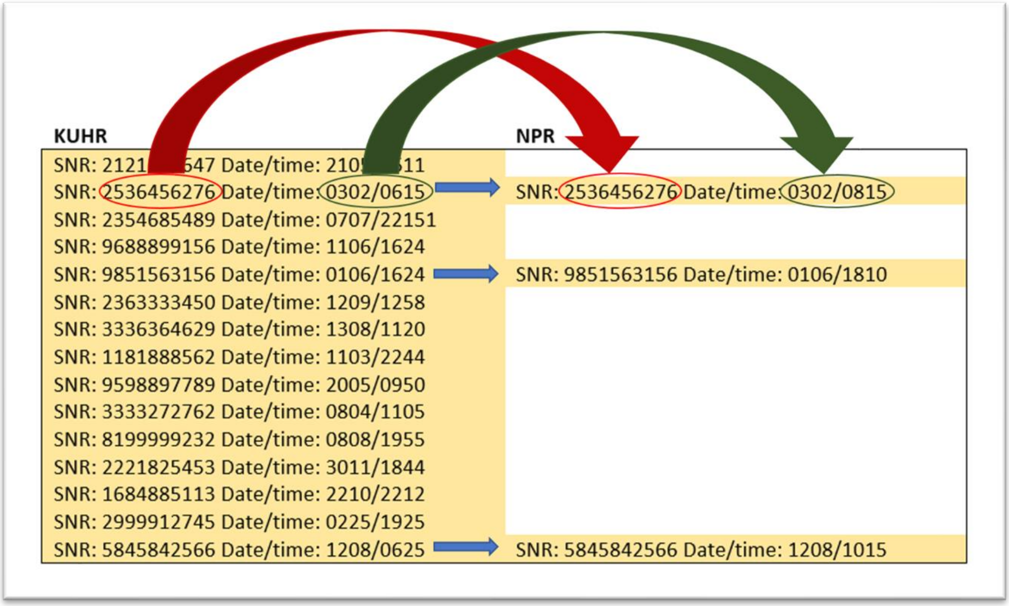

Figure 4. Model illustrating the architecture of the dataset for substudy II, showing the patients' serial number (SNR) and date and time (date/time) for the contact, both of which were used for the linkage of the primary care contact in the KUHR and the acute hospital admission in the NPR. We used a similar architecture for the dataset in substudy III.

Definition of variables

Referral diagnosis. In substudy II we used the KUHR ICPC-2 diagnosis to describe the condition assessed in primary care, hence the reason for referral. We only used consultations and home visits as primary care contacts in this study because the referral diagnosis was an important variable and the reliability of the diagnosis for simple contacts was more uncertain (9). The contacts were identified in the KUHR by the codes for consultations (2ad, 2ae, 2ak, 2fk) and home visits (11ad, 11ak).

ICPC-2 diagnoses were used to group presenting complaints into the three major reasons for referral – abdominal pain, chest pain, and shortness of breath.

The *abdominal pain* symptom group was defined as:

- Abdominal pain/cramps general (D01)
- Abdominal pain epigastric (D02)
- Abdominal pain epigastric other (D06)

The chest pain symptom group included:

- Chest pain not otherwise classified (NOS) (A11)
- Heart pain (K01)
- Pressure/tightness of the heart (K02)
- Cardiovascular pain NOS (K03)

The shortness of breath symptom group included:

- Pain in the respiratory system (R01)
- Shortness of breath/dyspnoea (R02)
- Wheezing (R03)
- Breathing problem other (R04)

When comparing the reason for referral with the hospital assessment, we used the primary discharge diagnosis (ICD-10) from the NPR.

3.2.4 Dataset for substudy III

In substudy III we assessed solely OOH doctors and their referral practice.

Definition of variables

We used only OOH consultations (codes 2ad and 2ak) in substudy III due to large variations in referral rates between home visits and consultations. We linked the consultations to the corresponding acute hospital admissions for the years 2016, 2017, and 2018 in a similar manner as in substudy II (Figure 4) described above in section 3.2.3.

Type of doctor

We categorized all doctors performing the OOH service as an intern, a GP, or an OOH physician. Interns were defined as a physician who had intern contacts in the KUHR in the same year as the current OOH contact. GPs had GP contacts the same year as the current OOH contact, but no intern contacts. OOH physicians had neither intern nor GP contacts in the same year as the current OOH contact.

Referral practice

We first calculated the individual doctor's referral rate by dividing the doctor's acute hospital referrals with all OOH consultations performed by that doctor. Then we calculated the overall referral rate for the whole municipality where the doctor performed the consultations by dividing all referrals from the municipality by all consultations in the municipality. To compensate for local organizational factors, local demography and local deprivation status the doctor's referral rate was then divided by the municipality's referral rate, estimating a variable we denoted as the individual **doctor's referral practice**. Thus, it was possible to categorize the doctors according to the context of the OOH service and the general referral rate in their municipality's OOH service.

Doctor's individual referral rate = Doctor's referrals / Doctor's OOH contacts
Municipality's referral rate = Municipality's referrals / Municipality's OOH contacts
Doctor's referral practice = Doctor's referral rate / Municipality's referral rate

Lastly, based on the doctor's referral practice, the doctors were divided into low, medium-low, medium-high, and high referral practice quartiles (Figure 5). Dividing doctors' referral practices into quartiles is common when studying this phenomenon (30-32).

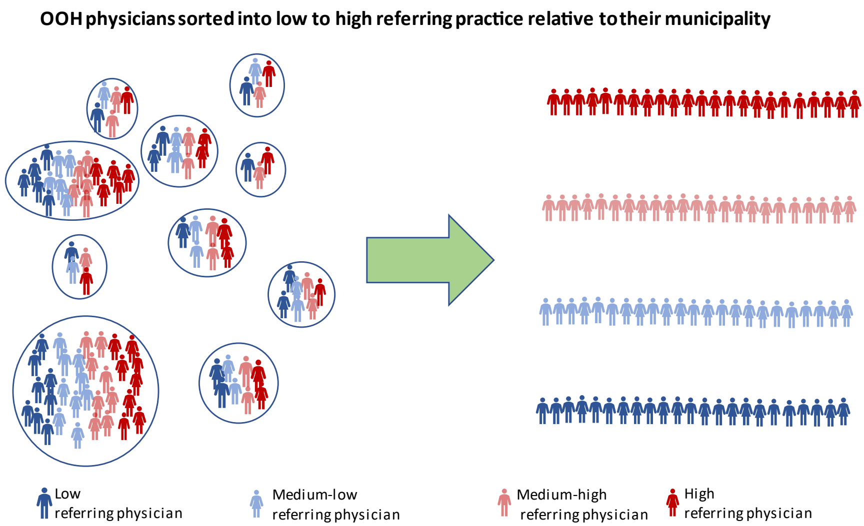

Figure 5. Physicians divided into quartiles from low to high referral practice relative to the municipality where they perform the OOH practice. The circles illustrate the municipalities hosting the OOH services.

Critical diagnoses and symptom diagnoses

We used the ICD-10 discharge diagnoses from the NPR to identify the selected critical conditions: AMI (I21), Acute appendicitis (K35), Pulmonary embolism (I26), and Cerebral infarction (I63). When no severe disease is revealed at hospital, symptom-describing diagnoses are applied upon discharge. Therefore, the NPR ICD-10 discharge diagnoses were also used to identify the admissions where no severe disease was revealed. We wanted to study the symptoms corresponding to the selected critical conditions above and which we identified in substudy II, namely Pain in throat and chest (R07), Abdominal pain (R10), Abnormal breathing (R06), and Dizziness (R42). By using the discharge diagnosis instead of the OOH physician's ICPC-2 diagnosis, we accounted for the substantial investigations performed at the hospital that provide a more reliable diagnosis. We also avoided the considerable bias concerning the OOH physician adjusting ICPC-2 coding to their choice of action, to refer or not to refer.

Both AMI and stroke are included as major critical emergencies in “The first hour quintet” of the European Emergency Data Project along with cardiac arrest and severe trauma, both of which are less frequent in an OOH setting (72). The last condition in “The first hour quintet” is severe breathing difficulty.

Morbidity

The ICPC-2 diagnoses in all GP and OOH contacts from the KUHR in 2013-2015 were used to calculate the ICPC morbidity index (73).

Mortality

The date of death was obtained from the SSB and was linked to the date of consultation. Thus, we could create a dichotomous variable for 30-day mortality.

Exclusions

In substudy III physicians lacking an ID number were excluded.

In the largest cities in Norway, Oslo, and Bergen, we observed divergent OOH services with different referral practices within the municipality. This probably reflects the existence of several OOH clinics in the municipality with different external factors affecting the referral practice, e.g., triage and patient selection. Hence, we could not calculate the individual doctor’s referral practice according to the OOH service he or she was working in. Therefore, Oslo and Bergen municipalities were excluded.

We also excluded contacts where the physician had changed physician type or municipality. Further, contacts originating from municipalities with fewer than 1000 consultations were excluded. Finally, we excluded physicians with fewer than 50 consultations.

3.3 Analyses and statistical methods

In substudy I prehospital paths, discharge diagnoses, and centrality were investigated and presented by numbers and rates without any statistical tests. Further, prehospital paths were described as the average number of admissions per hour.

In substudy II the number of contacts with different ICPC codes and the contacts leading to referral were obtained. Referral rates were calculated for GP and OOH contacts separately. A generalized linear model (GLM log binomial regression) was used to estimate associations between referral symptom groups and discharge diagnoses and between disease-specific referral diagnoses and discharge diagnoses. Patient age, sex, and if the patient had attended a GP or OOH doctor were used as explanatory variables and were adjusted for each other. The associations were presented as the relative risk (RR) with 95% confidence interval (CI). The log-binomial regression did not converge for three of the models, and we used a Poisson regression with robust variance to estimate the RRs (74).

In substudy III we described the distribution of OOH doctors' characteristics (sex, age, type of doctor, and OOH activity) with referral rates and distribution by referral practice quartiles. Three GLMs (log-binomial regression) were used to estimate the associations between doctor characteristics and the risk of being in the high versus the low referral practice quartile. The analyses were performed as crude, adjusted for doctor factors, and adjusted for doctor factors and the patient factors of sex, age (<16 or >69 years), morbidity, and night versus daytime or evening. Furthermore, we used GLM to estimate the RR of being referred to hospital after an OOH consultation for each of the doctor referral practice quartiles after adjusting for patient factors. In the same way we estimated the RR to be referred and given one of the diagnoses of Pain in throat and chest (R07), AMI (I21), Abdominal pain (R10), Acute appendicitis (K35), Abnormal breathing (R06), Pulmonary embolism (I26), Dizziness (R42), or Cerebral infarction (I63) after a consultation with a doctor in the different referral practice quartiles. Finally, we calculated the RR for 30-day mortality for patients not referred and the patients referred to hospital using the same method.

The analyses in substudy I were performed using Stata® 15.0 (Stata Corp., College Station, TX, USA). The analyses in substudy II and III were carried out using Stata 16.1.

3.4 Registry research

Large-scale registry research presupposes complete data sets. The administrator of the registry data often represents another institution than the researcher. To protect sensitive personal data, the registry administrator prepares the data separated from the researcher. Sometimes the control of the completeness of the dataset is out of the researcher's hands. In large datasets, this fact may also account for data linkage and the production of data subsets for analyses.

3.4.1 Reasons for correction in Paper I

The research data from the NPR and KUHR registries were delivered to our data handling institution, the University of Bergen, and directed to the institutional data processing centre for preparation of the research datasets. These datasets were first used for substudy I.

After **Paper I** was published and during analyses in substudy II, we became concerned that there might be some missing data in our KUHR file. This KUHR file was used in the preparation of research files for both substudy I and II. The expected numbers of GP and OOH doctor contacts did not correspond with what we found in our research dataset for substudy II. Because this total number of contacts was not available in the research dataset for substudy I, as presented in **Paper I**, the possibility of missing data could not have been discovered earlier.

After scrutinizing the data files and comparing with other external sources, it appeared that 8% of the GP and OOH physician contacts were missing in our original dataset. This appeared to be due to damage in our original file from the registry owner. It is impossible to clarify if the damage occurred during data extraction from the original data source, during export, during import, or in local storage, but it seems that there was a data size limit for a data file during one of these procedures. We discovered that the last observations in the original datasets were abruptly cut between variables without completing the observation. The exact explanation for this kind of damage to the data file is not known. Because the technical personnel at the data processing centre used the damaged file to create our research file, the error was hidden to the researchers and an incomplete research file was used for the analyses in **Paper I**.

When we became aware of the lack of data, we revised and controlled all the datasets and analyses. We then discovered a second error in our data material. During the linkage of the primary care contacts in the KUHR with emergency admissions in the NPR, regrettably all telephone contacts at night and interdisciplinary telephone contacts were not linked with the acute referrals to hospital. This accounted for 3% of emergency admissions.

Both described errors were of technical origin and had their origin outside the research group. They seriously affected the results in **Paper I** as most numbers were wrong. However, because the missing data constituted only a minor part of the total dataset, the main conclusions of the article were not affected. When we became aware of the situation, we contacted the Editor-in-Chief of the publishing journal, *BMC Health Services Research*, and informed them about the situation and asked for advice. The Editor showed understanding for the situation and encouraged us to prepare a correction containing new results and an updated discussion section, which was done. The correction is now linked to the original article both in PubMed and on the journal's website. In the Results and Discussion sections we use the corrected version of **Paper I** when presenting numbers, interpretations, and conclusions.

3.5 Research ethics and patient data protection

Gatekeeping for acute hospital admissions may have major impacts on patient safety and on hospital workload and costs. Furthermore, correct gatekeeping is a professional challenge and might be a considerable personal burden for the gatekeeper. Therefore, this topic should have the health services researcher's attention.

3.5.1 Ethical approvals

This study used pseudo-anonymized data by replacing the patient's personal identification number with a serial number. The sensitive information about the individual's health conditions recorded in the registries was therefore not accessible for the researchers. The data were presented at the group level to minimize the risk of backward identification.

The Regional Committee for Medical Research Ethics Western Norway (REK West) approved the project and waived the requirement for informed consent for the study on 30.01.2014 (reference number 2013/2344/REK West). Permission for a prolonged project period was given by REK West on 18.07.2019. The use of the data for research purposes was approved by the Norwegian Data Protection Authority on 15.09.2014 (reference number 14/0322-9/CGN). SSB, the Norwegian Directorate of Health, and the register owners approved the linkage of the registries.

4. Results

This section presents the main findings from **Paper I, Paper II** and **Paper III.** Again, due to the major correction for **Paper I**, the results from this substudy refer to the corrected article.

The published **Papers I-III** include extensive tables with all results according to the analyses performed. Selected results are presented for each substudy in this section, whereas the complete tables appear in the printed articles in the appendix.

4.1. Paper I

In 2014 there were 551,753 acute hospital admissions to somatic hospitals in Norway. One in ten (53,908) were birth related and had not visited a primary health care doctor before admission, which is in line with national routines for maternity care. Of the remaining 497,845 acute hospital admissions, 36% were referred by OOH doctors, 28% were referred by GPs, 2% were referred by outpatient clinics or PSPCs, and 35% had no identified prehospital contact in our material and were categorized as *direct admissions*.

During evenings and nights on weekdays and round-the-clock on weekends, patients referred from OOH doctors were the largest group. During daytime on weekdays, most patients were admitted by GPs (53%). On morning and midday hours on both weekdays and weekends, direct admissions were high.

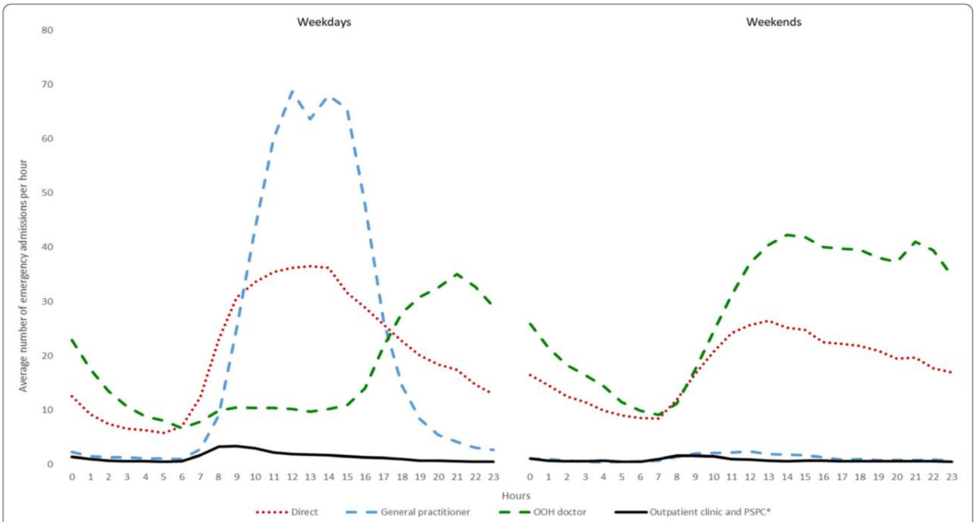

Fig. 2 All emergency admissions to somatic hospitals in 2014 in Norway, sorted by prehospital pathways and time of the day during weekdays and weekends

Figure 6. Prehospital paths for acute hospital admissions in 2014 shown for time of the day on weekdays and weekends. Published in ***Paper I****.*

In 2014 there were 97 emergency admissions to hospital per 1000 inhabitants in Norway. The rate was higher in the least central municipalities (115) and lower in the most central (87). Direct admissions accounted for a higher proportion in the most central municipalities, decreasing with decreasing centrality (45%–28%). On the contrary, the proportion of GP referrals increased with decreasing centrality (18%–34%), whereas OOH referrals were quite stable across centrality groups.

Injuries were the most frequent discharge diagnosis group (S and T), and the second-most frequent were diseases in the circulatory system (I) followed by symptoms and findings not elsewhere classified (R) and diseases in the respiratory system (J).

The most common single diagnoses were Pneumonia (J15, J18), Pain in throat and chest (R07), Abdominal and pelvic pain (R10), Atrial arrythmias (I48), and AMI (I21). The prehospital paths varied considerably between the different discharge diagnoses. GP referrals were more frequent among subacute or local conditions like anaemias, haemorrhoids, diverticulitis, sciatica, heart failure, and deep venous thrombosis. OOH referrals were high on a variety of acute conditions including acute appendicitis, foreign body in alimentary tract, mental and alcohol-related disorders, abdominal pain and other gastrointestinal disorders, and asthma. The largest group with a dominating direct prehospital pathway was malignant neoplasms. Also, procedural complications, head injuries, femur fractures, epilepsy, and several acute emergencies had high rates of direct admissions.

4.2 Paper II

In 2017, all 14,457,247 Norwegian GP and OOH contacts (consultations and home visits) resulted in 265,518 referrals to acute hospital admission in a somatic institution, including 43% from GPs and 57% from OOH doctors. The overall referral rate was 0.01 for GP contacts, and 0.11 for OOH contacts.

The ICPC-2 chapters used in the referral contacts had a similar distribution for GP and OOH contacts, but OOH contacts had almost twice as many referrals with a code from the chapter General and unspecified (A) compared with GP contacts.

ICPC-2 diagnoses

Abdominal pain (D01) was the most frequent referral diagnosis with 8% of all referrals, followed by Chest pain (A11) (5%), Pneumonia (R81) (3%), Shortness of breath (R02) (3%) and Atrial fibrillation (K78) (3%). The 30 most common referral diagnoses accounted for 53% of all referrals.

The referral diagnoses with the highest referral rates after OOH contacts were Appendicitis (D88) with 0.79, followed by Stroke/cerebrovascular disease (K90), Transient cerebral ischaemia (K89), Heart pain (K01) and Ischaemic heart disease with angina (K74) with rates of 0.78, 0.73, 0.66, and 0.65, respectively. Also, for GP contacts Appendicitis (D88) had the highest referral rate reaching 0.30, followed by Heart pain (K01), and Transient cerebral ischaemia (K89) with rates of 0.20 and 0.12, respectively.

The median age for patients referred from OOH services was lower compared to GP-referred patients (59 years versus 64 years). OOH patients referred with Bronchitis/bronchiolitis (R78) had the lowest median patient age (2 years), followed by

Appendicitis (D88) and Concussion (N79) (26 years and 29 years). Heart failure (K77) had the highest median age for both OOH and GP contacts (83 years and 82 years).

Referrals with a symptom-describing diagnosis in the ICPC-2 were common, and referrals with a diagnosis in the symptom groups of abdominal pain, chest pain, or shortness of breath accounted for 21% of all referrals.

Referrals for abdominal pain

In the abdominal pain symptom group the median patient age was 46 years, and women accounted for 60%. The most frequent discharge diagnosis after an abdominal pain referral was the corresponding symptom-describing ICD-10 diagnosis of Abdominal and pelvic pain (R10) (26%) followed by Acute appendicitis (K35) (12%) and Cholelithiasis (K80) (6%). For this symptom group there was a higher RR for the discharge diagnosis to be Ileus (K56) if the patient was referred from an OOH doctor compared to a GP referral (RR = 2.12, [95% CI: 1.84-2.45]), whereas the opposite was found for Diverticular disease (K57) (RR = 0.51, [0.46-0.56]). For women there was a higher relative risk for the symptom-describing discharge diagnosis of Abdominal and pelvic pain (R10) compared to men (RR = 1.38 [1.32-1.44]), whereas there was a lower risk for the discharge diagnoses of Acute appendicitis (K35) (RR = 0.59, [0.55-0.62]), Acute pancreatitis (K85) (RR = 0.54, [0.47-0.61]), and Calculus of kidney and ureter (N20) (RR = 0.40, [0.34-0.47]).

