Utilization of pre-hospital emergency medical services:

Analysis of trends and patient characteristics using routinely collected data

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Contents

List of abbreviations

ACSC	Ambulatory or Primary Care Sensitive Conditions
ALS	Advanced Life Support
CT	Computed Tomography
DRG	Diagnosis Related Groups
ED	Emergency Department
EMS	Emergency Medical Services
EU	European Union
GP	General Practitioner
HIS	Hospital Information System
ICD	International Statistical Classification of Diseases and Related Health Problems
KHEntgG	Krankenhausentgeltgesetz
NIHR	National Institute for Health Research
RCT	Randomised Controlled Trial
SHI	Statutory Health Insurance
STEMI	ST-Elevation Myocardial Infarction

List of publications

1) Use of pre-hospital emergency medical services in urban and rural municipalities over a 10 year period: an observational study based on routinely collected dispatch data

Authors: Kathrin Hegenberg, Heiko Trentzsch, Stefan Gross, Stephan Prückner

Journal: Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine

Impact Factor 2017: 2.312

Rank 6 of 26 (category EMERGENCY MEDICINE)

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2) Differences between cases admitted to hospital and discharged from the emergency department after emergency medical services transport

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1 Introduction

1.1 Background of the dissertation

Increasing utilization of pre-hospital emergency medical services (EMS) has been observed in many developed countries over the past 20 years [1]. In Germany, the number of EMS responses has increased by 105% since 2001 [2]. The organization of emergency care has recently moved into the focus of German health policy. In 2018, structural requirements for different levels of hospital emergency care were specified [3]. In the same year, the Advisory Council on the Assessment of Developments in the Health Care Sector (Sachverständigenrat zur Begutachtung der Entwicklung im Gesundheitswesen) recommended a set of measures for the coherent organization of cross-sectoral emergency care [2]. Based on these recommendations, the German Federal Ministry of Health has initiated several re-regulations. They include legal provisions to no longer consider pre-hospital medical services as solely transportation services, but as an independent medical service. Other major approaches are the establishment of integrated emergency centers as central contact points in selected hospitals as well as the establishment of integrated control centers to coordinate both emergency 112 and urgent 116117 services.

There is a substantial body of literature on measures of emergency department (ED) utilization and crowding [4,5], underlying causes and consequences as well as solutions [5–7]. Fewer studies investigate and describe pre-hospital emergency services use. This dissertation therefore summarizes research results based on the analysis of routinely collected EMS dispatch and hospital data. It gives insights into characteristics and trends of pre-hospital EMS use and characteristics of pre-hospital EMS patients that are transported to a hospital, contributing to the improvement of patient allocation decisions and the organization of EMS.

1.2 Short overview of the organization of emergency medical service systems in Germany

Systems that provide emergency care are complex. Across the world, heterogeneous EMS systems exist. They differ in many aspects, such as access to and pathways through the system, providers, financing and the patients they care for.

In Germany, EMS have long been established and can be traced back at least to the 18th century [8]. Germany is a federal parliamentary republic of 16 states (“Bundesländer”). Regulation and financing of emergency care substantially varies between them [9]. However, in all of the German federal states, emergency medical care is mainly divided into

three sectors: outpatient urgent care, emergency departments in hospitals, and pre-hospital emergency medical services [2]. These sectors will be briefly described in the following subchapters.

1.2.1 Outpatient urgent care and hospital emergency departments

During practice hours, outpatient care for urgent but non-emergency conditions is provided by ambulatory physicians. Outside practice hours, urgent care services are coordinated by the regional associations of statutory health insurance (SHI) physicians [9]. These services include on-call services, telephone counselling, home visits and urgent care centers [9]. Hospitals are obliged to provide emergency care and patients can seek emergency care at any hospital at their discretion. Since 2018, hospitals are categorized into different levels of emergency care based on equipment, staff qualifications, intensive care units and other criteria [3]. Pre-hospital EMS patients are usually transported to the nearest suitable ED for treatment, depending on their specific complaint and condition.