Referrals for chest pain

In the chest pain symptom group the median patient age was 62 years, and 44% were women. The symptom-describing ICD-10 diagnosis of Pain in throat and chest (R07) was the most frequent with 36% of the referrals, while AMI (I21) and Angina pectoris (I20) made up 12% and 10%, respectively. In this symptom group women had a lower RR to be discharged with a diagnosis related to ischaemic heart disease compared to men – AMI (I21) (RR = 0.54, [95% CI: 0.50-0.59]), Angina pectoris (I20) (RR = 0.70, [0.64-0.77]), and Chronic ischaemic heart disease (I25) (RR = 0.47, [0.40-0.55]). The discharge diagnosis of Heart failure (I50) was associated with higher age (RR = 2.13, [1.93-2.36]).

Referrals for shortness of breath

Patients referred with a diagnosis describing shortness of breath had a larger variation in discharge diagnoses compared to abdominal pain and chest pain. The most frequent discharge diagnoses were Heart failure (I50) (12%), Pneumonia (J12-J18) (11%), and Chronic obstructive pulmonary disease (J44) (8%).

Disease specific referral diagnoses: pneumonia, appendicitis, AMI and stroke

For patients with the referral diagnosis of Pneumonia (R81), 59% were discharged with the corresponding ICD-10 discharge diagnosis of Pneumonia (J12-J18), whereas few were discharged with the diagnosis of Pulmonary embolism (I26) or AMI (I21) (1% and 0.5%, respectively).

Half of the patients referred with Appendicitis (D88) were discharged with the diagnosis Acute appendicitis (K35), whereas for referrals with the ICPC-2 diagnosis code AMI (K75) 43% were discharged with the ICD-10 diagnosis AMI (I21), 7% with Angina pectoris (I20), and 4% with Chronic ischaemic heart disease (I25). For patients referred with the diagnosis Stroke (K90), 30% were discharged with the diagnosis Cerebral infarction (I63), 10% with Transient ischemic attack (G35), and 4% with Cerebral haemorrhage (I61).

4.3 Paper III

We identified 5,552 OOH doctors with a mean referral rate of 11.0%. Women had higher mean referral rates compared to men (11.7% versus 10.3%), and the referral rate decreased with increasing doctor age (11.8% for younger than 30 years versus to 8.2% for 30 years and older). Interns had a higher mean referral rate compared with GPs, and a low OOH consultation number was associated with high referral rate (11.8% for doctors with <150 consultations and 9.6% for doctors with ≥800 consultations).

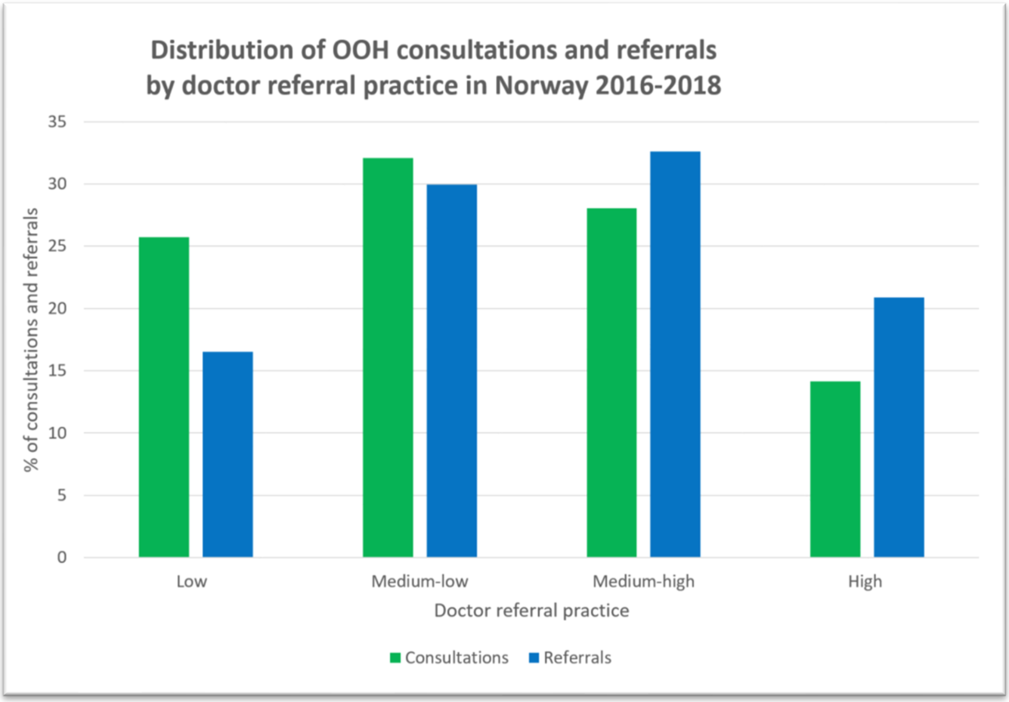

Fig 7: OOH doctors sorted into referral practice quartiles (low, medium-low, medium-high and high). Distribution of consultations and acute referrals to hospital performed by doctors in each referral practice quartile. From ***Paper III****.*

Referral practice

Each referral practice quartile (low, medium-low, medium-high, and high) included 1,388 doctors. A patient consulting a doctor in the high referral practice quartile had a RR of 1.46 [95% CI: 1.40-1.53] to be referred to hospital using the medium-low quartile as reference, whereas a patient consulting a doctor in the low quartile had a RR of 0.71 [0.68-0.75] to be referred. The mean referral rates in the quartiles low to high were 6.5%, 9.4%, 11.7%, and 14.9%.

Symptom diagnoses and critical diagnoses

The likelihood to be referred to hospital and then discharged with a symptom-describing ICD-10 diagnosis was highest for patients consulting a doctor from the highest referring practice quartile, and the differences were even higher than for all-cause admissions. The RR for referral and discharge with Pain in throat and chest (R07) was 1.63 [95% CI: 1.47-1.81], for Abdominal pain (R10) 1.49 [1.36-1.63], for Abnormal breath (R06) 1.43 [1.17-1.75], and for Dizziness (R42) 1.95 [1.67-2.27] if consulting a doctor in the high referral practice quartile relative to the mid-low quartile.

The likelihood of being diagnosed with a critical condition at hospital after an OOH consultation also increased with increasing referral practice. For the diagnoses AMI (I21), Acute appendicitis (K35), Pulmonary embolism (I26), and Stroke (I63), the RRs were 1.38 [95% CI: 1.26-1.52], 1.32 [1.21-1.43], 1.24 [1.05-1.47], and 1.19 [1.06-1.33], respectively, relative to the mid-low quartile.

All differences in likelihood for referral and discharge for the symptom diagnoses and critical diagnoses were outside the 95% CI, and the differences were greater for the symptom diagnoses compared to the critical diagnoses. Hospital stays <24 hours were more frequent in higher referral practice quartiles (range 10%–17%), but this effect was not found for patients referred and diagnosed with AMI or cerebral infarction. For all patients not referred to hospital, there were no difference between the referral practice quartiles in terms of 30-day mortality.

5. Discussion

5.1. Methodological considerations

5.1.1 Scientific theoretical considerations

This study was performed as an observational registry-based study. In a setting with complete registry coverage, this method is well suited for health services research aiming to investigate incidences, rates, and associations. However, the sample must be representative, and the analysed variables must be valid to capture the true situation. An observational study cannot reveal causality.

This thesis investigated the GP's and OOH doctor's roles as gatekeepers for acute referrals to hospital using national health registries. There is no clinical information included in the KUHR and NPR except for the diagnosis codes given. Therefore, the description of the GP's and OOH's role as a gatekeeper is mainly restricted to the quantitative perspective and not how the gatekeeping is performed in each case. We did not investigate any anamnestic information obtained, which examinations were performed, or the doctor's clinical reasoning. To investigate such perspectives, one would need more clinical information or use a qualitative study design.

Large quantitative studies reduce the effect of random error and increase precision, and our substudy I and II included the complete Norwegian population, whereas substudy III included approximately 4/5 of the population.

When calculating the referral rate for each doctor, we excluded doctors with <50 consultations in order to enhance the precision of the referral rate. The referral rate for doctors with few consultations might be inaccurate due to random patient exposure.

A systematic deviation between the scientific results and the truth is called a bias (75). Evaluating epidemiological studies implies discussing the risk of bias leading to false results.

5.1.1.1 Selection bias

Selection bias means a distortion in the selection of participants and different associations between exposure and outcome in participants and non-participants. In substudy I and II the included participants were the whole population utilizing GP and OOH services, thus resulting in no selection bias.

The scope of substudy III was referral practice, and the doctor's individual referral practice was adjusted to the mean referral practice in the pertinent OOH service (municipality). During the analyses in substudy III we found two different referral practice clusters in the OOH services of the two largest municipalities of Oslo and Bergen. This illustrates that the OOH services in these two municipalities constituted of two different types of OOH services, with one type set up for treating less serious illness and no injuries and the other treating the full variety of acute conditions. Because the doctors were sorted at the municipality level, we could not calculate the Oslo and Bergen doctors' referral practice relative to the single OOH service he or she was working in. Therefore, these two municipalities were excluded from our analyses.

Almost 20% of the population live in Oslo or Bergen. However, we do not assume there is a major difference in the referral practice and gatekeeping performance among the OOH doctors in Oslo and Bergen compared to the rest of Norwegian OOH services, although the higher rate of direct admissions in the most central municipalities may have had minor effects on the results. We do not suspect severe bias by excluding Oslo and Bergen.

5.1.1.2 Information bias

Information bias means that information is inaccurate or incorrect. In our study this is most relevant regarding the use of diagnoses and the definition of the referring agent.

Diagnoses

The clinical assessment leading to a diagnosis is crucial in medical work and is key for communication between clinicians (76, 77). Diagnoses make it possible to systemize and categorize patients' conditions. Therefore, we used diagnoses to describe the patients' conditions, both in the referral and at discharge.

In substudy II we used the ICPC-2 diagnoses included in the reimbursement claims from GPs and OOH doctors. These are made during a consultation or home visit lasting approximately 10–30 minutes and can contain some uncertainties regarding the diagnosis (76). The clinicians might also tend to use the previously used diagnosis because some software for medical records present recent diagnoses as suggestions for the actual claim. The fact that the primary care diagnosis given in the referral contact is included in the referral letter following the patient to hospital probably encourages the GPs and OOH doctors to be accurate when giving the diagnosis, leading to increased validity compared to diagnoses for non-referred patients. A study from Norway including 1,891 GP medical records found good correspondence between the clinical information in the medical record and the diagnoses given in 85% of the consultations (78). A Finnish study of physicians and paramedics working in helicopter emergency medical service (HEMS) showed only 52% inter rater agreement (79). Our study setting is GP and OOH services, which is more similar to the GP setting of the Norwegian study than the acute care setting in the Finish HEMS.

One can imagine an inter individual variation in the choice of diagnosis for a particular case because the clinical judgement will vary between clinicians. For example, if a patient presents for three doctors with chest pain atypical for cardiac disease, but with a history of ischaemic heart disease, one clinician might code this as Chest pain (A11), another as Heart pain (K01), and the third the clinician might have a strong suspicion for myocardial infarction classifying it as AMI (I21). Nevertheless, in our substudy II we found reasonably good concordance between the referral and discharge diagnoses from hospital. The use of diagnoses might differ between GP services and OOH services, but the accuracy within the services is probably similar. This might introduce some bias if the diagnoses are applied differently between the services.

The ICD-10 discharge diagnoses were included in the study and were used as the medical conclusion on the patient's current condition after a hospital stay. Also, inaccuracy regarding the discharge diagnosis cold lead to information bias.

The discharge diagnosis is often given after substantial investigations and should therefore be more accurate compared to the primary care referral diagnosis. However, the clinical condition at discharge does not always completely concur with the condition at the time of referral. The main discharge diagnosis could even be a diagnosis describing a clinical complication during the hospital stay. A patient referred with Hip symptoms/complaints (L13) where fracture of the femur is suspected might suffer a pulmonary embolism as a complication of immobilization and might be discharged with the diagnosis Pulmonary embolism (I26). Further, autopsy studies have shown a 20%–40% diagnostic discrepancy between antemortem and post-mortem diagnoses (76). These factors call for caution when using the discharge diagnosis as the final conclusion of the referral condition. Nevertheless, in our study the discharge diagnosis was the best available information on the condition revealed during the hospital stay. It is unlikely that the referral agent affects the discharge diagnosis.

Identification of referring agent

The codes representing different primary care contacts in the KUHR are crucial to identify the prehospital contacts. We defined the referral agent by linking the contacts where claims are registered 24 hours before the time of admission. This might be a contact not directly related to the admission. However, we found a distinct accumulation of GP or OOH contacts for the same person a short time prior to an admission. Further, the concurrence between the diagnoses used in the GP and OOH contacts prior to the admission and the discharge diagnosis for the hospital stay was strong. Both observations support our study design and reduce the concern for information bias with the referring agent.

5.1.2 Strengths and limitations

All three substudies were conducted with Norwegian national registry data, and the National personal identification number allowed secure identification of each individual in the registries. Few contacts were excluded, as described in section 3.2.2, section 3.2.3, and section 3.2.4. The KUHR registry consists of the GP and OOH doctors' claims, thus there is a considerable economic incentive to report properly. Although there are incentives to use contact codes that give better economic outcome, there are control systems to prevent divergent coding. The NPR data are extracted from hospital medical record for management and economic purposes, in addition to research. Therefore, both of these health registries are regarded as complete and well suited for quantitative studies, and they are widely used in research (6, 32, 65, 69, 80).

A complete data set was crucial for substudy I, which described the Norwegian prehospital paths. The completeness of the registries in all substudies ensured representativity for the Norwegian health care system, thus high internal validity. However external validity to other health care systems was lower. Gatekeeping performance and referral practice depend on the current health care system, which constitutes the context. Some important contextual factors include national gatekeeping routines or direct access to ED, the primary care and hospital capacity, the GP's participation in acute care, the OOH service's participation in critical conditions, and the morbidity in the population.

The three substudies used dataset from different time periods. Substudy I used data from 2014, substudy II used data from 2017, and substudy III used data from 2013–2015 to define morbidity and from 2016–2018 for the referral analyses. Although activity in the primary care and hospital services in the Norwegian health care system has been relatively stable, this should be taken into consideration when comparing findings across the substudies.

The strengths and limitations for each substudy are discussed separately below.

Substudy I

In substudy I the prehospital paths were defined as GP referral, OOH referral, outpatient clinics or PSPCs, or direct. The direct admissions were defined as all admissions where no prehospital contact was identified in our material. In the Norwegian health care system, these direct admissions could represent mainly three prehospital paths:

- The ambulance service brings the patient directly to hospital due to need for urgent care.
- The admission might be a result of hospital follow up of patients under hospital care.
- The admission might come after referral from a nursing home doctor.

To explore this assumption and to define the referring agent more precisely we conducted a local study for the two hospitals serving the city of Bergen and the surrounding municipalities (81). Medical student Margrethe Lauvik collected information over one week in November 2017 and identified 977 acute admissions to the two hospitals. She found that admissions representing the category *direct admission* in substudy I were 34% of all admissions and consisted of admissions with no doctor gatekeeping (true direct/ambulance) (26%), admissions by a hospital doctor (6%), and admissions from nursing homes (2%).

The prehospital paths were described by centrality in a simple frequency table in **Paper I** without any statistical adjustments. Because the material was complete, we interpreted the results to be valid for Norway in 2014. By performing statistical analyses, we could have explored the association between different centrality groups and prehospital paths.

Substudy II

In substudy II we used the ICPC-2 diagnoses included in the GP and OOH doctor claims to describe the reason for referral. All claims included one or more diagnoses, whereas 17% included two diagnoses, 3% included three diagnoses, and 1% included four. The first diagnosis was reported as the primary diagnosis, and we conducted the analyses using only the primary diagnosis. By not taking into account the rest of the diagnoses, we may have missed some information on the reasons for referral for 17% of the contacts.

To investigate some of the important reasons for referral, we grouped the referral diagnoses describing *abdominal pain* (D01, D02 and D06), *chest pain* (A11, K01-03), and *shortness of breath* (R01-04) as described in a Finnish study on classification for ED presenting complaints (82). Malmström et al. developed an ICPC-2 ED application for grouping related ED conditions by ED nurses. Such grouping might reduce the effect of the inter individual variation in coding for these analyses. On the other hand, similar diagnoses were analysed together despite different definitions. For example, in our symptom group *shortness of breath* included the diagnoses Pain in respiratory system (R01), Shortness of breath (R02), Wheezing (R03), and Breathing problem other (R04).

Substudy III

The main scope of substudy III was the different referral practices between OOH doctors. To increase the internal validity, doctors with fewer than 50 consultations were excluded. A major concern was the local organizational factors affecting the doctor referral rate, such as telephone triage routines, OOH accessibility, prehospital ambulance procedures, and distance to hospital. It is impossible to identify all these factors, and some are difficult to quantify. By defining the doctor's individual *referral practice* as the referral rate for the doctor divided by the overall referral rate of the municipality, the doctors were compared to all doctors working in the same municipality. Thus, we could quantify the referral practice and divide the doctors into referral practice quartiles. Each quartiles contained a range of referral practices but enabled analyses at the group level.

In the statistical analyses we adjusted for the patient factors affecting the probability for referral (age, sex, morbidity, and night consultation). The adjustment for patient factors only moderately affected the RR for referral, thus indicating a relatively equal distribution of patients between the referral practice quartiles.

To investigate the outcome for patients visiting doctors in the different referral practice quartile, we analysed 30-day mortality. This is a common unit of measure for fatal outcome in studies on procedures involving risk, including studies on referrals to acute admission (32, 83, 84). The 30-day mortality captures deaths following the acute case but do not measure loss of function, reduced quality of life, or missing preventive medical actions. This study did not investigate these aspects of the impact of different referral practice.

5.2 Discussion of the results

In the classic paper “Ecology of Medical Care” from 1961, White et al. estimated the adult population’s utilization of different health services during one month. We have not used this approach, and the major difference is that we accepted that patients might use primary care and hospital services more than once a year. Nevertheless, in 2014 we found 95 admissions per 1000 inhabitants, which corresponds to 8 admissions per 1000 inhabitants per month. White et al. found that 9 adults per 1000 had been admitted to hospital per month. These numbers are surprisingly corresponding.

5.2.1 Gatekeeping and prehospital paths

In substudy I we found that 36% of the patients having an acute admission to hospital were referred by an OOH doctor and 28% were referred by a GP. Lauvik et al. found similar numbers in the study from Haukeland University Hospital and Haraldsplass Deaconal Hospital in Bergen where 34% were referred from an OOH doctor and 25% from a GP (81). In a study of all admissions (both acute and non-acute admissions) from a medical department at Drammen Hospital during one week in 2014, Grondahl et al. found that 31% were referred from an OOH doctor and 26% from a GP (14). This indicates that our findings have strong external validity in a Norwegian setting and that OOH doctors as well as GPs contribute substantially in acute care.

In a gatekeeping system the patients are obliged to see a doctor, usually a primary care doctor, before referral, and in a strict gatekeeping system this should apply for all cases. In substudy I, 35% were direct admission. This indicates that one third of the patients bypass standard primary care doctor gatekeeping. Some of these probably undergo doctor gatekeeping by hospital doctors or nursing home doctors. The rest probably undergo gatekeeping by other emergency health care professions like EMCCs and ambulance personnel. Assuming the Bergen hospital region corresponds to the whole of Norway regarding organizational factors like centrality and the distribution of the municipalities and population, our numbers fit well with Lauvik et al.'s study from Haukeland University Hospital and Haraldsplass Deaconal Hospital in Bergen where direct admissions by our definition accounted for 34% (81). A large patient group where hospital doctor follow-up is suitable is cancer patients. We found 5% of all acute admissions to be direct admissions with a diagnosis in the neoplasm ICD-10 chapter (C), while Lauvik et al. found 6% were referred by hospital doctors.

The study from Drammen had only 18% direct admissions (14). Because the Drammen study included non-urgent admissions and we found higher direct admissions for the most urgent cases (injuries, traumas, cerebral haemorrhage, heart infarctions, and other acute cases) it was expected for there to be a lower share of direct admissions in the Drammen study.

5.2.2 Diagnoses

In a Danish study, Søvsø et al. divided the patients who contacted EMCC or OOH services into two groups, one group with short hospital contacts (<24 hours) and the other with hospital admissions (≥24 hours). Injury and poisoning were the most frequent hospital ICD-10 chapter used in both short hospital contacts (34%) and in hospital admissions (17%) (64). Symptoms and signs (R) accounted for 11% in the short hospital contacts and 16% in the hospital admission group. This was in line with our findings in substudy I. The circulatory system was considerably lower compared to our findings (1% and 9%, respectively). However, these numbers are not directly comparable to our results because this Danish study included only hospital contacts after contacting EMS or OOH services, whereas we included all admission pathways but only included admissions (>8 hours hospital stay). In another Danish study, Christensen et al. found injury and poisoning (S and T) to be the most frequent ICD-10 diagnoses chapters after calls to the EMS with subsequent ambulance transportation to hospital (30%), followed by symptoms and signs (R) (18%) (83). This would be comparable to a share of the direct admissions in substudy I.

ICPC-2 diagnoses given in GP and OOH contacts leading to referrals to acute hospital admissions were analysed in substudy II. The referral diagnoses cannot be directly compared to the Danish studies of ICD-10 discharge diagnoses. We found general and unspecified (A) to be the highest after an OOH consultation or home visit, which corresponds with the ICD-10-chapter symptoms and signs (R).

5.2.2.1 Abdominal pain

The most frequent referral diagnosis was Abdominal pain (D01) at 8%. This was the second most frequent reason for contacting the OOH services in Norway and for contacting the ED in Finland (34, 82). In a Norwegian study, 26% of patients with an acute appointment with the GP because of acute abdominal pain were referred to acute hospital admission (85). A GP acute appointment is comparable to an OOH consultation, and in our substudy II the Abdominal pain (D01) contacts referral rate was also 26%. One could expect the OOH referral rate to be even higher due to the expected higher urgency at OOH services compared to acute appointments at GP offices.

5.2.2.2 Chest pain

Chest pain (A11) was the second most frequent referral diagnosis with 5% of all referrals, and the referral rate after a contact with Chest pain diagnosis from OOH doctors was 37%, and 10% from GPs. Heart pain (K01) was less frequent but with a higher referral rate of 66% from OOH doctors and 20% from GPs. In our study, heart disease with angina presented with a 65% referral rate from OOH doctors and 7% from GPs. A small study on chest pain in a Norwegian OOH setting found that 50% of the patients with chest pain were referred (86). In this study the patients were recruited according to the major presenting symptom and not according to the ICPC-2 diagnosis. A study from the

Netherlands found that 14% of patients attending GPs about chest pain were referred directly to a cardiologist (87). It is probable that patients in these studies included patients with the all the diagnoses of Chest pain (A11), Heart pain (K01), Ischaemic heart disease with angina (K74), and AMI (K75) as well as patients diagnosed with chest pain attributed to the musculoskeletal system, i.e. Chest symptom complaint (L04). The Dutch study found that no more than a quarter of the patients referred were diagnosed with acute coronary syndrome. This corresponds with our findings.

After referral with a diagnosis in the chest pain group, women had higher RR to be discharged with the diagnosis Pain in throat and chest (R07) and lower RR to be discharged with ischaemic heart disease compared to men. For both women and men chest pain is a core symptom for AMI. Recently, atypical symptom presentation among women has received increased attention (88-90), and this fits with our findings. The knowledge that cardiovascular diseases (CVD) have lower prevalence in women than men is another explanation for the difference. When diagnosed with CVD, women have higher mortality rate and poorer prognosis (91). Therefore, the challenges in proper diagnostics for CVD among women should receive further attention.

5.2.3 Referral rates and referral practice

5.2.3.1 Referral rates

From **Paper II** the referral rate *per contact* (consultations and home visits) was 11% from OOH doctors. In **Paper III** we calculated the OOH doctors' referral rate. This gave a mean OOH doctor referral rate of 10%. There are three main reasons for this difference:

- OOH doctors with many contacts had lower referral rates.

- In substudy II the contacts were defined as consultations or home visits, whereas in substudy III only consultations were included. Home visits have higher referral rates compared to consultations.
- Substudy III had 33% of the contacts excluded.

Using national health registries, Svedahl et al. studied acute referrals to hospital after contacts with GPs working OOH. By calculating the referral rate from their Table 1, the overall referral rate in their study was 13% (32). This is quite similar to our findings and is comparable to a study from a single OOH primary care centre in Norway where 14% of all OOH contacts were referred to hospital (49).

Comparing referral rates between countries is difficult due to the different organization of acute care (92). In an English study from 2007, 9% of OOH contacts led to a referral (31). In a study from Denmark, Søvsø et al. found that 4–8% of patients calling the OOH primary care were admitted (64). This is lower than our 11%, but the Danish study setting is not directly comparable to the Norwegian because the rate in Denmark is calculated based on all patients calling OOH services, and not the consultations with an OOH doctor. In Norway, the telephone triage nurse in the LEMC decides if the patient needs to attend an OOH consultation, and 23% of the patients calling the LEMCs are handled solely by nurse counselling, and thus it is expected that the referral rate after OOH consultations in Norway will be higher compared to telephone contacts in Denmark (34).

Referrals to acute hospital admission from daytime GP activity has received less scientific attention. We found that 1% of GP contacts resulted in an acute referral to hospital. Although a low share of GP contacts led to referral, these referrals constituted 28% of all acute admissions. The lower referral rate for GP contacts compared to OOH contacts by different referral ICPC-2 diagnoses elaborates this picture. This illustrates that GPs in Norway perform a wide range of tasks in addition to acute primary care. These tasks include preventive health care services, diagnosing and treating non-urgent cases, and following up patients with chronic diseases, and this is in line with Norwegian regulations (5).

Female and younger doctors as well as doctors with few OOH consultations had higher mean referral rates, as shown in **Paper III**. Svedahl et al. found the same, with the strongest effect for consultations with patients aged 0–10 years (32). Also, in England female doctors working OOH had higher referral rates (31).

5.2.3.2 Referral practice

In substudy III we calculated the OOH doctors' referral practice by dividing the OOH doctors' referral rate by the referral rate of the other OOH doctors in the same municipality. In studies of referrals including only one OOH service, the calculation of referral rate is sufficient to divide doctors according to referrals because all of the doctors work in the same service. Rossdale et al. studied 149 GPs working in one general practice OOH cooperative in England (31). The GPs were grouped into quartiles from low to high referral rates, with the mean referral rates per quartile being 4%, 7%, 11%, and 17%. While the difference between the quartiles was more than four times larger between the low and high quartiles in the English study, we found the referral rate to be 2.5 times higher between the low and high quartiles. This could indicate that the differences in referral rates for OOH doctors in Norway are smaller compared to England.

5.2.4 Symptom diagnoses and critical conditions

In **Paper II** the most common discharge diagnosis for patients referred with a diagnosis in the symptom group Abdominal pain (D01, D02 and D06) was the symptom-describing diagnosis of Abdominal and pelvic pain (R10) (26%) followed by Acute appendicitis (K35) (12%), Cholelithiasis (K80) (6%), Diverticular disease (D57) (4%), and Functional intestinal disorder (K59) (4%). This indicates that for 30% no severe disease was revealed.

The most common discharge diagnosis after referral with a diagnosis in the symptom group Chest pain (A11, K01-K03) was Pain in throat and chest (R07) with 36%. When adding Other soft tissue disorder including myalgia (M79), 40% had no severe condition revealed. Only 26% had ischaemic heart disease.

It is difficult to establish consensus on the appropriate level for primary care doctor gatekeeping for each critical condition, and it is expected that the risk to be referred and then discharged with a symptom-describing diagnosis is higher for patients having a consultation with a doctor in the high referral practice quartile compared to a doctor in the low quartile. The admissions with a symptom-describing discharge diagnosis are the target for the effort to reduce the numbers of referrals and are the basis for the discussion on “avoidable admissions” (52, 93). Reducing these referrals could save both patient concern and hospital workload and health care costs (23, 24, 31, 49, 52, 93). Also, the high rates of patients with hospital stays <24 hours might be an indication of possible avoidable admissions.

In substudy III we found that the likelihood to be referred and diagnosed with our selected critical conditions (AMI, acute appendicitis, pulmonary embolism, and cerebral infarction) increased from the low to the high referral practice quartile. Certainly, this effect was smaller for the critical conditions compared to the symptom-describing diagnoses, but it implies that some cases of critical conditions are overlooked for patients consulting a doctor in the lower referral practice quartiles. Svedahl et al. described this for a sample of critical conditions in a material of GPs attending OOH services, but this has not been shown for the critical conditions separately (32). The 30-day mortality for the not referred patients was the same for all referral practice quartiles in our material, and Svedahl et al. did not find any differences in 30-day mortality in their material. Therefore, we can presume that the overlooked cases may be less severe and thus have a low risk of short-term mortality. Morbidity, long-time mortality, and the risk and consequences of missing secondary prevention after being diagnosed with AMI, pulmonary embolism, or stroke have not been investigated here and would require more clinical data and a longer follow up period.

5.3 Implications of the results

The findings in this study have implications for the understanding prehospital decision making in acute care in the Norwegian health care system and should be taken into consideration when planning prehospital systems and procedures.

5.3.1 Referral rates establish hospital workload

For the OOH doctors there were considerable differences in referral practice. The RR to be referred after a consultation varied between the referral practice quartiles from 0.71 in the low quartile to 1.46 in the high quartile when analysed with the medium-low quartile as the reference. This constitutes a 2.06-fold higher RR for referral by the high referral practice quartile compared to the low referral quartile.

Based on unadjusted referral rates, the number of patients referred would vary. If all 1,361,731 OOH patients in 2017 had seen a doctor in the high referral practice quartile with a referral rate of 14.9%, the number of acute referrals to hospital from OOH doctors would increase from approximately 150,000 to 200,000. If all the patients visiting an OOH doctor in 2017 had seen a doctor in the low referral practice quartile (referral rate of 6.5%), the number of acute referrals would be reduced to approximately 90,000. This does not take into consideration that patients not referred who saw a low referral doctor might recontact health services and be referred later. Findings from Svedahl et al. suggest this (32).

The significantly lower number of referrals in this latter model could be promising in terms of possible health care workload and cost reduction by identifying avoidable admissions. Svedahl et al. found higher costs for GPs with high referral practice working

OOH due to more acute hospital admissions compared to doctors with low referral practice (32). Our calculations of differences in referrals by applying high or low referral practices exceeded the previously identified levels of avoidable admissions by Grondahl et al. (7% of referrals from GP and OOH services to a medical department) and Lillebo et al. (21% of acute hospital admissions from OOH services) (14, 49).

5.3.2 Avoidable admissions

Referrals where the patient is discharged with the symptom diagnosis Pain in throat and chest (R07), and thus no severe disease was revealed, could be a marker for avoidable referrals. In substudy III we found a 2.72-fold higher risk to be referred and diagnosed with this diagnosis at hospital after a consultation in the high versus the low referral practice quartile. This might be interpreted as medical overactivity and might encourage health authorities to aim for a generally reduced referral practice. However, our findings on critical conditions as illustrated by AMI should call for caution.

5.3.3 Overlooked acute myocardial infarctions

In substudy III we found a 1.75-fold higher RR for referral and diagnosis at hospital with AMI after an OOH consultation if the consultation was by a doctor in the high referral practice compared to the low. There are clear definitions for the diagnosis AMI at hospital (94), and therefore we can assume that a strict referral practice will lead to some cases of overlooked AMI. Even if there was no increase in 30-day mortality for the patients not referred, the morbidity and long-term mortality was not investigated nor were the long-term economic consequences.

It is possible that the overlooked AMIs in the low referral practice quartile are less severe with low risk of fatal outcome. Less severe AMI might also present with vague or atypical symptoms that are more prone to different assessments between the referral practice quartiles. It is less likely that major AMIs with typical core symptoms of heart infarction (severe chest pain with radiation to left arm, breathing disabilities, pale and cold skin, and so on) undergo different gatekeeping. To improve the accuracy of prehospital AMI diagnostics, the prehospital diagnostic process, including the diagnostic tools, should be investigated (95).

5.3.4 Symptom diagnoses and critical conditions

We found patterns similar to the symptom diagnosis Pain in throat and chest (R07) and the critical condition AMI (I21) for all other symptom-describing diagnoses investigated (Abdominal pain (R10), Abnormal breath (R06), and Dizziness (R42)) and the critical conditions (Acute appendicitis (K35), Pulmonary embolism (I26), and Cerebral infarction (I63)). There are more patients referred where no severe disease was revealed in the high referral practice group. We can also assume that critical cases are missed by the low referring practice doctors. Because there was no difference in 30-day mortality between the referral practice quartiles for not referred patients, it is likely that the least severe cases are missed when it comes to referrals for acute appendicitis, pulmonary embolism, and cerebral infarction. It is known that all of these conditions are sometimes missed during primary assessment and gatekeeping (96-103). The strong trend for the critical conditions being studied indicates that this phenomenon probably also applies to other critical diagnoses. It is possible that the not referred patients with critical conditions recontact the health services and are referred with a diagnostic delay as Svedahl et al. found indications of this in their study (32).

One should be cautious in applying our results found at the group level to the individual OOH doctor performing gatekeeping with high or low referral practice. The quality of each individual doctor’s gatekeeping is a consequence of the doctor’s clinical reasoning. Fear of litigation and malpractice may lead to low tolerance for risk for critical cases. A thorough clinical examination and risk assessment might leave an OOH doctor in the low referral practice with few missed critical cases. On the contrary, a doctor in the high referral practice group might have high referral practice without identifying the critical cases.

This calls for more attention to prehospital diagnostic processes in education, professional development, and research. Higher referral practice should be accepted for less experienced doctors, and feedback on referred cases should be obligatory for all cases. The framework for decision making and gatekeeping for acute hospital referrals in the OOH primary care setting should be emphasized rather than encouraging general strict gatekeeping (32).

Thorough assessment for critical conditions is vital for high quality acute primary care. One example of recent initiatives for enhancing diagnostic accuracy is the introduction of point-of-care ultrasound in primary care performed by GPs, OOH doctors, or emergency physicians (104). The use of high-sensitivity cardiac troponin T in a primary care setting when assessing and observing patients with chest pain is another example of enhancing diagnostic accuracy (95). Implementing a clinical decision rule including a cardiac biomarker point of care test can improve prehospital diagnostic accuracy and reduce unnecessary referrals (87). The value and feasibility of detecting acute kidney injury to identify patients at risk of critical outcome in a prehospital setting should be investigated (28).

5 Conclusion

Two thirds of all acute hospital admissions are referred from a GP or an OOH doctor, and the patients thus have been exposed to primary care gatekeeping. OOH doctors refer a higher number of patients and have higher referral rates compared to GPs. This fits with the nature of the services. GPs contribute with substantial acute care, and during daytime on weekdays GPs are the major referring agent for acute hospital admissions. In rural municipalities, GP referrals to acute hospital admissions are more common compared to the central municipalities.

There was a wide range of reasons for acute referrals to hospital from GPs and OOH doctors. The referral rates showed a considerable variation between the clinical conditions and between the GP and OOH services. Abdominal pain and chest pain were the dominating reasons for referral, and corresponding symptom-describing diagnoses were the most frequent discharge diagnoses for these referrals. For referrals with the referral diagnoses pneumonia, acute appendicitis, AMI, and stroke, the corresponding discharge diagnoses were the most frequent.

Increasing doctor experience was associated with lower referral rate. The referral rate was more than double between the low and high referral practice quartiles. The risk to be referred to hospital without any disease being revealed was higher for the patients who had seen a doctor with a high referral practice. There was the same but weaker association for some critical conditions. Low referral practice may increase the risk for critical conditions being overlooked, and variation in individual referral practice has an impact on both hospital costs and patient safety.

6 Further perspectives

6.1 Further research

Based on the findings in this study, there are several issues that should be investigated.

Prehospital paths for acute admissions to hospital were described in this study by linking existing health registries. More information on the referral agent in the registries would allow for more precise identification of the referral agent for acute admissions for different clinical conditions, and the referrals that do not come from GPs or OOH doctors may be more precisely described. This calls for improvement of the national health registries.

Variance in referral practice is of major importance for both patient security and hospital cost and workload, and the reasons for this variance should be investigated. Psychological, relational, educational, and organizational factors have not been sufficiently explored.

We studied the variation in referral practice between OOH doctors. There should also be attention to the variance between the OOH services. The effects of factors like telephone triage routines, staffing, distance to hospital, equipment, and patient safety culture on referral practice should be examined.

We have studied the effect of different referral practices for some critical conditions, and similar studies should be performed for all major critical conditions. By including clinical data both in the prehospital assessment and at hospital, these studies could be the basis for improved diagnostic accuracy.

The long-term consequences of different referral practices for OOH doctors should be explored. We have assumed there is no severe loss in health outcome between the different referral quartiles because there is no difference in 30-day mortality for the not referred patients. This should be explored further.

Research on acute referrals to hospital should consider using the method of calculating referral practice developed in this study because this would enable comparisons of referral activity between different OOH services.

6.2 Implications for health services

The results in this thesis call for increased attention to prehospital diagnostic processes, and education and professional development should emphasize this. Aspects of referral practice should be implemented in the general understanding of assessing acute cases, and awareness of the consequences of different referral practice should be integrated in the understanding of clinical reasoning and risk management.

Further, the framework for decision making and gatekeeping for acute hospital referrals in the primary care setting should be developed and strengthened. This is the case for all major clinical problems in acute care and calls for collaboration between primary care and secondary care to develop better diagnostic tools.

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PAPERS I-III

PAPER I

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RESEARCH ARTICLE Open Access

General practitioners' and out-of-hours doctors' role as gatekeeper in emergency admissions to somatic hospitals in Norway: registry-based observational study

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Abstract

Background: Primary care doctors have a gatekeeper function in many healthcare systems, and strategies to reduce emergency hospital admissions often focus on general practitioners' (GPs') and out-of-hours (OOH) doctors' role. The aim of the present study was to investigate these doctors' role in emergency admissions to somatic hospitals in the Norwegian public healthcare system, where GPs and OOH doctors have a distinct gatekeeper function.

Methods: A cross-sectional analysis was performed by linking data from the Norwegian Patient Registry (NPR) and the physicians' claims database. The referring doctor was defined as the physician who had sent a claim for a consultation with the patient within 24 h prior to an emergency admission. If there was no claim registered prior to hospital arrival, the admission was defined as direct, representing admissions from ambulance services, referrals from nursing home doctors, and admissions initiated by in-hospital doctors.

Results: In 2014 there were 497,587 emergency admissions to somatic hospitals in Norway after excluding birth related conditions. Direct admissions were most frequent (43%), 31% were referred by OOH doctors, 25% were referred by GPs, whereas only 2% were referred from outpatient clinics or private specialists with public contract. Direct admissions were more common in central areas (52%), here GPs' referrals constituted only 16%. The prehospital paths varied with the hospital discharge diagnosis. For anaemias, 46–49% were referred by GPs, for acute appendicitis and mental/alcohol related disorders 52 and 49% were referred by OOH doctors, respectively. For both malignant neoplasms and cardiac arrest 63% were direct admissions.

Conclusions: GPs or OOH doctors referred many emergencies to somatic hospitals, and for some clinical conditions GPs' and OOH doctors' gatekeeping role was substantial. However, a significant proportion of the emergency admissions was direct, and this reduces the impact of the GPs' and OOH doctors' gatekeeper roles, even in a strict gatekeeping system.

Keywords: Norway, General practitioners, After-hours care, Out-of-hours medical care, Gatekeeping, Referral and consultation, Emergencies, Patient admission

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Background

An aging population and new diagnostic and therapeutic possibilities, combined with growing expectations, put extra demands on the healthcare system. Emergency hospital admissions represent a considerable workload and expense for the healthcare systems worldwide. Reducing these admissions has been a priority for many years [1–6]. Several studies have described various factors influencing the rate of emergency admissions, and a variety of factors has been found to be associated with excess of admissions or avoidable admissions [7–9]. Age older than 65 years is associated with higher emergency hospital admission rates in the UK and US [7, 10, 11]. On the other hand, continuity of care in general practice and access to a preferred general practitioner (GP) have been shown to reduce the emergency admission rates in general [4, 7, 9], and also for ambulatory care sensitive conditions [12]. There is variation in admission rates by clinical condition in the US [13]. However, analyses of the overall picture of prehospital paths and effects of gatekeeping have received less attention.

GPs are gatekeepers in many healthcare systems. Gatekeeping means that patients have to see a primary care provider who decides whether specialist care is necessary. Such referral regulates the access to specialty care, hospital care, or diagnostic tests. It is supposed to give better control over the healthcare costs and more targeted and efficient hospital healthcare [14]. It has been found to lower utilization of healthcare services and expenditures [15].

Access to specialist healthcare in Norway is generally referral based, and patients cannot meet at hospital emergency rooms in Norway without a prior contact with prehospital healthcare [16]. This makes the Norwegian healthcare system well suited to study the impact of strict gatekeeping on emergency admissions. A Norwegian study from a single hospital indicated that patients admitted for emergencies to a medical department often did not have any contact with GPs or out-of-hours (OOH) doctors prior to the admission [17]. However, a nationwide analysis of the prehospital paths for emergency hospital admissions in a public healthcare system where GPs and OOH doctors have a distinct gatekeeper function, like Norway, has not been conducted.

The aim of the present study was to investigate the prehospital paths for emergency admissions to somatic hospitals in Norway and describe variations in the gatekeeping role of the GPs and OOH doctors with respect to geographical centrality and time of day. In addition, we wanted to explore GPs' and OOH doctors' role in emergency admissions to hospital in relation to the clinical conditions involved.

Methods

The study was designed as a registry based cross-sectional analysis using data from the total population in Norway.

Norwegian healthcare system

All Norwegian residents have access to a public healthcare system, covered by the National Insurance Scheme. Patients older than 15 years have to pay an out of pocket fee for consultations with GPs, OOH doctors, ambulatory care specialists, and outpatient clinics in hospitals (15–33€ in 2014). There is a maximum sum (219 € in 2014) on how much a patient may have to pay during one calendar year [16]. Hospital stays and ambulance services are free of charge.

The municipalities organize the primary healthcare, including GPs and OOH services, while the state is in charge of hospitals and the ambulance services [16, 18]. In 2001, the Norwegian government established a patient list scheme with Regular General Practitioners (RGP scheme). The Norwegian Health Economics Administration (HELFO) is administrator for the scheme, which provides a personal RGP for every resident [19].

RGPs provide medical care for their patients during office hours, both in acute and non-acute cases [19, 20]. OOH services provide healthcare in case of emergencies 24 h a day by consultations, home visits and callouts, also when the RGPs' practices are closed [21]. In 2014, there were 191 OOH services in Norway, 80 were organized as municipal operations and 111 as inter-municipal cooperation [22]. The RGPs are obliged to participate in the OOH services [20]. In addition, some interns and doctors with other specialties also work at OOH services.

If a life-threatening condition is suspected, the public can call 113 – the emergency medical communication centre (EMCC). In case of less serious conditions, GPs can be contacted during office hours, and OOH services are accessible at all times at the national number 116117. The EMCC and OOH services work closely connected through a national emergency radio network. Depending on the symptoms' presentation, the EMCC decides whether the patient needs ambulance transport directly to hospital, or should be seen by another healthcare provider, like a GP or OOH doctor. The OOH service usually has a call-first routine, but at some places, patients may show up directly.

Study setting

Based on data from all registered inhabitants during 2014 in Norway ($N = 5{,}109{,}056$) we identified all emergency admissions to Norwegian hospitals in the period from 1 January until 31 December 2014. As psychiatric hospitals were not included in the study, we use the term somatic hospital admissions. Three national registries were used as data sources; Statistics Norway (SSB), Control and Payment of Reimbursement to Health Service Providers database (KUHR), and The Norwegian Patient Registry (NPR).

SSB contains official demographic data about the Norwegian population. SSB has classified all municipalities based on centrality, which is a description of a municipality's geographical position in relation to workplaces and public services. The classification gives every municipality a value from 0 to 1000. Based on this value the municipalities are then categorized into 6 groups, with group 1 representing the most urban municipalities in the capital region, and group 6 referring to the most rural municipalities [23].

The KUHR database is administrated by HELFO, which receives compensation claims from all GPs, OOH doctors, and private specialists with public contract (PSPC). These claims are registered together with additional information about care provider's ID-number, patient's ID-number, diagnosis, gender, age, address, date and time and type of service provided (consultation, home visit or telephone consultation). GP contacts and OOH contacts are coded separately.

NPR records information about all the patients' contacts with specialist healthcare, including information about the patient's ID number, gender, age, date and time and type of service performed, including institution, degree of urgency, and discharge diagnosis. For some administrative reasons, NPR also included information from the OOH services in the second largest city (Bergen), and these contacts were in this study included as OOH service contacts.

Contacts with other medical services, such as nursing home doctors, private medical providers, or the ambulance services, are not included in these registries.

SSB pseudo anonymized the 2014 population data by replacing the patient's ID-number with a serial number. This number was then sent to NPR and HELFO, and these registries also replaced the ID-number with the same serial number. Thus, data from all three sources could be combined.

Variables and definitions

NPR categorizes every admission according to degree of urgency. We defined an emergency admission as a patient requiring hospital admission immediately or within 24 h after the contact determining admission is necessary.

NPR contains no variable for referring agent. Therefore, we made a proxy for this by linking each admission to a prehospital contact if the contact was within 24 h prior to the time of admission. In case of admission on a Monday, a contact during the preceding weekend was accepted as the referral contact. Since GPs and OOH doctors are not always able to fill out the claims when seeing the patient in emergency consultations, delayed compensation claims produced within 12 h after the admission time was also defined as a referral contact.

For some admissions, there were more than one contact prior to the admission. These contacts were prioritized and included in the following order: OOH contact, GP contact, outpatient contact, and PSPC contact, reflecting that an OOH contact may be assumed to be the most urgent contact.

The emergency admissions were then categorized into four prehospital paths, according to the healthcare services that had provided the gatekeeping or the referral service. The admission was recognized as (1) a GP admission, (2) an OOH doctor admission, or (3) a PSPC admission, if the patient had seen one of these services a short time before admission, respectively. If there was no such contact found prior to the admission, it was categorized as (4) a direct admission.

Weekday was defined as Monday to Friday, and weekend as Saturday and Sunday, corresponding to GPs opening hours. Public holidays were also defined as weekend.

The prehospital paths were analysed based on the International Statistical Classification of Diseases and Related Health Problems version 10 (ICD-10) [24]. The admissions were presented by diagnosis chapters using the first letter in the ICD-10 codes. When analysing more specific diagnoses we used the first three characters of the diagnosis code, thus reducing the number of diagnoses.

When analysing discharge diagnoses typical for GP contacts or OOH contacts prior to admission or diagnoses for direct admissions, we excluded diagnoses with less than 500 cases. Some diagnoses (ICD-chapters) were expected to be the result of direct hospital follow-ups, and were excluded: O (pregnancy, childbirth, and the puerperium) and Z (persons encountering health services for examination and investigation). Chapter C (malignant neoplasms) showed a specific pattern and was therefore analyzed as one unit.

According to national routines on maternity care, women in labour can contact hospital directly for admission to a maternity ward. A birth-related admission was defined as either an admission with the primary discharge ICD-10 diagnosis "Outcome of delivery" (Z37) or "Liveborn infant according to place of birth and type of delivery" (Z38). All admissions in the diagnosis chapter containing conditions originating in the perinatal period (P) were also defined as a birth-related admission. The large majority of birth admissions were identified as direct admissions and were excluded from further analyses (Fig. 1). However, birth related admissions with a GP or OOH contact prior to admission, were kept as a GP or OOH contact.

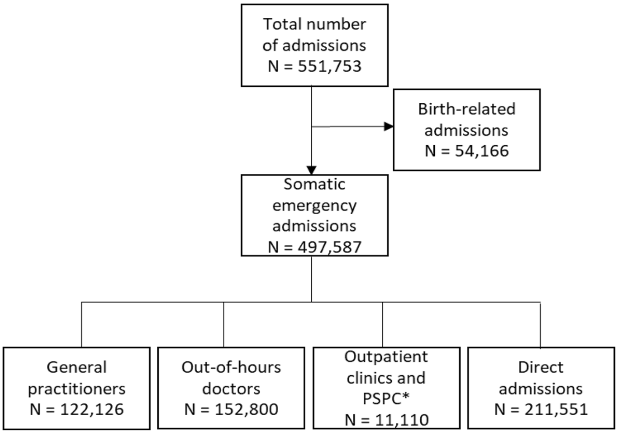

Fig. 1 Prehospital pathways for emergency admissions. Legend: Prehospital pathways for all the emergency admissions to somatic hospitals in Norway in 2014 *Private specialist with public contract

Analyses
The analyses were carried out by using Stata® 15.0 (Stata Corp., College Station, TX, USA). A flow chart was constructed for the predefined prehospital paths. Prehospital paths, discharge diagnoses, and centrality were analysed by frequency two-way tables. As the material is a complete national data set, all differences are real and without statistical uncertainty. The results are therefore presented without any statistical tests.

Results
There were 551,753 emergency hospital admissions to somatic hospitals in Norway in 2014, according to our case definition. One in ten admissions were birth related, hence not supposed to have visited a primary healthcare doctor before admission (Fig. 1). After excluding the birth-related admissions from the material, the distribution of the remaining 497,587 somatic emergency hospital admissions by referring agents is shown in Fig. 1. Direct admissions were most frequent (43%), 31% were referred by OOH doctors, 25% were referred by GPs, whereas only 2% were referred from outpatient's clinics or PSPCs.

Day and time of admission
Large differences in prehospital paths were found for weekdays vs. weekends, and by day and night hours (Fig. 2). On weekdays, most patients were admitted during the daytime, 59% from 8 am to 4 pm. GP contacts were the main prehospital path in this period, with a little dip representing lunch hour. No patients were admitted from GPs during weekends. Patients referred from the OOH services were the largest group during evenings and nights on weekdays, and from midday until 2 am during afternoons and nights on weekends. Direct admissions were dominating during morning hours, both weekdays and weekends.

Centrality patterns
Tables 1 and 2 show emergency admissions by centrality group, referring agent, and per 1000 inhabitants. The mean number of emergency admissions per 1000 inhabitants per year was 97, highest in the least central group (115), and lowest in the most central group (87). For direct admissions, we found an increasing proportion by increasing centrality, so in the most central (urban) areas more than half of the admissions to somatic hospitals in 2014 were direct admissions. For the two least central areas, with 12% of the population and 14% of the admissions, only 37% of the admissions were direct.

There was an increasing proportion of referrals from GPs by decreasing centrality, as referrals from GPs constituted only 16% in the most central group and 31% of the admissions in the two least central groups of municipalities. The proportion of patients referred from OOH doctors was relatively stable by centrality group, varying from 28 to 32% in the various centrality groups. Outpatient clinics and PSPCs referred few patients, and had low shares in all centrality groups, but reached 5% in the most central group. Hospitals in the most central regions had up to 61% direct admissions, whereas the most rural had only 29% (data not shown).

Diagnoses
Among all the emergency admissions, injuries were the most frequent discharge diagnosis group, followed by diseases in the circulatory system, symptoms and

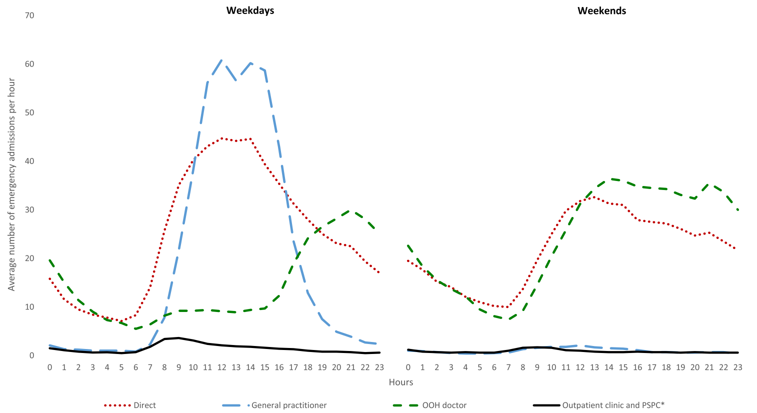

Fig. 2 Emergency admissions by prehospital pathway and time of the day. Legend: All emergency admissions to somatic hospitals in 2014 in Norway, sorted by prehospital pathways and time of the day during weekdays and weekends

findings not elsewhere classified, and diseases in the respiratory system (Fig. 3).

Table 3 shows the 20 most common diagnoses by the four prehospital paths, these diagnoses constituted 35% of all admissions. Pneumonia (J15, J18) was the most common diagnosis, followed by pain in throat and chest (R07), abdominal and pelvic pain (R10), atrial arrhythmias (I48), and acute myocardial infarction (I21). Several kinds of injuries were also in the top 20, together with major chronic diseases such as chronic obstructive pulmonary disease (COPD) and heart failure.

Prehospital paths differed considerably between different discharge diagnoses (Table 4). The GPs (25% of all emergency admissions) had a much higher share of, e.g. anaemias and other conditions of the blood, sciatica, heart failure, and various local subacute diseases like haemorrhoids, diverticulitis, and deep venous thrombosis. OOH doctors (31% of all admissions) had a high share of referrals for various acute conditions, like appendicitis, foreign body in alimentary tract, mental and alcohol related disorders, abdominal pain and other acute gastro-intestinal conditions, asthma, and nephrolithiasis. The direct prehospital path (43% of all admissions) was most common for the diagnosis of agranulocytosis, hydrocephalus and cardiac arrest, but all with relatively small absolute numbers. All diagnoses on the top 20 list for direct admissions had a percentage above 50, revealing a list of conditions being extensively removed from undergoing a gatekeeper process. Admissions for malignant neoplasms was by far the largest group(C) (63%, $N = 24,190$), followed by fractures and other orthopedic conditions, epilepsy, and chronic diseases of the lungs, kidneys and heart. Major and common emergencies, such as stroke (52%), acute myocardial infarction (50%) and pneumonia (40%) did not reach the top 20 list of direct admissions but had high absolute numbers.

Table 1 Frequency of all emergency admissions to somatic hospitals in Norway 2014 by patient residence centrality

	All admissions		Population	
Centrality	N	%	N	Admissions per 1000
1 (most central)	88,050	18	1,011,602	87
2	121,976	25	1,199,290	102
3	123,990	25	1,357,164	91
4	94,407	19	906,580	104
5	48,956	10	459,368	107
6 (least central)	20,092	4	175,052	115
Sum	497,471[a]	100	5,109,056	97

[a] 116 cases missing the centrality variable

Discussion

Main results

We found that 25% of emergency-admitted patients to somatic hospitals in Norway in 2014 were referred by a GP and 31% by an OOH doctor. The largest group of patients were admitted without a registered contact prior to admission (direct admission, 43%). While referrals from GPs were most frequent during office hours, OOH doctors referred patients mainly during evenings, nights and weekends. Direct admissions had the same diurnal pattern as the total emergency admissions, more admissions in daytime and less during the night. Fewer patients living in the most central region were referred by GPs than in less central regions (16% versus 24–31%). More patients were directly admitted (52%) in the most central areas.

Table 2 Variation in prehospital paths by patient residence centrality for all emergency admissions to somatic hospitals in Norway 2014 (*N* = 497,587[a])

	General practitioner		Out-of-hours doctor		Outpatient clinic or PSPC[b]		Direct admission	
Centrality	N	%	N	%	N	%	N	%
1 (most central)	13,838	16	24,804	28	4038	5	45,370	52
2	28,695	24	39,335	32	2271	2	51,675	42
3	32,060	26	37,024	30	2241	2	52,665	42
4	26,397	28	29,909	32	1675	2	36,426	39
5	14,972	31	15,458	32	667	1	17,859	36
6 (least central)	6156	31	6226	31	217	1	7493	37

[a] 116 cases missing the centrality variable
[b] Private specialist with public contract

When analysing the prehospital paths for different discharge diagnoses, we found considerable variation. It is likely that the explanation for this lies in the nature of the clinical presentation and urgency of the medical conditions, in addition to health service factors. Similar to the findings of Vest-Hansen et al. in Denmark, this study showed that pneumonia was the most common admitted emergency medical condition [25].

Strengths and limitations

Our study includes all residents of Norway, and all their GP- and OOH contacts, and all emergency admissions to somatic hospitals in 2014. Hence, there is no selection bias. The registries used are based on data delivered with the purpose of managing funding of primary- and specialist healthcare and are therefore probably complete. This means that the material is fully representative for Norway.

There is no information of referring services in the NPR, and we therefore had to make an algorithm for this purpose. The algorithm linked 57% of all emergency admissions to a referring service. Some of the prehospital contacts categorized as referring contacts might be random contacts with no connection to the admission. Nevertheless, we found a clear accumulation of contacts within the 24 h before admission, reducing the likeliness for high incidence of random linkage. Some prehospital contacts with GP or OOH services may not provide sufficient help, leading patients to contact EMCC, which might result in a direct admission by ambulance services. However, only for the most urgent cases would this comply with the national admission routines.

We used the discharge diagnosis to describe the medical condition for each admission. This does not give accurate information about the clinical presentation at the time of admission, which is the basis for deciding

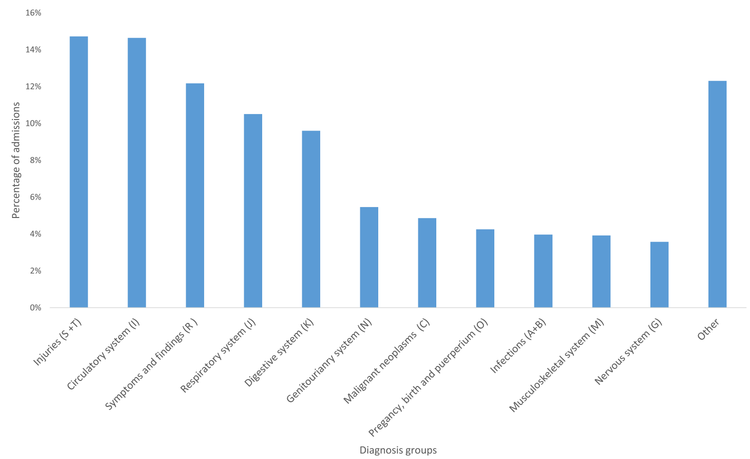

Fig. 3 Emergency admissions by diagnosis groups. Legend: Distribution of admissions by diagnosis groups for the discharge diagnosis (ICD-10) after emergency admissions to somatic hospitals (except normal birth and related conditions) in Norway 2014 (*N* = 497,587)

Table 3 Distribution of prehospital pathways for all admissions (except birth related conditions), and by discharge diagnosis (ICD-10 codes) for the 20 most common diagnosis after somatic hospital stays in Norway 2014

	General practitioner		Out-of-hours doctor		Outpatient clinic or PSPC[a]		Direct admission		Sum	
	N	%	N	%	N	%	N	%	N	%
All admissions	122,126	25	152,800	31	11,110	2	211,551	43	497,587	100
Diagnosis (ICD-10)										
Pneumonia (J15 + J18)	5595	27	6557	32	3161	1	8198	40	20,488	100
Pain in throat and chest (R07)	4332	27	6613	41	138	1	5287	32	16,320	100
Abdominal and pelvic pain (R10)	4538	29	7163	46	88	1	3723	24	15,518	100
Atrial fibrillation and flutter (I48)	3990	34	3314	28	94	1	4391	37	11,873	100
Acute myocardial infarction (I21)	2386	21	3115	28	178	1	5694	50	11,310	100
Fracture of femur (S72)	1240	12	2684	27	115	2	5821	58	9958	100
Chronic obstructive pumonary disease (J44)	2350	26	2897	32	213	1	3705	41	9003	100
Intracranial injury (S06)	1045	13	3276	40	51	4	3595	44	8249	100
Other dissorders of urinary system (N39)	1899	25	2697	36	333	1	2842	38	7498	100
Cerebral infarction (I63)	1687	23	1835	25	60	1	3831	52	7409	100
Heart failure (I50)	2579	35	1874	25	56	1	2859	39	7392	100
Angina pectoris (I20)	1915	28	1922	28	80	2	2794	41	6750	100
Complications of procedures (T81)	1139	20	1338	23	119	3	3151	54	5820	100
Alcohol related disorders (F10)	546	9	2838	49	192	0	2368	41	5779	100
Acute appendicitis (K35)	1686	30	2958	52	27	0	987	17	5642	100
Syncope and collapse (R55)	1177	22	1954	37	11	1	2108	40	5294	100
Choleolithiasis (K80)	1424	28	2193	44	55	1	1355	27	5002	100
Medical observation (Z03)	1383	28	1527	31	30	1	1945	40	4914	100
Fracture of forearm (S52)	629	13	1799	38	59	7	2013	42	4777	100
Fracture of lower leg, including ancle (S82)	562	12	1645	35	228	5	2247	48	4682	100
Sum	42,102		60,199		2463		68,914		173,678	35 (of all)

[a] Private specialist with public contract

the prehospital path. Using the referral diagnosis from the gatekeeping GP and OOH doctor could put extra information on this, but the 43% direct admission would not have such a referral diagnosis. Reasons for encountering GPs or OOH services are not generally available in Norway, and it is thus not possible to link e.g. abdominal pain, fever, etc. to the referral situation.

Gatekeeping

Generally, a gatekeeping system gives power to primary care doctors (GPs and OOH doctors) to decide whether a patient needs specialty care, hospital care, or a diagnostic test, and patients not have access to specialist or hospital care without a prior examination and a referral [26]. Gatekeeping is associated with lower utilization of health services and has been suggested to reduce hospitalizations [15]. In a healthcare system facing capacity problems, this is a preferred development. Recently there has been debate on the value of gatekeeping related to GPs' workload and patient choice [14]. Although Norway has a gatekeeper-based healthcare system, we found that only 56% of the emergency-admitted patients came through the primary healthcare gatekeeping system. This is in line with the findings of Grondal et al. from a smaller study at a medical department in Norway, where GPs and OOH doctors referred 26 and 31%, respectively [17]. A reasonable level of gatekeeping for emergency admissions is not possible to determine. However, the variation by centrality could indicate that primary care doctor gatekeeping can be obtained for two thirds of emergency admissions. This could reduce the workload and expenses in hospital care [14].

The diagnoses where the GP played a major role as gatekeeper in our material were anaemias, of which 45–49% of the patients were referred by GP, infections (34–44%) and worsening of chronic disease (34–38%). These diagnoses seem to be less urgent, and might be identified at a regular control consultation, or an extra emergency contact at the GP office. This resembles the picture from Denmark where anaemia, diabetes, atrial fibrillation and

Table 4 Emergency admissions by discharge ICD-10 diagnosis where contact with a) GP or b) out-of-hour (OOH) doctor, or c) direct admission is the dominating prehospital pathway

a) GP contact before admission (*N* = 122,126)		
	Admissions with the discharge diagnose	GP contact before admission
Diagnosis	N	%
Iron deficiency anaemia (D50)	1980	49
Haemorrhoids (K64)	655	46
Other anaemias (D64)	1274	45
Anal and rectal abscess (K61)	1214	44
Diverticular disease (K57)	3234	44
Intervertebral disc disorders (M51)	2156	44
Mononucleosis (B27)	517	42
Phlebitis and thrombophlebitis (I80)	1428	42
Localized swelling, head (R22)	523	41
Venous embolism and thrombosis (I82)	548	39
Excessive vomiting in pregnancy (O21)	1205	39
Gout (M10)	659	38
Malaise and fatigue (R53)	516	38
Other spondylopathies (M48)	735	37
Ulcerative colitis (K51)	969	37
Disturbances of skin sensation (R20)	745	36
Facial nerve disorders (G51)	516	36
Cutaneous abscess (L02)	1509	35
Heart failure (I50)	7392	35
Osteomyelitis (M86)	526	34
b) OOH doctor contact before admission (*N* = 152,800)		
	Admissions with the discharge diagnose	OOH contact before admission
Diagnosis	N	%
Acute appendicitis (K35)	5642	52
Foreign body in alimentary tract (T18)	690	52
Effects of other external causes (T75)	732	51
Mental/alcohol disorders (F10)	5779	49
Mental/psychoactive subst. Disorders (F19)	1717	49
Acute tonsillitis (J03)	1130	48
Acute pancreatitis (K85)	1995	46
Abdominal and pelvic pain (R10)	15,518	46
Haemorrhage, airways (R04)	1129	46
Mental/opioids disorders (F11)	757	46
Viral intestinal infections (A08)	1433	46
Adverse effects (T78)	1419	45
Viral infection of unspecified site (B34)	1065	44
Cholelithiasis (K80)	5002	44
Gatroenteritis and colitis (A09)	3225	44
Asthma (J45)	2100	43
Calculus of kidney (N20)	3324	43
Disorders of vestibular function (H81)	2017	43

Table 4 Emergency admissions by discharge ICD-10 diagnosis where contact with a) GP or b) out-of-hour (OOH) doctor, or c) direct admission is the dominating prehospital pathway *(Continued)*

Paralytic ileus/ intestinal obstruction (K56)	3356	42
Dorsalgia (M54)	3648	42
c) Direct admissions except the ICD-10 diagnosis groups *pregnancy, childbirth and* the puerperium (0XX), and *factors influencing health status and contact with health services (ZXX)* (*N* = 211,551)		
	Admissions with the discharge diagnose	Direct admission
Diagnosis	N	%
Agranulocytosis (D70)	749	72
Hydrocephalus (G91)	587	68
Malignant neoplasms (C)	24,190	63
Cardiac arrest (I46)	539	63
Orthopaedic complications (T84)	2001	62
Pneumonitis due to food and vomit (J69)	836	59
Intracerebral haemorrhage (I61)	1421	58
Fracture of femur (S72)	9958	58
Superficial injury of thorax (S20)	522	58
Mental/sedatives dissorders (F13)	658	58
Epilepsy (G40)	3874	57
Multiple sclerosis (G35)	969	55
Open wound of head (S01)	849	55
Respiratory failure, unspecified (J96)	2388	55
Complications of procedures ICA (T81)	5820	54
Chronic ischaemic heart disease (I25)	2954	54
Chronic kidney disease (N18)	2080	53
Sequelae of cerebrovascular disease (I69)	828	53
Parkinson's disease (G20)	661	53
Aortic aneurysm and dissection (I71)	982	53

heart failure show a reduction in admission rate from office-hours when GPs work, to evening, night and weekend [25]. Skarshaug et al. found a similar pattern in another Norwegian study, showing that 74% of the patients admitted with heart failure had a GP contact within the previous month [27].

The OOH doctor more often was referring patients with conditions where medical investigation and treatment is more urgent, like abdominal pain (42–52%) and mental illness/substance abuse and intoxication (46–49%).

Direct admissions

The direct admissions are the most frequent prehospital path in our material, and may represent admissions from nursing homes, admissions initiated by hospital doctors following up the patients in specialist healthcare, or directly admitted by ambulance services. As expected, direct admissions are more frequent for highly urgent conditions such as cardiac arrest (63%) and intracerebral haemorrhage (58%) suggesting direct admissions by ambulance service. Our study also shows that 37 and 42% of these cases, respectively, do have a GP or OOH contact before admission. According to national guidelines, cerebral infarction should be managed by direct prehospital path [28]. However, 23% were referred by GPs and 25% by OOH doctors. A study from The Netherlands found that as many as 49% of patients with acute stroke had a GP contact before admission [29]. Probably, some of these patients contact their GP or other primary care providers instead of EMCC in emergencies. The clinical presentation of such urgent conditions is not always the classic acute pattern, similar to stroke and acute coronary syndrome [29, 30].

On the other hand, we know that the OOH doctors and GPs are highly involved in acute cases. In 2014, 65% of the Norwegian OOH services reported that the doctors participate in emergency callouts always or often, when alarmed [22]. One earlier study showed that GPs or OOH doctors participated in 42% of alerted emergency cases [31, 32]. In 2015, the new emergency medicine regulation in Norway stated that the OOH doctors are obliged to be contacted in the emergency communication system and to participate in emergency callouts, when needed [21].

Some medical conditions are followed up in specialist care at hospitals. It is likely that worsening or complications may be discovered at specialist care consultations, or by the patient's direct contact to the hospital. This might contribute to the high proportion of direct admissions for malignant neoplasms (63%) and orthopaedic complications (62%). Grondal et al. found that 18% of all admissions to a medical department were from outpatient clinics and open return agreements [17]. It is likely that admissions from outpatient clinics at the hospital are often converted for administrative reasons directly from an outpatient contact to an emergency admission without registering the outpatient clinic contact. Also, some of the patients with a discharge diagnosis of malignant disease might have been admitted because of acute symptoms, and then diagnosed with cancer during the hospital stay. Again, these patients would, according to national procedures, usually have been guided by the EMCC or OOH services to a primary care doctor to get a medical examination and referral.

Hip fracture (S72) had a high proportion of direct admissions (58%), illustrating a condition where GP or OOH consultation often is not necessary in order to reveal the need for hospital care. This supports the finding of Skarshaug et al. where 50% of patients urgently admitted to hospital with hip fracture had no GP or OOH contact the month prior to emergency admission [27].

Referrals from nursing home doctors are not specified in our material but included in the direct admissions. We found the same proportion of direct admissions for patients between the age of 80–89 years as for the total population (43%), and only slightly increased direct admissions (47%) for patients 90 years and older. This indicates that admissions from nursing home doctors do not significantly affect the proportion of direct admissions.

Time of the day

The gatekeeping function was delivered by the GPs and OOHs doctor according to activity in the services, GP in the opening hours, and OOH doctors the rest of the week. The gatekeeper activity is slightly higher than direct admissions throughout the day, with a period in the morning, both on weekdays and weekends, where the direct admissions are more frequent than GP and OOH referrals. This might be because some emergencies are discovered in the morning when the patient and the relatives wake up, or by that the OOH and GP services have less capacity in the transition time between night-shift and daytime work.

Centrality

GPs and OOH doctors participate less in the emergency callouts in the most central regions in Norway [31, 32]. This may explain the low gatekeeper activity of GPs in the central area, but we did not find the same effect for OOH doctors. Thus, hyper-acute cases with callouts represent relatively few admissions, and therefore the effect of this is relatively sparse. The GPs' low share of referrals to hospitals may rather be due to GPs in most central regions being less accessible for urgent consultations than their more rural colleagues, but this is not possible to investigate in the present study. Unlike Bankart et al. we found higher rates of emergency admissions in rural areas [7].

Interpretations

Based on our findings, Norwegian GPs and OOH doctors are gatekeepers in fewer emergency admissions to somatic hospitals than expected, when taking into account the rather strict gatekeeping system that is principally in place. The direct prehospital path representing admissions from ambulance services, referrals from nursing home doctors, and admissions initiated by hospital doctors, represent a larger part of the emergency admissions. This should be taken into account when planning health care services, including strategies in order to reduce hospital overload. On the other hand, there are many clinical conditions where both GPs' and OOH doctors' gatekeeping role are considerable.

Conclusions

GPs or OOH doctors referred many emergencies to somatic hospitals, and for some clinical conditions GPs' and OOH doctors' gatekeeping role was considerable. GP referrals were less frequent in the most central areas. A significant number of the emergency admissions had no GP or OOH doctor contact before admission. These direct admissions were more frequent in central areas, for highly urgent conditions and conditions likely to be followed up in specialist care at hospital. The proportion of direct admissions reduces the impact of the GPs' and OOH doctors' gatekeeper roles on emergency admissions, even in a strict gatekeeping system.

Abbreviations

EMCC: Emergency medical communication centre; GP: General practitioner; HELFO: Norwegian Health Economics Administration; ICD-10: The International Statistical Classification of Diseases and Related Health Problems version 10; KUHR: Control and Payment of Reimbursement to Health Service Providers database; NPR: Norwegian Patient Registry; OOH: Out-of-hours; PSPC: Private specialist with public contract; RGP: Regular general practitioner; SSB: Statistics Norway

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Authors' contributions
JB has contributed the research idea, the applying for license to perform the study, the data processing, the analyses and the writing of the manuscript. SH has been the main supervisor in all aspects of the study. He has contributed the designing and writing of the manuscript. SP has contributed considerable input to language and writing of the manuscript, including figures and tables. ØH has contributed statistical analyses and supervising on STATA, in addition to scientific input on research questions and the manuscript. HS has contributed scientific input on the research questions, the impact of the results and the manuscript. All authors have read and approved the manuscript.

Authors' information
Data from the Norwegian Patient Register has been used in this publication. The interpretation and reporting of these data are the sole responsibility of the authors, and no endorsement by the Norwegian Patient Register is intended nor should be inferred.

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Availability of data and materials
The data used in this study are available from The Norwegian Directorate of Health (www.helsedirektoratet.no/) and Statistics Norway (www.ssb.no), but restrictions apply to the availability of these data, which were used under licence for the current study, and so are not publicly available. However, data are available from the authors upon reasonable request and with included permission from The Norwegian Directorate of Health, Statistics Norway, the Regional Ethical Committee, and Norwegian Data Protection Authority.

Ethics approval and consent to participate
Ethical approval was obtained from the Regional Ethical Committee for Medical and Health Research Ethics, Region West (30.01.2014) (reference number 2013/2344/REK vest) and Norwegian Data Protection Authority (15.09.2014) (reference number 14/0322–9/CGN). The Regional Ethical Committee for Medical and Health Research Ethics, Region West gave permission to use the data without asking the patients for consent. Norwegian Data Protection Authority approved the use of the data for research purposes in this project. The register owners, Statistics Norway and the Norwegian Directorate of Health, approved linkage of registries. The data were pseudo anonymized by third party (Statistics Norway), and analyzed at group level to minimize the risk for individuals to be identified.

Consent for publication
Not applicable.

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

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BMC Health Services Research

CORRECTION **Open Access**

Correction to: General practitioners' and out-of-hours doctors' role as gatekeeper in emergency admissions to somatic hospitals in Norway: registry-based observational study

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Following publication of the original article [1], the authors would like to correct several numbers in the following paragraphs. In addition, Fig. 1, Fig. 2, Fig. 3, Table 1, Table 2, Table 3, and Table 4 need to be corrected as well.

The numbers need to be corrected for two reasons, both technical and originating from the preparation of the research data files. First, the authors discovered that the material missed data for 8% of primary care contacts due to a data transfer error between the university and the main public data registry. Second, technical personnel in our data centre had made an error in the algorithm when linking datasets, leading to less prehospital contacts linked to emergency hospital admissions. As a result, most numbers in the Results, Tables and Figures were affected. Most of the changes were, however, of insignificant magnitude, and the errors did not affect the main conclusions of the article.

The updated paragraphs are given below, and include the whole results and discussion section, as well as all tables and figures.

The original article can be found online at https://doi.org/10.1186/s12913-019-4419-0.

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1. Results in the Abstract:

Results: In 2014 there were 497,845 emergency admissions to somatic hospitals in Norway after excluding birth related conditions. Referrals by OOH doctors were most frequent (36%), 35% were direct admissions, 28% were referred by GPs, whereas only 2% were referred from outpatient clinics or private specialists with public contract. Direct admissions were more common in central areas (45%), here GPs' referrals constituted only 18%. The prehospital paths varied with the hospital discharge diagnosis. For anaemias, 52–56% were referred by GPs, for acute appendicitis and mental/alcohol related disorders 57% and 56% were referred by OOH doctors, respectively. For malignant neoplasms 56% and cardiac arrest 57% were direct admissions

2. Results in main text:

Results

There were 551,753 emergency hospital admissions to somatic hospitals in Norway in 2014, according to our case definition. One in ten admissions were birth related, hence not supposed to have visited a primary healthcare doctor before admission (Fig. 1). After excluding the birth-related admissions from the material, the distribution of the remaining 497,845 somatic emergency hospital admissions by referring agents is shown in Fig. 1. Referrals by OOH doctors were most frequent (36%), 35% were direct admissions, 28% were referred by GPs, whereas only 2% were referred from outpatient's clinics or PSPCs.

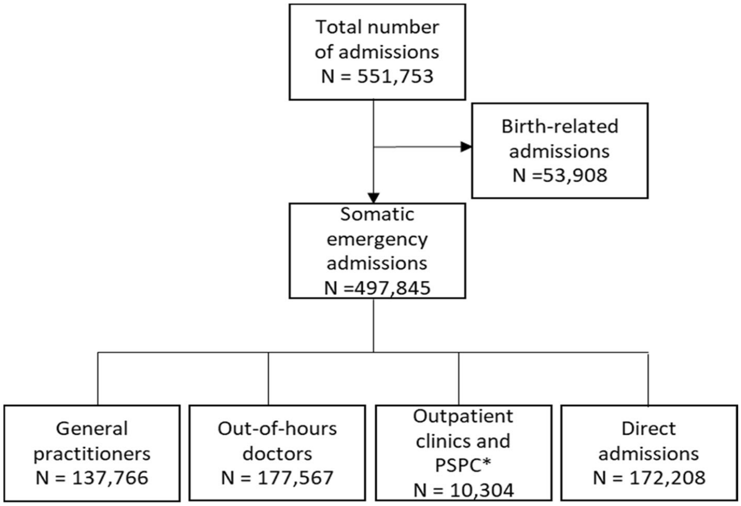

Fig. 1 Prehospital pathways for all the emergency admissions to somatic hospitals in Norway in 2014 *Private specialist with public contract

Day and time of admission

Large differences in prehospital paths were found for weekdays vs. weekends, and by day and night hours (Fig. 2). On weekdays, most patients were admitted during the daytime, 53% from 8 am to 4 pm. GP contacts were the main prehospital path in this period, with a little dip representing lunch hour. No patients were admitted from GPs during weekends. Patients referred from the OOH services were the largest group during evenings and nights on weekdays,

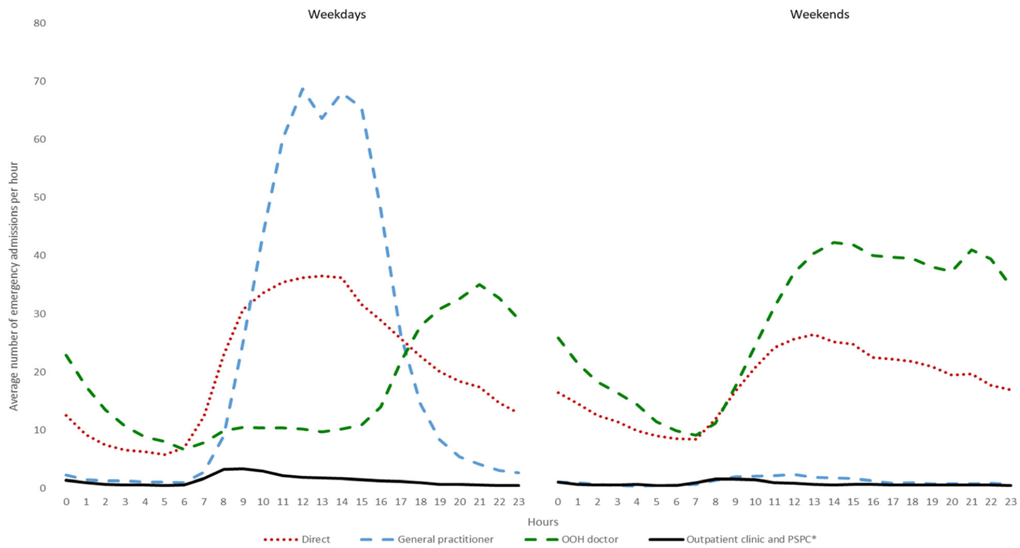

Fig. 2 All emergency admissions to somatic hospitals in 2014 in Norway, sorted by prehospital pathways and time of the day during weekdays and weekends

and all weekends. Direct admissions were high during morning hours and midday, both weekdays and weekends.

Centrality patterns

Table 1 and Table 2 show emergency admissions by centrality group, referring agent, and per 1000 inhabitants. The mean number of emergency admissions per 1000 inhabitants per year was 97, highest in the least central group (115), and lowest in the most central group (87). For direct admissions, we found an increasing proportion by increasing centrality, so in the most central (urban) areas almost half of the admissions to somatic hospitals in 2014 were direct admissions. For the two least central areas, with 12% of the population and 14% of the admissions, only 28% of the admissions were direct.

There was an increasing proportion of referrals from GPs by decreasing centrality, as referrals from GPs constituted only 18% in the most central group and 34% of the admissions in the two least central groups of municipalities. The proportion of patients referred from OOH doctors was relatively stable by centrality group, varying from 32 to 37% in the various centrality groups. Outpatient clinics and PSPCs referred few patients, and had low shares in all centrality groups, but reached 4% in the most central group. Hospitals in the most central regions had up to 57% direct admissions, whereas the most rural had only 22% (data not shown).

Diagnoses

Among all the emergency admissions, injuries were the most frequent discharge diagnosis group, followed by diseases in the circulatory system, symptoms and findings not elsewhere classified, and diseases in the respiratory system (Fig. 3).

Table 3 shows the 20 most common diagnoses by the four prehospital paths, these diagnoses constituted 35% of all admissions. Pneumonia (J15, J18) was the most common diagnosis, followed by pain in throat and chest (R07), abdominal and pelvic pain (R10), atrial arrhythmias (I48), and acute myocardial infarction (I21). Several

Table 1 Frequency of all emergency admissions to somatic hospitals in Norway 2014 by patient residence centrality

Centrality	All admissions		Population	
	N	%	N	Admissions per 1000
1 (most central)	88,086	18	1,011,602	87
2	122,043	25	1,199,290	102
3	124,055	25	1,357,164	91
4	94,456	19	906,580	104
5	48,982	10	459,368	107
6 (least central)	20,107	4	175,052	115
Sum	497,729[a]	100	5,109,056	97

[a]116 cases missing the centrality variable

kinds of injuries were also in the top 20, together with major chronic diseases such as chronic obstructive pulmonary disease (COPD) and heart failure.

Prehospital paths differed considerably between different discharge diagnoses (Table 4). The GPs (28% of all emergency admissions) had a much higher share of, e.g. anaemias and other conditions of the blood, sciatica, heart failure, and various local subacute diseases like haemorrhoids, diverticulitis, and deep venous thrombosis. OOH doctors (36% of all admissions) had a high share of referrals for various acute conditions, like appendicitis, foreign body in alimentary tract, mental and alcohol related disorders, abdominal pain and other acute gastro-intestinal conditions, asthma, and nephrolithiasis. The direct prehospital path (35% of all admissions) was most common for the diagnosis of agranulocytosis, hydrocephalus and cardiac arrest, but all with relatively small absolute numbers. The top seven diagnoses with direct admissions had a percentage above 50, revealing a list of conditions being extensively removed from undergoing a gatekeeper process. Admissions for malignant neoplasms was by far the largest group(C) (56%, $N = 24{,}190$), followed by fractures and other orthopedic conditions, epilepsy, and chronic diseases of the lungs, kidneys and heart. Major and common emergencies, such as stroke (42%), acute myocardial infarction (42%) and pneumonia (29%) did not reach the top 20 list of direct admissions but had high absolute numbers.

3. Discussion in main text

Main results

We found that 28% of emergency-admitted patients to somatic hospitals in Norway in 2014 were referred by a GP and 36% by an OOH doctor. The second largest group of patients were admitted without a registered contact prior to admission (direct admission, 35%). While referrals from GPs were most frequent during office hours, OOH doctors referred patients mainly during evenings, nights and weekends. Direct admissions had the same diurnal pattern as the total emergency admissions, more admissions in daytime and less during the night. Fewer patients living in the most central region were referred by GPs than in less central regions (18% versus 27–34%). More patients were directly admitted (45%) in the most central areas.

When analysing the prehospital paths for different discharge diagnoses, we found considerable variation. It is likely that the explanation for this lies in the nature of the clinical presentation and urgency of the medical conditions, in addition to health service factors. Similar to the findings of Vest-Hansen et al. in Denmark, this study showed that pneumonia was the most common admitted emergency medical condition (25).

Table 2 Variation in prehospital paths by patient residence centrality for all emergency admissions to somatic hospitals in Norway 2014 (*N* = 497,729[a])

	General practitioner		Out-of-hours doctor		Outpatient clinic or PSPC[b]		Direct admission	
Centrality	N	%	N	%	N	%	N	%
1 (most central)	15,820	18	28,596	32	3828	4	39,842	45
2	32,363	27	45,181	37	2098	2	42,401	35
3	36,372	29	43,537	35	2045	2	42,101	34
4	29,651	31	34,676	37	1537	2	28,592	30
5	16,708	34	18,104	37	606	1	13,564	28
6 (least central)	6845	34	7424	37	189	1	5649	28

[a]116 cases missing the centrality variable
[b]Private specialist with public contract

Strengths and limitations

Our study includes all residents of Norway, and all their GP- and OOH contacts, and all emergency admissions to somatic hospitals in 2014. Hence, there is no selection bias. The registries used are based on data delivered with the purpose of managing funding of primary- and specialist healthcare and are therefore probably complete. This means that the material is fully representative for Norway.

There is no information of referring services in the NPR, and we therefore had to make an algorithm for this purpose. The algorithm linked 65% of all emergency admissions to a referring service. Some of the prehospital contacts categorized as referring contacts might be random contacts with no connection to the admission. Nevertheless, we found a clear accumulation of contacts within the 24 h before admission, reducing the likeliness for high incidence of random linkage. Some prehospital

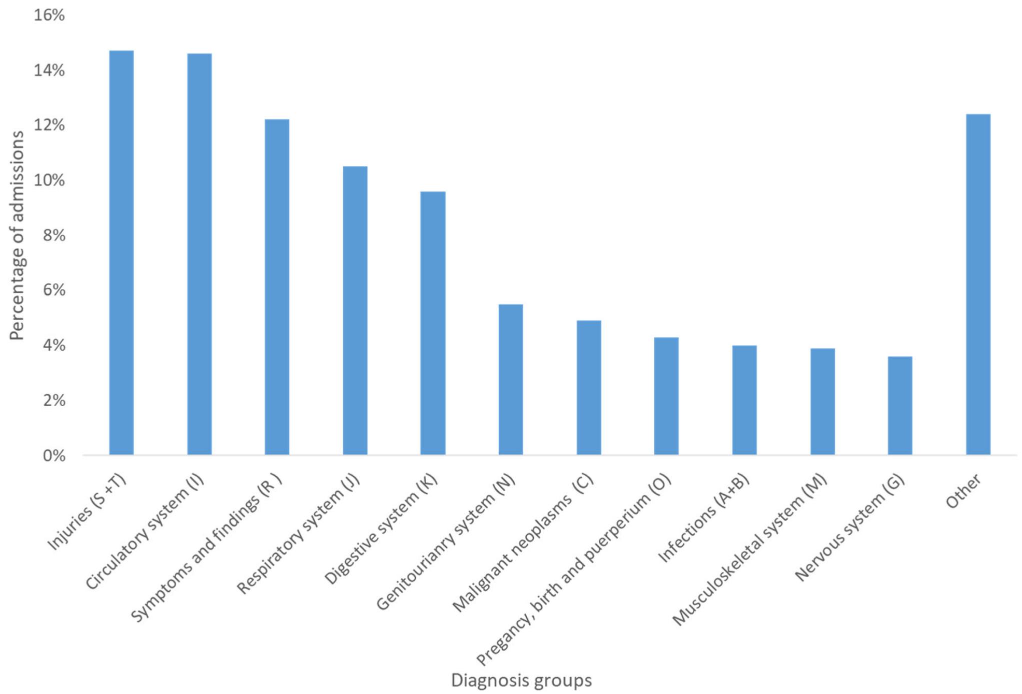

Fig. 3 Distribution of admissions by diagnosis groups for the discharge diagnosis (ICD-10) after emergency admissions to somatic hospitals (except normal birth and related conditions) in Norway 2014 (*N* = 497,845)

Table 3 Distribution of prehospital pathways for all admissions (except birth related conditions), and by discharge diagnosis (ICD-10 codes) for the 20 most common diagnosis after somatic hospital stays in Norway 2014

	General practitioner		Out-of-hours doctor		Outpatient clinic or PSPC[a]		Direct admission		Sum	
	N	%	N	%	N	%	N	%	N	%
All admissions	137,766	28	177,567	36	10,304	2	172,208	35	497,845	100
Diagnosis (ICD-10)										
Pneumonia (J15 + J18)	6499	32	7918	39	109	1	5962	29	20,488	100
Pain in throat and chest (R07)	4710	29	7613	47	74	0	3923	24	16,320	100
Abdominal and pelvic pain (R10)	4930	32	7874	51	81	1	2633	17	15,518	100
Atrial fibrillation and flutter (I48)	4423	37	3885	33	170	1	3395	29	11,873	100
Acute myocardial infarction (I21)	2699	24	3814	34	92	1	4705	42	11,310	100
Fracture of femur (S72)	1634	16	3417	34	192	2	4715	47	9958	100
Chronic obstructive pumonary disease (J44)	2743	30	3461	38	45	0	2754	31	9003	100
Intracranial injury (S06)	1178	14	3734	45	316	4	3021	37	8249	100
Other dissorders of urinary system (N39)	2233	30	3158	42	49	1	2058	27	7498	100
Cerebral infarction (I63)	1973	27	2313	31	45	1	3078	42	7409	100
Heart failure (I50)	2935	40	2191	30	72	1	2194	30	7392	100
Angina pectoris (I20)	2107	31	2253	33	113	2	2277	34	6750	100
Complications of procedures (T81)	1257	22	1581	27	174	3	2808	48	5820	100
Alcohol related disorders (F10)	641	11	3262	56	24	0	1852	32	5779	100
Acute appendicitis (K35)	1827	32	3233	57	9	0	573	10	5642	100
Syncope and collapse (R55)	1305	25	2240	42	45	1	1704	32	5294	100
Choleolithiasis (K80)	1549	31	2488	50	22	0	943	19	5002	100
Medical observation (Z03)	1567	32	1735	35	52	1	1560	32	4914	100
Fracture of forearm (S52)	698	15	1992	42	317	7	1770	37	4777	100
Fracture of lower leg, including ancle (S82)	630	13	1858	40	211	5	1983	42	4682	100
Sum	47,538		70,020		2212		53,908		173,678	35 (of all)

[a]Private specialist with public contract

contacts with GP or OOH services may not provide sufficient help, leading patients to contact EMCC, which might result in a direct admission by ambulance services. However, only for the most urgent cases would this comply with the national admission routines.

We used the discharge diagnosis to describe the medical condition for each admission. This does not give accurate information about the clinical presentation at the time of admission, which is the basis for deciding the prehospital path. Using the referral diagnosis from the gatekeeping GP and OOH doctor could put extra information on this, but the 35% direct admission would not have such a referral diagnosis. Reasons for encountering GPs or OOH services are not generally available in Norway, and it is thus not possible to link e.g. abdominal pain, fever, etc. to the referral situation.

Gatekeeping

Generally, a gatekeeping system gives power to primary care doctors (GPs and OOH doctors) to decide whether a patient needs specialty care, hospital care, or a diagnostic test, and patients not have access to specialist or hospital care without a prior examination and a referral (26). Gatekeeping is associated with lower utilization of health services and has been suggested to reduce hospitalizations (15). In a healthcare system facing capacity problems, this is a preferred development. Recently there has been debate on the value of gatekeeping related to GPs' workload and patient choice (14). Although Norway has a gatekeeper-based healthcare system, we found that only 65% of the emergency-admitted patients came through the primary healthcare gatekeeping system. This is in line with the findings of Grondal et al. from a smaller study at a medical department in Norway, where GPs and OOH doctors referred 26 and 31%, respectively (17). A reasonable level of gatekeeping for emergency admissions is not possible to determine. However, the variation by centrality could indicate that primary

Table 4 Emergency admissions by discharge ICD-10 diagnosis where contact with a) GP or b) out-of-hour (OOH) doctor, or c) direct admission is the dominating prehospital pathway

a) GP contact before admission (*N* = 137,766)		
	Admissions with the discharge diagnose	**GP contact before admission**
Diagnosis	**N**	**%**
Iron deficiency anaemia (D50)	1980	56
Other anaemias (D64)	1274	52
Haemorrhoids (K64)	655	48
Diverticular disease (K57)	3234	48
Abscess of anal and rectal regions (K61)	1214	47
Intervertebral disc disorders (M51)	2180	47
Localized swelling, head (R22)	523	46
Phlebitis and thrombophlebitis (I80)	1428	46
Gout (M10)	659	44
Mononucleosis (B27)	517	43
Other spondylopathies (M48)	735	43
Venous embolism and thrombosis (I82)	548	43
Excessive vomiting in pregnancy (O21)	1205	42
Malaise and fatigue (R53)	516	41
Ulcerative colitis (K51)	969	40
Heart failure (I50)	7392	40
Atherosclerosis (I70)	1097	39
Disturbances of skin sensation (R20)	745	39
Facial nerve disorders (G51)	516	39
Osteomyelitis (M86)	526	39
b) OOH doctor contact before admission (*N* = 177,567)		
	Admissions with the discharge diagnose	**OOH contact before admission**
Diagnosis	**N**	**%**
Foreign body in alimentary tract (T18)	690	60
Mental/psychoactive subst. disorders (F19)	1717	58
Effects of other external causes (T75)	732	58
Acute appendicitis (K35)	5642	57
Mental/alcohol disorders (F10)	5779	56
Mental/opioids disorders (F11)	757	54
Acute tonsillitis (J03)	1130	53
Haemorrhage, airways (R04)	1129	53
Acute pancreatitis (K85)	1995	52
Viral intestinal infections (A08)	1433	51
Abdominal and pelvic pain (R10)	15,518	51
Cholelithiasis (K80)	5002	50
Adverse effects (T78)	1419	50
Viral infection of unspecified site (B34)	1065	49
Gastroenteritis and colitis (A09)	3225	49
Paralytic ileus / intestinal obstruction (K56)	3356	48
Disorders of vestibular function (H81)	2017	48
Asthma (J45)	2100	48

Table 4 Emergency admissions by discharge ICD-10 diagnosis where contact with a) GP or b) out-of-hour (OOH) doctor, or c) direct admission is the dominating prehospital pathway *(Continued)*

Dorsalgia (M54)	3648	47
Calculus of kidney (N20)	3324	47
c) Direct admissions except the ICD-10 diagnosis groups *pregnancy, childbirth and* the puerperium (0XX), and *factors influencing health status and contact with health services (ZXX)* (*N* = 172,208)		
	Admissions with the discharge diagnose	**Direct admission**
Diagnosis	**N**	**%**
Agranulocytosis (D70)	749	66
Hydrocephalus (G91)	587	64
Cardiac arrest (I46)	539	57
Malignant neoplasms (C)	24,190	56
Orthopaedic complications (T84)	2001	54
Superficial injury of thorax (S20)	522	53
Intracerebral haemorrhage (I61)	1421	51
Mental/sedatives dissorders (F13)	658	49
Open wound of head (S01)	849	49
Multiple sclerosis (G35)	969	49
Complications of procedures ICA (T81)	5820	48
Epilepsy (G40)	3874	48
Fracture of femur (S72)	9958	47
Chronic ischaemic heart disease (I25)	2954	47
Aortic aneurysm and dissection (I71)	982	46
Fracture of skull and facial bones (S02)	1132	45
Pleural effusion, not elsewhere classified (J90)	915	45
Nonrheumatic aortic valve disorders (I35)	1280	44
Convulsions, not elsewhere classified (R56)	1838	44
Pneumonitis due to food and vomit (J69)	836	44

care doctor gatekeeping can be obtained for two thirds of emergency admissions. This could reduce the workload and expenses in hospital care (14).

The diagnoses where the GP played a major role as gatekeeper in our material were anaemias, of which 52–56% of the patients were referred by GP, infections (39–47%) and worsening of chronic disease (39–44%). These diagnoses seem to be less urgent, and might be identified at a regular control consultation, or an extra emergency contact at the GP office. This resembles the picture from Denmark where anaemia, diabetes, atrial fibrillation and heart failure show a reduction in admission rate from office-hours when GPs work, to evening, night and weekend (25). Skarshaug et al. found a similar pattern in another Norwegian study, showing that 74% of the patients admitted with heart failure had a GP contact within the previous month (27).

The OOH doctor more often was referring patients with conditions where medical investigation and treatment is more urgent, like abdominal pain (47–57%) and mental illness/substance abuse and intoxication (54–56%).

Direct admissions

The direct admissions are the second most frequent prehospital path in our material, and may represent admissions from nursing homes, admissions initiated by hospital doctors following up the patients in specialist healthcare, or directly admitted by ambulance services. As expected, direct admissions are more frequent for highly urgent conditions such as cardiac arrest (57%) and intracerebral haemorrhage (51%) suggesting direct admissions by ambulance service. Our study also shows that 43 and 49% of these cases, respectively, do have a GP or OOH contact before admission. According to national guidelines, cerebral infarction should be managed by direct prehospital path (28). However, 27% were referred by GPs and 31% by OOH doctors. A study from The Netherlands found that as many as 49% of patients with acute stroke had a GP contact before admission (29). Probably, some of these patients contact their GP or other primary care providers instead of EMCC in emergencies. The clinical presentation of such urgent conditions is not always the classic acute pattern, similar to stroke and acute coronary syndrome (29, 30).

On the other hand, we know that the OOH doctors and GPs are highly involved in acute cases. In 2014, 65% of the Norwegian OOH services reported that the doctors participate in emergency callouts always or often, when alarmed (22). One earlier study showed that GPs or OOH doctors participated in 42% of alerted emergency cases (31, 32). In 2015, the new emergency medicine regulation in Norway stated that the OOH doctors are obliged to be contacted in the emergency communication system and to participate in emergency callouts, when needed (21).

Some medical conditions are followed up in specialist care at hospitals. It is likely that worsening or complications may be discovered at specialist care consultations, or by the patient's direct contact to the hospital. This might contribute to the high proportion of direct admissions for malignant neoplasms (56%) and orthopaedic complications (54%). Grondal et al. found that 18% of all admissions to a medical department were from outpatient clinics and open return agreements (17). It is likely that admissions from outpatient clinics at the hospital are often converted for administrative reasons directly from an outpatient contact to an emergency admission without registering the outpatient clinic contact. Also, some of the patients with a discharge diagnosis of malignant disease might have been admitted because of acute symptoms, and then diagnosed with cancer during the hospital stay. Again, these patients would, according to national procedures, usually have been guided by the EMCC or OOH services to a primary care doctor to get a medical examination and referral.

Hip fracture (S72) had a high proportion of direct admissions (47%), illustrating a condition where GP or OOH consultation often is not necessary in order to reveal the need for hospital care. This supports the finding of Skarshaug et al. where 50% of patients urgently admitted to hospital with hip fracture had no GP or OOH contact the month prior to emergency admission (27).

Referrals from nursing home doctors are not specified in our material but included in the direct admissions. We found the same proportion of direct admissions for elderly patients as for the total population, 80–89 years 33, and 34% for patients 90 years and older. This indicates that admissions from nursing home doctors do not significantly affect the proportion of direct admissions.

Time of the day

The gatekeeping function was delivered by the GPs and OOHs doctor according to activity in the services, GP in the opening hours, and OOH doctors the rest of the week. The gatekeeper activity is higher than direct admissions throughout the day, with a period in the morning, both on weekdays and weekends, where the direct admissions are as frequent as GP and OOH referrals. This might be because some emergencies are discovered in the morning when the patient and the relatives wake up, or by that the OOH and GP services have less capacity in the transition time between night-shift and daytime work.

Centrality

GPs and OOH doctors participate less in the emergency callouts in the most central regions in Norway (31, 32). This may explain the low gatekeeper activity of GPs in the central area, but we did not find the same effect for OOH doctors. Thus, hyper-acute cases with callouts represent relatively few admissions, and therefore the effect of this is relatively sparse. The GPs' low share of referrals to hospitals may rather be due to GPs in most central regions being less accessible for urgent consultations than their more rural colleagues, but this is not possible to investigate in the present study. Unlike Bankart et al. we found higher rates of emergency admissions in rural areas (7).

Interpretations

Based on our findings, Norwegian GPs and OOH doctors are gatekeepers in fewer emergency admissions to somatic hospitals than expected, when taking into account the rather strict gatekeeping system that is principally in place. The direct prehospital path representing admissions from ambulance services, referrals from nursing home doctors, and admissions initiated by hospital doctors, represent a large part of the emergency admissions. This should be taken into account when planning health care services, including strategies in order to reduce hospital overload. On the other hand, there are many clinical conditions where both GPs' and OOH doctors' gatekeeping role are considerable.

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PAPER II

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RESEARCH

Open Access

Reasons for acute referrals to hospital from general practitioners and out-of-hours doctors in Norway: a registry-based observational study

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Abstract

Background: General practitioners (GPs) and out-of-hours (OOH) doctors are gatekeepers to acute hospital admissions in many healthcare systems. The aim of the present study was to investigate the whole range of reasons for acute referrals to somatic hospitals from GPs and OOH doctors and referral rates for the most common reasons. We wanted to explore the relationship between some common referral diagnoses and the discharge diagnosis, and associations with patient's gender, age, and GP or OOH doctor referral.

Methods: A registry-based study was performed by linking national data from primary care in the physicians' claims database with hospital services data in the Norwegian Patient Registry (NPR). The referring GP or OOH doctor was defined as the physician who had sent a claim for the patient within 24 h prior to an acute hospital stay. The reason for referral was defined as the ICPC-2 diagnosis used in the claim; the discharge diagnoses (ICD-10) came from NPR.

Results: Of all 265,518 acute hospital referrals from GPs or OOH doctors in 2017, GPs accounted for 43% and OOH doctors 57%. The overall referral rate per contact was 0.01 from GPs and 0.11 from OOH doctors, with large variations by referral diagnosis. Abdominal pain (D01) (8%) and chest pain (A11) (5%) were the most frequent referral diagnoses. For abdominal pain and chest pain referrals the most frequent discharge diagnosis was the corresponding ICD-10 symptom diagnosis, whereas for pneumonia-, appendicitis-, acute myocardial infarction- and stroke referrals the corresponding disease diagnosis was most frequent. Women referred with chest pain were less likely to be discharged with ischemic heart disease than men.

Conclusions: The reasons for acute referral to somatic hospitals from GPs and OOH doctors comprise a wide range of reasons, and the referral rates vary according to the severity of the condition and the different nature between GP and OOH services. Referral rates for OOH contacts were much higher than for GP contacts. Patient age, gender and referring service influence the relationship between referral and discharge diagnosis.

Keywords: Norway, General practitioners, After-hours care, Out-of-hours medical care, Gatekeeping, Referral and consultation, Emergencies, Patient admission, ICPC-2, Abdominal pain, Chest pain, Shortness of breath, Pneumonia, Appendicitis, Myocardial infarction, Stroke

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Background

For patients with acute conditions visiting a general practitioner (GP) or an out-of-hours (OOH) doctor, referral to acute admission to hospital is sometimes required in order to obtain adequate investigation and treatment. These acute admissions to hospitals constitute a large part of hospital activity and in the years 2015–2019, more than two thirds of all admissions in Norway were acute [1]. Patients referred acute to hospital comprise all age groups, but the elderly have a higher incidence of acute severe disease and are more frequently admitted to hospital [2, 3]. Health authorities worldwide are concerned about emergency department overcrowding, and that extended diagnostic possibilities and a development towards more defensive medicine will put the health services under considerable stress [4–6].

A gatekeeping system, where the patients are obliged to see a GP or an OOH doctor before referral, may regulate the access to acute hospital care, and is implemented in many healthcare systems. Gatekeeping may reduce unplanned hospital admissions in general, and especially for the elderly [7, 8]. In the Norwegian healthcare system, the GPs and OOH doctors are gatekeepers to specialist care, including hospital admissions, for all kind of emergencies, including traumas. In a previous study we found that two thirds of acute admissions to hospitals in Norway 2014 came after contact with a GP or an OOH-doctor [9, 10], the rest were direct admissions of different kinds.

Discharge diagnoses after acute admissions in Norway have been well described, and similar diagnoses for patients admitted to hospital after emergency ambulance transport in Denmark are published [9–11]. However, reasons for acute referrals to hospital from GPs and OOH doctors specifically, and potentially different patterns and rates between these referral agents have not been explored in detail.

Abdominal pain and chest pain are known as two dominant clinical symptom groups in OOH services and acute referrals to hospital from primary care [12, 13]. Likewise, pneumonia, appendicitis, acute myocardial infarction (AMI) and stroke are important referral diagnoses in terms of both numbers and severity [14–17]. Nevertheless, the referral rates for these clinical presentations and conditions have not been thoroughly investigated. Furthermore, there is little knowledge of the relationship between the referral diagnosis from GP and OOH doctors and the subsequent discharge diagnosis from hospital.

The aim of the present study was therefore to investigate the whole range of reasons for acute referral to somatic hospital stay from GPs and OOH doctors in Norway, including referral rates for the most frequent ICPC-2 diagnoses. For three common clinical problems, abdominal pain, chest pain, and shortness of breath, and for the frequent or important referral diagnoses of pneumonia (R81), appendicitis (D88), AMI (K75), and stroke (K90), we also wanted to investigate the associations between the diagnosis given in referral contacts and the discharge diagnosis from hospital, and how these associations varied between GPs and OOH doctors and with patient's gender and age.

Methods

Norway has a well-established public primary healthcare system including a Regular General Practitioners scheme (RGPs) and OOH services [9, 10]. RGPs provide healthcare for both acute and non-acute cases including follow up, whereas the OOH services provide care in acute cases outside the opening hours of RGPs' surgeries. The municipalities are responsible for the primary healthcare, including RGPs and OOH services. The state organizes the specialist care, including ambulances and hospitals.

Data sources

The study is registry-based, using data from national health registries covering the whole population in Norway in 2017.

All GP and OOH contacts result in a claim to the Control and Payment of Reimbursement to Health Service Providers database (KUHR), managed by The Norwegian Health Economics Administration (HELFO). A single claim contains the patient's national identification number, time and date for the contact, and if the contact is a simple contact (e.g. telephone contact), an office consultation, or a home visit. Also, it is mandatory to include one or more diagnostic codes according to International Classification of Primary Care (ICPC-2) [18]. This diagnosis will be routinely transferred to the referral letter and recorded as the reason for referral. In our material, 17% of the KUHR claims contained more than one diagnosis. We used the main (primary) diagnosis in our analyses. The ICPC-2 codes are divided into chapters denoted by a letter that identifies an organ system, followed by a two-digit number referring to either a symptom (code 01–29) or a disease (code 70–99). ICPC-2 was developed to describe the reasons for encounter in primary health care or general practice and reflects the content of primary care, last updated in 2016 [19, 20].

Psychiatric hospitals were not included. We therefore use the term somatic hospital admissions in our study. All hospital stays are recorded in the Norwegian Patient Registry (NPR), which includes information on patient's national identification number, time and date of the admission, degree of urgency, and one or more discharge diagnoses using the International Statistical Classification of Diseases and Related Health Problems version 10 (ICD-10). For the hospital discharge diagnoses we used the main diagnosis with three characters. An acute hospital admission was defined by the NPR's data form as an admission required immediately or within 24 h and lasting for more than 24 h. These admissions were then included if they were related to a GP or OOH contact.

Study population, variables and definitions, and linkage procedures

In this study we defined a GP or OOH doctor contact as a consultation or a home visit, telephone contacts were excluded. All such contacts with GPs ($N = 14,457,247$) or OOH doctors ($N = 1,361,731$) during 2017 were included. For GPs this represent both acute and follow up contacts.

Statistics Norway (SSB) created a pseudo-anonymized identification number which replaced the national identification number in the KUHR and NPR databases. Thereby data from both sources could be combined without revealing the patients' identities.

A GP or OOH-doctor contact in KUHR was defined as the referral contact for a patient if it occurred within 24 h before an acute admission in NPR. By this definition we identified 265,518 referrals to hospital from a GP or an OOH doctor.

A suitable grouping of ICPC-2 codes into presenting complaints in emergency departments (EDs) has been described by Malmström et al. [21]. We applied this for the symptom groups abdominal pain, chest pain and shortness of breath. The abdominal pain symptom group was defined by the following codes: abdominal pain/cramps general (D01), abdominal pain epigastric (D02) and abdominal pain localized other (D06). The chest pain symptom group was defined by these codes: chest pain NOS (A11), heart pain (K01), pressure/tightness of heart (K02) and cardiovascular pain NOS (K03). Shortness of breath was included pain in respiratory system (R01), shortness of breath/dyspnoea (R02), wheezing (R03), and breathing problem other (R04). This group was named after the most frequent reason, shortness of breath.

We used the referral disease diagnoses pneumonia (R81), appendicitis (D88), acute myocardial infarction (K75), and stroke (K90) to study associations between a specific disease diagnosis given at referral and the discharge diagnoses after hospital stay.

Statistical analyses

Numbers and frequencies for ICPC-2 chapters and the 30 most common ICPC-2 diagnoses that led to a referral were obtained. Referral rates were calculated by dividing GP and OOH contacts leading to a referral by all contacts with the same diagnosis.

For referrals in the abdominal pain symptom group, we identified the ten most frequent discharge diagnoses. Generalized linear model (GLM) log-binomial regression were used to estimate relative risk (RR) of the patient being discharged with each of these diagnoses compared with all other discharge diagnoses after a referral with abdominal pain symptom. The patients' ages, genders and if the patient had been referred by a GP or OOH doctor were used as explanatory variables and were adjusted for each other. RR was calculated for females with males as reference, age was divided by 10 and then used as a continuous variable giving RR with a 10-years increase, and OOH doctor referrals were compared with GP referrals as reference. The RRs were presented with 95% confidence intervals (CI). For referrals in both the chest pain symptom group and shortness of breath symptom group the ten most frequent discharge diagnoses were identified, and equivalent GLM were used for each of the ten discharge diagnoses.

For the four disease-specific referral diagnoses pneumonia (R81), appendicitis (D88), AMI (K75) and stroke (K90) we conducted frequency analyses for discharge ICD-10 diagnoses representing >3% of the patients referred with these diagnoses, respectively. GLM were used to estimate the RR for the discharge diagnoses. For the referral diagnosis pneumonia (R81) the corresponding discharge ICD-10 diagnosis pneumonia was used as comparison. For appendicitis (D88), AMI (K75) and stroke (K90) we used respectively acute appendicitis (K35), AMI (I21) and cerebral infarction (I63) as comparison in the analyses. Explanatory variables were gender, age, and referral from an OOH doctor or a GP. For three of the models the log-binomial regression did not converge, and a Poisson regression with robust variance estimates was applied to estimate RR [22].

The analyses were performed using Stata 16.1. (StataCorp. 2019. Stata Statistical Software: Release 16. College Station, TX: StataCorp LLC.)

Results

In 2017 GP and OOH-doctor contacts (consultations and home visits) resulted in 265,518 referrals to acute somatic hospital admission, 150,577 after OOH contacts and 114,941 after GP contacts (Table 1). The mean patient age for referrals was 56 years, whereas for all contacts the mean age was 47 years. Women accounted for 50% of the patients referred, but 58% of all the contacts.

GP and OOH contacts leading to referral had a similar distribution of ICPC-2 chapters. General and unspecified (A), digestive (D) and cardiovascular (K) were the most frequent chapters used (Table 1). OOH referrals had a higher share of the chapter general and unspecified (A), whereas GP referrals had a higher share of cardiovascular (K).

The 30 most common referral diagnoses accounted for 53% of the referrals, with abdominal pain/cramps general (D01) (8%), chest pain (A11) (5%) and pneumonia (R81)

Table 1 ICPC-2 diagnosis chapter for GP and OOH contacts leading to acute referrals to hospitals

	Referrals		GP referrals		OOH referrals	
	N	% of total	N	% of total referrals	N	% of total referrals
Total	**265,518**	**100**	**114,941**	**43**	**150,577**	**57**
ICPC-2 diagnosis chapter[a]						
General and unspecified (A)	47,821	18	16,067	6	31,754	12
Blood and immune mechanisms (B)	3539	1	2574	1	965	0
Digestive (D)	49,666	19	20,454	8	29,212	11
Eye (F)	2172	1	1063	0	1109	0
Ear (H)	890	0	471	0	419	0
Cardiovascular (K)	38,927	15	19,989	8	18,938	7
Musculoskeletal (L)	26,524	10	11,004	4	15,520	6
Neurological (N)	20,287	8	7858	3	12,429	5
Psychological (P)	8707	3	2809	1	5898	2
Respiratory (R)	34,936	13	16,174	6	18,762	7
Skin (S)	8255	3	3897	1	4358	2
Endocrine and metabolic (T)	5702	2	3411	1	2291	1
Urological (U)	10,432	4	4667	2	5765	2
Pregnancy and family planning (W)	3993	2	2588	1	1405	1
Female genital (X)	1415	1	814	0	601	0
Male genital (Y)	1960	1	1029	0	931	0
Social problems (Z)	227	0	31	0	196	0

Legend: Distribution of ICPC-2 diagnosis chapter for GP and OOH consultations and home visits leading to referral to acute admissions to hospitals in Norway 2017

[a] Process codes counted for 65 emergency referrals, 41 by GP and 24 by OOH doctors

(3%) being the most frequent (Table 2). Of all 14,457,247 GP contacts, the referral rate was only 0.01, whereas the rate for OOH doctor contacts was 0.11 of all 1,361,731 contacts. The diagnosis with the highest referral rate both from GPs and OOH doctors was appendicitis (D88), with 0.30 and 0.79, respectively. Patients referred from OOH doctors were younger than patients referred from the GPs. The lowest patient median age was for OOH patients referred with acute bronchitis/bronchiolitis (R78) (2 years and interquartile range (IQR) 1–69) and appendicitis (D88) (26 years, IQR 18–39). The diagnosis with the oldest patients was heart failure (K77) with median age of 82 years for GP referrals and 83 years for OOH referrals with IQR 74–88 and 74–89 respectively.

Referrals with an ICPC-2 diagnosis in the symptom groups abdominal pain (27,052 patients), chest pain (19,546 patients) or shortness of breath (8371 patients) accounted for 21% of all referrals (Tables 3, 4, 5).

Referrals for abdominal pain

The median patient age for the abdominal pain symptom group referrals was 46 years (Table 3), and 60% were women. Every fourth patient referred with abdominal pain was discharged with a similar symptom diagnosis from ICD-10, abdominal and pelvic pain (R10). The second and third most frequent discharge diagnoses were acute appendicitis (K35) (12%) and cholelithiasis (K80) (6%).

For the abdominal pain symptom group, there was a higher relative risk for the discharge diagnosis to be ileus (K56) if the patient was referred from an OOH doctor compared with a referral from a GP (RR = 2.12 [95%CI: 1.84–2.45]). The opposite was found for diverticular disease (K57) with a lower relative risk of being discharged with diverticular disease if referred from OOH compared to GP (RR = 0.51 [95%CI: 0.46–0.56]). The relative risk for the discharge diagnosis of abdominal and pelvic pain (R10) was higher for women compared to men (RR = 1.38 [95%CI: 1.32–1.44]), but lower for acute appendicitis (K35) (RR = 0.59 [95%CI: 0.55–0.62]), acute pancreatitis (K85) (RR = 0.54 [95%CI: 0.47–0.61]) and calculus of kidney and ureter (N20) (RR = 0.40 [95%CI: 0.34–0.47]).

Referrals for chest pain

The median patient age in the chest pain symptom group was 62 years, and 44% were women (Table 4). One third of patients referred with chest pain were discharged with the ICD-10 code describing the similar

Table 2 Frequency of ICPC-2 diagnoses by GP and OOH doctor when referring to acute hospital admission

Referral diagnoses ICPC-2	All referrals (265,518)		GP				OOH			
				Referrals (114,941)				Referrals (150,577)		
	N	%	Contacts[a] N	Referral rate	Age Median (IQR)	% Female	Contacts[a] N	Referral rate	Age Median (IQR)	% Female
Total	**265,518**	**100**	**14,457,247**	**0.01**	**64 (43–77)**	**51**	**1,361,731**	**0.11**	**59 (34–75)**	**50**
Abdominal pain/craps general (D01)	21,260	8	204,152	0.04	48 (28–67)	61	52,550	0.26	45 (27–65)	59
Chest pain NOS (A11)	14,077	5	45,280	0.10	64 (52–75)	42	26,088	0.37	62 (50–74)	43
Pneumonia (R81)	8793	3	83,218	0.05	72 (59–82)	52	22,181	0.21	75 (61–84)	48
Shortness of breath/dyspnoea (R02)	7806	3	63,345	0.05	71 (57–82)	47	14,029	0.32	71 (49–82)	50
Atrial fibrillation/flutter (K78)	6892	3	290,943	0.01	74 (67–82)	43	6323	0.45	71 (61–79)	46
COPD (R95)	5643	2	105,601	0.03	74 (68–80)	52	10,852	0.28	73 (67–80)	54
Heart pain (K01)	5319	2	8976	0.20	64 (53–74)	46	5310	0.66	62 (50–73)	45
Vertigo/dizziness (N17)	5082	2	99,867	0.02	69 (52–79)	60	12,499	0.22	70 (53–80)	54
Fainting/ syncope (A06)	4353	2	19,402	0.07	70 (47–81)	51	9356	0.31	68 (44–79)	50
Infectious disease other (A78)	4162	2	32,656	0.04	66 (44–77)	47	7773	0.35	70 (49–81)	44
Stroke/cerebrovascular disease (K90)	4078	2	41,866	0.04	74 (65–83)	48	2986	0.78	73 (62–82)	47
Fever (A03)	3895	1	42,768	0.03	34 (2–66)	48	17,854	0.14	32 (1–69)	44
Abdominal pain localized other (D06)	3812	1	43,181	0.04	46 (28–66)	64	9259	0.24	39 (25–60)	62
Headache (N01)	3624	1	108,973	0.01	43 (29–61)	60	12,972	0.17	42 (28–61)	62
Disease/condition unspecified (A99)	3544	1	129,088	0.01	60 (38–75)	50	33,417	0.07	56 (31–75)	50
Heart failure (K77)	3069	1	54,594	0.04	82 (74–88)	42	2543	0.43	83 (74–89)	46
Ischaemic heart disease with angina (K74)	2995	1	24,769	0.07	70 (60–79)	36	2042	0.65	69 (58–79)	41
Skin infection other (S76)	2682	1	37,180	0.03	63 (48–74)	42	12,341	0.12	60 (44–73)	40
Cystitis/urinary infection other (U71)	2632	1	182,861	0.01	72 (57–82)	55	50,608	0.03	73 (55–84)	50
Hip symptom/complaint (L13)	2614	1	79,674	0.01	78 (67–87)	67	6185	0.27	81 (70–87)	65
Injury musculoskeletal system NOS (L81)	2595	1	67,921	0.01	64 (38–78)	46	24,595	0.07	57 (27–76)	47
Appendicitis (D88)	2581	1	3377	0.30	30 (18–47)	50	1990	0.79	26 (18–39)	55
Transient cerebral ischaemia (K89)	2536	1	9263	0.12	72 (61–81)	55	1982	0.73	73 (63–82)	52
Concussion (N79)	2465	1	18,661	0.03	25 (9–64)	46	9489	0.20	29 (13–64)	43
Pyelonephritis/pyelitis (U70)	2353	1	9624	0.09	59 (36–73)	65	5399	0.27	56 (30–74)	66
Disease digestive system other (D99)	2293	1	24,280	0.04	64 (50–76)	51	2533	0.57	63 (48–75)	47
Cholecystitis / cholelithiasis (D98)	2249	1	19,713	0.05	59 (44–72)	58	5847	0.21	52 (37–66)	62
Acute bronchitis/bronchiolitis (R78)	2147	1	138,933	0.01	29 (1–70)	48	19,238	0.05	2 (1–69)	44
Palpitations /awareness of heart (K04)	2083	1	42,869	0.02	66 (50–78)	58	8706	0.15	63 (44–75)	56
Abdominal pain epigastric (D02)	1980	1	39,268	0.02	54 (35–70)	61	7198	0.18	51 (34–67)	61

Table 2 (continued)

Referral diagnoses ICPC-2	All referrals (265,518)		GP				OOH			
				Referrals (114,941)				Referrals (150,577)		
	N	%	Contacts[a] N	Referral rate	Age Median (IQR)	% Female	Contacts[a] N	Referral rate	Age Median (IQR)	% Female
Sum 30	139,614	53								

Legend: The frequency of the 30 most common ICPC-2 diagnoses used by general practitioners (GPs) and out-of-hours (OOH) doctors when referring to acute admission to hospitals in Norway 2017, presented for all admissions, and for GP daytime practice and OOH services separately

IQR Interquratile range

[a] Contact is defined as a consultation or home visit

Table 3 Discharge diagnoses for patients referred to acute hospital admission with abdominal pain (D01, D02 and D06)

Discharge ICD-10 diagnoses	All		OOH referrals			Age			Gender (F)		
	N	%	%[a]	RR[c]	95% CI	Median (IQR)	RR[c]	95% CI	%[b]	RR[c]	95% CI
Abdominal and pelvic pain (R10)	7127	26	64	1.02	0.98–1.06	34 (23–52)	0.86	0.85–0.86	68	1.38	1.32–1.44
Acute appendicitis (K35)	3166	12	63	0.98	0.92–1.05	32 (20–50)	0.80	0.79–0.81	48	0.59	0.55–0.62
Cholelithiasis (K80)	1664	6	66	1.17	1.06–1.28	58 (42–73)	1.21	1.19–1.24	56	0.89	0.81–0.98
Diverticular disease (K57)	1483	5	45	0.51	0.46–0.56	61 (51–72)	1.31	1.28–1.34	60	1.09	0.99–1.20
Functional intestinal disorder (K59)	1141	4	64	1.06	0.94–1.19	56 (28–76)	1.11	1.09–1.14	58	0.94	0.84–1.06
Ileus (K56)	1031	4	78	2.12	1.84–2.45	65 (50–76)	1.34	1.30–1.38	52	0.81	0.72–0.92
Acute pancreatitis (K85)	814	3	69	1.32	1.14–1.52	57 (44–71)	1.18	1.15–1.22	43	0.54	0.47–0.61
Calculus of kidney and ureter (N20)	666	2	65	1.07	0.91–1.25	51 (36–66)	1.07	1.04–1.11	37	0.40	0.34–0.47
Noninfl. disorders of ovary. f. tube. broad lig (N83)	448	2	67	1.20	0.99–1.45	31 (23–40)	0.75	0.72–0.78	100	1	
Other gastroenteritis and colitis (A09)	417	2	59	0.81	0.67–0.98	33 (21–52)	0.83	0.80–0.87	64	1.10	0.90–1.34
Other	9095	34	62			50 (30–71)			61		
All	27,052	100	63			46 (27–66)			60		

Legend: Distribution of discharge diagnoses for patients referred to acute hospital admission by general practitioner (GP) and out-of-hours (OOH) doctor with the ICPC-2 diagnosis: abdominal pain (D01, D02 and D06) in Norway 2017

IQR Interquartile range

[a] Percent of referrals with abdominal pain-diagnosis (D01, D03 or D06) and the current ICD-10 discharge diagnosis which are referred by OOH doctor

[b] Percent of women in referrals with abdominal pain-diagnosis (D01, D03 or D06) and the current ICD-10 discharge diagnosis

[c] Relative risk for the different discharge ICD-10 diagnoses for OOH referrals relative to GP referrals, for a 10-years increase in age, and for female patients relative to male patients *compared with all discharge diagnoses after abdominal pain admission*

symptom, pain in throat and chest (R07). AMI (I21) accounted for 12%, and angina pectoris (I20) for 10%.

Among patients in the chest pain symptom group, a discharge diagnosis of heart failure (I50) was associated with higher age (RR = 2.13 [95%CI: 1.93–2.36]). Women referred with chest pain had a lower relative risk of being discharged with a diagnosis related to ischemic heart disease: AMI (I21) (RR = 0.54 [95% CI 0.50–0.59]), angina pectoris (I20) (RR = 0.70 [95%CI: 0.64–0.77]) and chronic ischemic heart disease (I25) (RR = 0.47 [95%CI 0.40–0.55]) compared with men.

Referrals for shortness of breath

In the shortness of breath symptom group the median age was 70 years, and 50% were women (Table 5). Heart failure (I50), pneumonia (J12–18) and chronic obstructive pulmonary disease (J44) were the most common discharge diagnoses with 12, 11 and 8%, respectively. The discharge diagnoses after referral for shortness of breath showed a larger variation compared to abdominal pain and chest pain and had fewer discharges with a symptom describing diagnosis. Among patients discharged with the diagnosis acute bronchiolitis (J21) 75% were less than 2 years.

Disease specific referral diagnoses: pneumonia, appendicitis, AMI, and stroke

The four referral diagnoses: pneumonia (R81), appendicitis (D88), AMI (K75), and stroke (K90) accounted for 16,811 admissions (6% of all). 59% of the patients referred with the diagnose pneumonia (R81) were discharged with a corresponding ICD-10 pneumonia-diagnosis (J12–18) (Table 6). Only 1% of patients referred with pneumonia were discharged with pulmonary embolism (I26), and 0,5% with AMI (I21).

Of patients referred with appendicitis (D88) 51% were discharged with the corresponding ICD-10 diagnosis acute appendicitis (K35), and 24% with the symptom describing diagnosis abdominal and pelvic pain (R10) (Table 7).

For patients referred with the diagnosis AMI (K75), 43% were discharged with the corresponding ICD-10 diagnosis AMI (I21), 12% with pain in throat and chest (R07), and 7% with angina pectoris (I29) (Table 8). The discharge diagnosis heart failure (I50) was associated with higher age (RR = 1.96 [95%CI: 1.51–2.55]).

After referral with the diagnosis stroke (K90), 30% of the patients were discharged with the ICD-10 diagnosis cerebral infarction (I63), 10% with transient cerebral ischemic attack (TIA) (G45) and 4% with intracerebral

Table 4 Discharge diagnoses for patients referred to acute hospital admission with chest pain (A11, K01, K02 and K03)

Discharge ICD-10 diagnoses	All		OOH referrals			Age			Gender (F)		
	N	%	%[a]	RR[c]	95% CI	Median (IQR)	RR[c]	95% CI	%[b]	RR[c]	95% CI
Pain in throat and chest (R07)	6965	36	69	0.98	0.95–1.02	56 (46–68)	0.85	0.84–0.86	46	1.15	1.11–1.19
Acute myocardial infarction (I21)	2277	12	66	0.98	0.90–1.06	68 (59–77)	1.30	1.26–1.33	32	0.54	0.50–0.59
Angina pectoris (I20)	1873	10	61	0.77	0.71–0.84	69 (58–78)	1.27	1.24–1.31	38	0.70	0.64–0.77
Other soft tissue disorder incl. myalgia (M79)	992	5	68	0.95	0.83–1.08	56 (45–68)	0.82	0.79–0.85	51	1.48	1.31–1.68
Chronic ischaemic heart disease (I25)	758	4	68	1.05	0.90–1.22	65 (56–74)	1.17	1.12–1.22	28	0.47	0.40–0.55
Atrial fibrillation and flutter (I48)	573	3	72	1.27	1.06–1.51	73 (66–82)	1.59	1.50–1.69	46	0.88	0.75–1.04
Pneumonia (J12–18)	385	2	72	1.26	1,01-1,57	70 (59–81)	1.30	1.21–1.38	42	0.80	0.66–0.98
Heart failure (I50)	250	1	69	1.13	0.87–1.48	80 (70–88)	2.13	1.93–2.36	43	0.67	0.52–0.87
Essential (primary) hypertension (I10)	239	1	63	0.82	0.63–1.06	67 (57–75)	1.13	1.04–1.22	58	1.70	1.31–2.19
Gastro-oesophageal reflux disease(K21)	237	1	64	0.83	0.63–1.07	62 (51–74)	1.01	0.93–1.09	50	1.27	0.99–1.65
Other	5125	26	70			64 (50–76)			47		
All	19,546	100	68			62 (50–74)			44		

Legend: Distribution of discharge diagnoses for patients referred to acute hospital admission by general practitioner (GP) and out-of-hours (OOH) doctor with the ICPC-2 diagnosis: chest pain (A11, K01, K02 and K03) in Norway 2017

IQR Interquartile range

[a] Percent of referrals with chest pain-diagnosis (A11, K01, K02 and K03) and the current ICD-10 discharge diagnosis which are referred by OOH doctor

[b] Percent of women in referrals with chest pain-diagnosis (A11, K01, K02 and K03) and the current ICD-10 discharge diagnosis

[c] Relative risk for the different discharge ICD-10 diagnoses for OOH referrals relative to GP referrals, for a 10-years increase in age, and for female patients relative to male patients *compared with all discharge diagnoses after chest pain admission*

Table 5 Discharge diagnoses for patients referred to acute hospital admission with shortness of breath (R01, R02, R03 and R04)

Discharge ICD-10 diagnoses	All		OOH referrals			Age			Gender (F)		
	N	%	%[a]	RR[c]	95% CI	Median (IQR)	RR[c]	95% CI	%[b]	RR[c]	95% CI
Heart failure (I50)	991	12	57	1,00	0,89-1,12	82 (73–88)	1,60	1,53-1,68	41	0,66	0,59-0,74
Pneumonia (J12–18)	943	11	67	1,48	1,30-1,68	73 (59–83)	1,08	1,05-1,11	50	1,04	0,92-1,17
Chronic obstructive pulmonary disease (J44)	633	8	62	1,2	1,03-1,40	74 (67–82)	1,25	1,20-1,30	55	1,19	1,03-1,39
Abnormalities of breathing (R06)	529	6	50	0,66	0,56-0,78	62 (38–76)	0,92	0,90-0,95	56	1,39	1,17-1,64
Pulmonary embolism (I26)	371	4	49	0,69	0,56-0,84	66 (52–76)	1,02	0,98-1,06	45	0,87	0,71-1,06
Atrial fibrillation and flutter (I48)	298	4	41	0,52	0,42-0,65	76 (69–84)	1,36	1,26-1,45	43	0,76	0,61-0,96
Asthma (J45)	288	3	68	1,20	0,94-1,54	31 (3–60)	0,75	0,72-0,77	50	1,10	0,88-1,38
Pain in throat and chest (R07)	277	3	55	0,80	0,64-1,02	53 (38–68)	0,9	0,87-0,94	58	1,49	1,18-1,89
Acute bronchiolitis (J21)[d]	213	3	75	1,17	0,89-1,54	1 (1–1)			39	0,92	0,72-1,17
Other acute lower respiratory infection (J22)	175	2	57	0,82	0,61-1,11	59 (13–76)	0,86	0,82-0,90	55	1,38	1,02-1,85
Other	3653	44	59			69 (47–81)			48		
All	8371	100	59			70 (50–81)			50		

Legend: Distribution of discharge diagnoses for patients referred to acute hospital admission by general practitioner (GP) and out-of-hours (OOH) doctor with the ICPC-2 diagnosis: shortness of breath (R01, R02, R03 and R04) in Norway 2017

IQR Interquartile range

[a] Percent of referrals with shortness of breath (R01, R02, R03 and R04) and the current ICD-10 discharge diagnosis which are referred by OOH doctor

[b] Percent of women in referrals with shortness of breath (R01, R02, R03 and R04) and the current ICD-10 discharge diagnosis

[c] Relative risk for the different discharge ICD-10 diagnoses for OOH referrals relative to GP referrals, for a 10-years increase in age, and for female patients relative to male patients *compared with all discharge diagnoses after shortness of breath admission*

[d] Relative risk for a 10-years increase in age is not estimated due to no variation in age

Table 6 Discharge diagnoses for patients referred to acute hospital admission with the diagnosis pneumonia (R81). Relative risk for different discharge ICD-10 diagnoses by explanatory variables (referrals, age and gender), compared with discharged with pneumonia (J12–18)

Discharge ICD-10 diagnoses	All		OOH referrals			Age			Gender (F)		
	N	%	%[a]	RR[c]	95% CI	Median (IQR)	RR[c]	95% CI	%[b]	RR[c]	95% CI
Pneumonia (J12–18)	5173	59	52			72 (57–83)			51		
COPD (J44)	488	6	56	1.09	0.92–1.29	75 (69–82)	1.21	1.15–1.27	52	1.06	0.90–1.26
Influenza (J10)	328	4	59	1.27	1.02–1.57	76 (65–85)	1.14	1.08–1.21	51	1.01	0.82–1.24
Other diagnoses chapter J (respiratory)	1041	12	51	0.98	0.88–1.10	69 (44–80)	0.90	0.88–0.91	49	0.93	0.84–1.04
Diagnoses chapter I (circulatory)	420	5	49	0.84	0.70–1.01	81 (71–88)	1.32	1.24–1.41	50	0.96	0.80–1.15
Diagnoses chapter N (genitourinary)	285	3	57	1.14	0.91–1.44	81 (71–86)	1.26	1.18–1.35	47	0.86	0.69–1.08
Other	1058	12	50	0.91	0.82–1.02	73 (64–83)	1.07	1.04–1.10	45	0.82	0.73–0.91
All	8793	100	52			73 (60–83)			50		

Legend: Distribution of discharge diagnoses for patients referred to acute hospital admission by general practitioner (GP) and out-of-hours (OOH) doctor with the ICPC-2 referral code pneumonia (R81) in Norway 2017

IQR Interquartile range

[a] Percent of OOH doctor in referrals with pneumonia (R81) diagnosis and the current ICD-10 discharge diagnosis

[b] Percent of women in referrals with pneumonia (R81) diagnosis and the current ICD-10 discharge diagnosis

[c] Relative risk for the different ICD-10 discharge diagnoses for OOH referrals relative to GP referrals, for a 10-years increase in age, and for female patients relative to male patients *compared with discharge with pneumonia (J12–18)*

Table 7 Discharge diagnoses for patients referred to acute hospital admission with the diagnosis appendicitis (D88). Relative risk for different discharge ICD-10 diagnoses by explanatory variables (referrals, age and gender), compared with discharged with acute appendicitis (K35)

Discharge ICD-10 diagnoses	All		OOH referrals			Age			Gender (F)		
	N	%	%[a]	RR[c]	95% CI	Median (IQR)	RR[c]	95% CI	%[b]	RR[c]	95% CI
Acute appendicitis (K35)	1318	51	62			29 (19–44)			43		
Abdominal and pelvic pain (R10)	613	24	61	0.95	0.84–1.07	22 (16–32)	0.82	0.79–0.86	68	2.04	1.77–2.35
Diverticular disease (K57)[d]	79	3	41	0.68	0.44–1.07	46 (29–56)	1.71	1.58–1.85	48	0.93	0.61–1.40
Other diagnoses chapter K (digestive)	180	7	59	0.94	0.71–1.24	29 (19–49)	1.06	0.98–1.14	48	1.20	0.91–1.57
Diagnoses chapter N (genitourinary)	172	7	70	1.32	0.98–1.79	29 (19–41)	0.94	0.86–1.01	87	7.13	4.65–10.94
Other	219	8	54	0.72	0.57–0.93	24 (13–38)	0.86	0.79–0.93	50	1.32	1.03–1.69
All	2581	100	61			27 (18–82)			53		

Legend: Distribution of discharge diagnoses for patients referred to acute hospital admission by general practitioner (GP) and out-of-hours (OOH) doctor with the ICPC-2 referral code appendicitis (D88) in Norway 2017

IQR Interquartile range

[a] Percent of OOH doctor in referrals with appendicitis (D88) diagnosis and the current ICD-10 discharge diagnosis

[b] Percent of women in referrals with appendicitis (D88) diagnosis and the current ICD-10 discharge diagnosis

[c] Relative risk for the different ICD-10 discharge diagnoses for OOH referrals relative to GP referrals, for a 10-years increase in age, and for female patients relative to male patients *compared with discharge with acute appendicitis (K35)*

[d] Poisson regression was used to estimate RR

haemorrhage (I61), whereas 56% had other diagnoses (Table 9).

Discussion

Main results

Of all GP contacts only 1% resulted in a referral for acute admission to somatic hospital, whereas OOH doctors referred 11%. Referral rates for GP and OOH contacts vary greatly by referral diagnosis. Abdominal pain, chest pain and shortness of breath were the dominant symptom diagnoses in referrals and had a considerable variation in discharge diagnoses. For both abdominal pain and chest pain the corresponding symptom diagnosis was the most frequent. For the referral diagnoses pneumonia, appendicitis, AMI and

Table 8 Discharge diagnoses for patients referred to acute hospital admission with the diagnosis acute myocardial infarction (K75). Relative risk for different discharge ICD-10 diagnoses by explanatory variables (referrals, age and gender), compared with discharged with acute myocardial infarction (I21)

Discharge ICD-10 diagnoses	All		OOH referrals			Age			Gender (F)		
	N	%	%[a]	RR[c]	95% CI	Median (IQR)	RR[c]	95% CI	%[b]	RR[c]	95% CI
Acute myocardial infarction (I21)	583	43	63			66 (56–76)			25		
Pain in throat and chest (R07)[d]	160	12	54	0.71	0.54–0.93	62 (53–74)	0.79	0.71–0.87	36	1.81	1.35–2.42
Angina pectoris (I20)	93	7	40	0.47	0.32–0.69	72 (64–81)	1.21	1.04–1.41	27	0.87	0.56–1.34
Chronic ischaemic heart disease (I25)	60	4	47	0.47	0.29–0.77	61 (54–67)	0.74	0.61–0.90	15	0.68	0.34–1.37
Atrial fibrillation and flutter (I48)	49	4	51	0.73	0.43–1.23	76 (69–82)	1.51	1.21–1.89	43	1.37	0.78–2.41
Heart failure (I50)	41	3	66	1.30	0.71–2.35	81 (73–88)	1.96	1.51–2.55	51	1.50	0.81–2.75
Other diagnoses chapter I (circulatory)	121	9	62	0.99	0.71–1.38	71 (57–81)	1.05	0.93–1.20	37	1.48	1.04–2.11
Other diagnoses chapter R (symptoms)	63	5	60	0.95	0.59–1.52	71 (60–82)	1.09	0.90–1.31	43	1.85	1.12–3.06
Diagnoses chapter J (respiratory)	62	5	55	0.83	0.52–1.32	77 (69–83)	1.52	1.25–1.85	39	1.16	0.70–1.91
Other	127	9	42	0.52	0.38–0.72	70 (59–83)	1.03	0.91–1.16	46	1.94	1.40–2.68
All	1359	100	57			68 (57–79)			32		

Legend: Distribution of discharge diagnoses for patients referred to acute hospital admission by general practitioner (GP) and out-of-hours (OOH) doctor with the ICPC-2 referral code acute myocardial infarction (K75) in Norway 2017

IQR Interquartile range

[a] Percent of OOH doctor in referrals with myocardial infarction (K75) diagnosis and the current ICD-10 discharge diagnosis

[b] Percent of women in referrals with myocardial infarction (K75) diagnosis and the current ICD-10 discharge diagnosis

[c] Relative risk for the different ICD-10 discharge diagnoses for OOH referrals relative to GP referrals, for a 10-years increase in age, and for female patients relative to male patients *compared with discharge with acute myocardial infarction (I21)*

[d] Poisson regression was used to estimate RR

Table 9 Discharge diagnoses for patients referred to acute hospital admission with the diagnosis stroke (K90). Relative risk for different discharge ICD-10 diagnoses by explanatory variables (referrals, age and gender), compared with discharged with cerebral infarction (I63)

Discharge ICD-10 diagnoses	All		OOH referrals			Age			Gender (F)		
	N	%	%[a]	RR[c]	95% CI	Median (IQR)	RR[c]	95% CI	%[b]	RR[c]	95% CI
Cerebral infarction (I63)	1243	30	58			75 (67–83)			42		
TIA (G45)	398	10	60	1.07	0.90–1.27	76 (67–84)	1.02	0.95–1.09	53	1.38	1.16–1.64
Intracerebral haemorrhage (I61)	145	4	63	1.19	0.86–1.63	77 (67–83)	0.99	0.87–1.11	49	1.28	0.93–1.75
Diagnoses chapter R (symptoms)	589	14	58	0.95	0.83–1.07	69 (53–80)	0.82	0.80–0.83	51	1.29	1.14–1.46
Other diagnoses chapter I (circulatory)	382	9	57	0.95	0.80–1.13	74 (65–83)	0.96	0.89–1.02	43	1.05	0.87–1.25
Other diagnoses chapter G (nervous)	366	9	60	0.95	0.80–1.14	67 (51–77)	0.76	0.74–0.79	52	1.36	1.15–1.60
Diagnoses chapter J (respiratory)	133	3	48	0.69	0.50–0.95	81 (73–86)	1.36	1.17–1.58	40	0.79	0.56–1.10
Other[d]	822	20	54	0.90	0.81–1.00	74 (63–82)	0.91	0.87–0.94	50	1.25	1.13–1.39
All	4078	100	57			74 (63–83)			47		

Legend: Distribution of discharge diagnoses for patients referred to acute hospital admission by general practitioner (GP) and out-of-hours (OOH) doctor with the ICPC-2 referral code stroke (K90) in Norway 2017

IQR Interquartile range

[a] Percent of OOH doctor in referrals with stroke (D90) diagnosis and the current ICD-10 discharge diagnosis

[b] Percent of women in referrals with stroke (D90) diagnosis and the current ICD-10 discharge diagnosis

[c] Relative risk for the different ICD-10 discharge diagnoses for OOH referrals relative to GP referrals, for a 10-years increase in age, for female patients relative to male patients *compared with discharge with acute cerebral infarction (I63)*

[d] Poisson regression was used to estimate RR

stroke the corresponding discharge diagnoses were dominant. Some of the discharge diagnoses were associated with high patient age, female gender, and if the referral came either from a GP or an OOH doctor.

Strengths and limitations

The study includes all residents in Norway in 2017, all GP and OOH doctor contacts and all acute referrals to somatic hospitals. Therefore, there is no selection bias. The data sources are registries containing activity data delivered to manage funding of primary and specialist healthcare, and therefore presumably accurate and complete. This ensures the representativity for the situation in Norway.

In our analyses we used only the primary diagnosis. Therefore, we may have missed some information on the reason for referral in cases with more than one diagnosis given.

Diagnosis coding may vary between doctors, both in general practice and in OOH services. In a clinical situation with abdominal pain when appendicitis is suspected, the physician may apply either a symptom diagnosis *abdominal pain/cramps general (D01)* or the disease diagnose *appendicitis (D88).* Probably, in some cases a more precise or severe diagnosis than the right one according to diagnosis criteria may be used to prepare the hospital receiving the patient. Distinction between symptom and disease diagnosis in referrals must be interpreted with caution. In a prehospital setting in helicopter medical services in Finland, ICPC-2 coding was tested for inter-rater reliability for six written fictional cases [23]. The researchers found an overall agreement of only 52%. Nevertheless, research in Norwegian general practice concludes that GPs' use of ICPC-2 codes corresponds well with the patient records in 85% of the consultations [24]. This supports the use of ICPC-2 diagnosis to describe the reason for referral. Our results reveal a coherence between referral ICPC-2 diagnosis and the hospital discharge diagnosis, supporting the design.

The linkage between the GP and OOH doctor contacts in KUHR and hospital admission in NPR has some uncertainties. The primary care contact prior to admission might be random, and not related to the admission. In a previous study we found a distinct accumulation of GP and OOH contacts within 24 h before acute hospital admission [9, 10]. This indicates that the assumption that a contact within 24 h before an admission is the referral contact, is valid. The present study supports this further by demonstrating the relationship between the referral and the discharge diagnoses.

Referral rates and reasons for referral

Our overall OOH referral rate (11%) is higher than the rate described in studies from England (7 and 10%) [25, 26], and Denmark (4–8%) [27], but lower than a study from a single OOH primary care centre in Norway (14%) [5].

Diagnoses from the ICPC-2 chapter general and unspecified conditions (A) was most frequent for referrals from OOH doctors, similar to findings from other studies [11, 27]. The variation of referral rates for different ICPC-2 diagnoses reflects the severity of the conditions as well as the nature of the services. For atrial fibrillation, the GPs' referral rate was only 0.01 whereas the OOH referral rate was 0.45. According to national guidelines, newly discovered atrial fibrillation should be referred for immediate further investigations and treatment, whereas chronic atrial fibrillation requires comprehensive GP follow up, but not admission. There is a similar effect for GP contacts with a diagnosis of appendicitis (D88) where as much as 70% were not referred. This probably represent GP follow up, rather than acute assessment. These figures underline the different nature of GP daytime services and OOH services, and therefore the proportions of contacts for a diagnosis related to admission are not directly comparable.

Abdominal pain is a common symptom in general practice, and the second most frequent reason for contacting OOH services [13, 21, 28]. In a Norwegian study of patients offered acute appointment with a GP because of abdominal pain, the GP referred 26% acutely to hospital [13]. In our study only 4% of GP patients with abdominal pain/cramps or localized abdominal pain were acutely referred to hospital, illustrating that GPs provide care for both acute and chronic complaints. OOH services provide emergency primary healthcare with only acute appointments and correspond better with the patients in the other Norwegian GP study. For OOH patients with abdominal pain/cramps or localized abdominal pain, 26 and 24% were referred in our material, which fits well with the GP study.

We found that the referral rates for chest pain and heart pain from OOH doctors were 0.37 and 0.66, respectively. In a prospective study from Norwegian OOH services 50 out of 100 patients presenting at the casualty clinic with chest pain as the main symptom were referred to hospital [12]. However, we do not know the referral diagnosis for these referrals.

Abdominal pain, chest pain and shortness of breath symptom groups

For referrals with abdominal and chest pain symptoms, the most frequent ICD-10 discharge diagnoses were the corresponding symptom-based diagnoses abdominal and pelvic pain (R10) and pain in throat and chest (R07). Our previous study showed that these discharge diagnoses were the overall second and third most frequent discharge diagnoses after acute admissions to hospital, irrespective of referral agent [9, 10]. Such extensive use of symptom diagnoses both in referrals and discharges could serve as a reminder of the diagnostic challenges in both primary care and in hospitals but might as well be an indication of defensive medicine.

Only 1% of patients referred with chest pain were discharged with gastro-oesophageal reflux disease (K01). This could be due to effective gatekeeping treating these patients in primary care and is in line with previous research from Norway where 5 out of 100 patients attending OOH services with chest pain were diagnosed with dyspepsia by OOH doctor, and none were referred to hospital [12].

Chest pain is a core presenting symptom for AMI for both women and men, although atypical symptom presentations in women have received increased attention [15, 29, 30]. We found that women referred with a chest pain diagnosis had a lower relative risk of being discharged with a discharge diagnosis of ischemic heart disease compared with men. This adds to previous knowledge of gender differences in acute ischemic heart disease presentation.

Referrals for pneumonia, appendicitis, AMI, or stroke

GPs accounted for a somewhat larger share of the disease-specific referral diagnoses pneumonia (R81), appendicitis (D88), AMI (K75), and stroke (K90) than the symptom groups abdominal pain, chest pain, and shortness of breath, suggesting that GPs are more likely than OOH doctors to use specific disease diagnoses. This could be due to better knowledge of the patient's history or better diagnostic facilities.

For referrals with diagnoses pneumonia, appendicitis and AMI the most frequent discharge diagnoses were the corresponding disease diagnosis. Correspondingly, referrals with the diagnosis stroke were often discharged with a diagnosis of cerebral infarction, TIA, or intracerebral haemorrhage. This indicates that when the referral diagnosis is a disease-specific diagnosis, the primary care doctor is more certain of a specific disease compared with cases where a symptom diagnosis is used. Hospital doctors could take this into consideration when receiving patients referred acutely from primary care with a disease-specific diagnosis.

Patients from OOH services with the referral diagnosis AMI are less likely to be discharged with the diagnosis angina pectoris or chronic ischemic heart disease than patients from general practice. Angina pectoris and chronic ischemic heart disease typically have a less acute presentation, leading to contact with the GP rather than the OOH services, again illustrating that GPs treat cases with a lower degree of urgency.

An adequate gatekeeper role for acute hospital admissions must balance the task to discover all patients with serious conditions with the risk of unnecessary admissions [5, 31]. The aim is to avoid missed diagnosis (false negatives) at an acceptable level of false positives where no or minor disease are revealed in hospital. Low risk taking would lead to defensive medicine, increasing costs without gained health and overdiagnosis. On the other hand, too restrictive referral practice would lead to an increased number of undiagnosed severe conditions. Such underdiagnosis will severely affect the individual patient's health. Finding the right balance in referral practice is a major challenge for primary care doctors performing a gatekeeper function in prehospital acute care. Continuity of care in general practice may help in this task. Length of patient continuity with a named regular GP is associated with lower use of OOH services, fewer hospital admissions and even lower mortality [32].

Our study reveals that one third of patients referred with chest pain and one quarter of patients referred with abdominal pain were discharged with a symptom diagnosis, hence no severe condition was revealed at hospital. Likewise, 24% of patients referred with appendicitis, and 12% referred with AMI were discharged with a symptom describing discharge diagnosis. We believe this to be a reasonable level of accuracy, but attention to this topic should be high and an objective for further research. The topic of referral practice should be emphasized in medical education, and policy makers should be aware of the issue over- and underdiagnosis.

Lessons learned

Referrals to hospital are always a matter of clinical medical assessment. In a gatekeeping system this also applies for emergencies. Both GPs and OOH doctors seem to perform gatekeeping for acute hospital admissions based on their setting and the different patient populations. Our findings suggest that there should be an accept of more symptom-based referrals from OOH services. The GP's knowledge of the patient's medical history is valuable also when performing gatekeeping for acute referrals to hospital. The large variation of referral diagnoses implies that a broad medical competence is necessary when assessing emergencies.

Conclusions

Referral rates for OOH contacts were much higher than for GPs' contacts, and showed considerable variation by different diagnoses, thus reflecting the severity of the conditions and the nature of the services. Abdominal pain and chest pain were two major reasons for referral, and the most frequent discharge diagnosis for both was the corresponding ICD-10 symptom describing diagnosis. Women referred with chest pain were less likely to be discharged with a diagnosis reflecting ischemic heart disease, whereas women referred with AMI were more often discharged with the diagnosis pain in throat and chest.

Abbreviations

GP: General practitioner; OOH: Out-of-hours; AMI: Acute myocardial infarction; ICPC-2: International Classification of Primary Care, second edition; RGP: Regular general practitioner; KUHR: Control and Payment of Reimbursement to Health Service Providers database; HELFO: Norwegian Health Economics Administration; NPR: Norwegian Patient Registry; ICD-10: The International Statistical Classification of Diseases and Related Health Problems version 10; SSB: Statistics Norway; ED: Emergency department; GLM: Generalized linear models; CI: Confidence intervals; IQR: Interquartile range; TIA: Transient cerebral ischemic attack.

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Authors' contributions

JB has contributed the research idea, the application for the license to perform the study, the data processing, the analyses and the writing of the manuscript. ØH has contributed with statistical analyses and supervising on STATA, in addition to scientific input on research questions and the manuscript. HS has contributed scientific input on the research questions, the impact of the results and the manuscript. VB has contributed statistical analyses and supervising on STATA. SH has contributed scientific input on the research idea, the research questions, the impact of the results and the manuscript. All authors have read and approved the manuscript.

Authors' information

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Availability of data and materials

The data used in this study are delivered from The Norwegian Directorate of Health and Statistics Norway, with restrictions only to be used under licence for researchers in the current study, and so are not publicly available. However, the registry data used in this study will be available from the authors upon reasonable request and with included permission from The Norwegian Directorate of Health, Statistics Norway, the Regional Ethical Committee, and Norwegian Data Protection Authority.

Declarations

Ethics approval and consent to participate

The Regional Ethical Committee for Medical and Health Research Ethics, Region West approved the project (30.01.2014) (reference number 2013/2344/REK vest). The Regional Ethical Committee for Medical and Health Research Ethics, Region West also waived the requirement of the informed consent for the study. Norwegian Data Protection Authority approved the use of the data for research purposes in this project (15.09.2014) (reference number 14/0322–9/CGN). The register owners, Statistics Norway and the Norwegian Directorate of Health, approved linkage of registries. The data were pseudo anonymized by third party (Statistics Norway) and analysed at group level to minimize the risk for backwards identification of individuals. All analyses were carried out, and methods were used, in accordance with relevant guidelines and regulations (declaration of Helsinki).

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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