1.2.2 Pre-hospital emergency medical services

The core component of pre-hospital EMS is a fast response and transport to a hospital in case of life-threatening or time-critical medical conditions. Whereas emergency care in hospitals is often under the responsibility of ministries of health, pre-hospital emergency medical care is regulated by ministries of the interior and often integrated with fire and technical security services. [9] Apart from emergency rescue services, EMS organizations often operate planned non-emergency patient transport services. However, the provision of planned patient transported is not the focus of this dissertation. Pre-hospital EMS are an integral part of EMS, as they provide immediate medical care to people who are acutely ill or injured. Across the world, two main models can be distinguished: one where the patient is brought to the doctor and one where the doctor is brought to the patient for treatment at scene and during transport [10]. The German system falls under the latter, even though heterogeneity in organization and financing exists within the country, as pre-hospital EMS is regulated by federal law. An emergency physician will only be dispatched in addition to an ambulance when criteria for physician dispatch are met. Emergencies that require a pre-hospital emergency physician usually involve patients with unstable vital signs and/or a number of pre-defined emergency situations [11]. The transport of a physician to the scene is predominantly rendezvous-based, which means that the physician arrives in a rapid response car [12]. European Union (EU) countries ensure that an emergency response across Europe can be activated by calling the European emergency telephone number 112 [13]. German federal states are usually further subdivided into a number of regions.

Regional dispatch centers run by different operators handle 112 calls. Depending on the state, ambulance response times are usually regulated by law and therefore often predetermine ambulance infrastructure. Dispatchers decide on the type and number of pre-hospital EMS units based on keyword-based dispatch protocols. Levels of EMS response for emergency rescue include paramedic staffed ambulances and rapid response cars staffed with emergency physicians. In most cases, costs of ambulance use are covered by the patient's social security institution. Regulations on reimbursement of pre-hospital EMS differ by state. In Bavaria, reimbursement is negotiated between the social security institutions and providers of EMS services annually in advance.

1.3 Utilization of pre-hospital emergency medical services

1.3.1 Defining pre-hospital emergency medical services utilization

There is not only heterogeneity among EMS systems. The definition of utilization also varies and many different criteria are used to measure EMS use. Before analyzing pre-hospital EMS use, several terms need to be defined to facilitate comparisons of studies.

First, most health services research literature distinguishes between need, demand and utilization [14]. Definitions of need and health need are manifold, as they depend on the context and the perspective from which need is defined [15,16]. Need manifests itself as demand for a certain service. Demand can be defined as a subjective preference for a service that a person wants or intends to use [14]. Subjective demand can be set in relation to objective demand, for example a disease or functional impairment ascertained after examination [14]. Utilization then implies the take-up of a service. As only utilization is directly observable it is the main focus of many analyses and is the focus of this dissertation.

It is also important to establish different measures of EMS utilization. Existing literature uses a number of measures, such as the number of calls, incidents, events, dispatches, responses or patients. An emergency incident or event is usually understood as the occurrence of a potentially life-threatening situation, which can involve a single patient, such as a heart attack, or several patients, such as a traffic accident. Multiple calls can be associated with the same event or incident. In consequence, one or several dispatches and responses can be necessary to respond to a situation. Multiple dispatches and responses for the same incident or event usually occur when more than one patient is involved or when additional units are required. For instance, multiple dispatches and responses per incident usually occur when an emergency physician in rapid response cars is dispatched in addition to the paramedic-staffed ambulance. Multiple dispatches and responses can be assigned to the same incident, and analyzed as a single emergency incident or event. To measure EMS

utilization, the first paper in this dissertation mainly relies on emergency incidents or events, whereas the second relies on emergency patients transported to a hospital.

1.3.2 Influencing factors, patterns, and trends of emergency medical services utilization

To provide timely and adequate treatment to patients who require immediate emergency care, pre-hospital EMS systems need to be carefully planned. Knowledge about factors influencing utilization, the frequency of emergencies, and their temporal and regional distribution is crucial for appropriate planning and to respond to changes in utilization.

EMS use varies in quantity, regionally and temporally. There are many explanations behind these variations and increasing utilization, and many potential factors that influence pre-hospital EMS use have been identified. Literature about factors influencing pre-hospital EMS has discussed or investigated factors influencing utilization and factors associated with ambulance use for transportation to the ED, compared to other modes of transportation. These factors can be divided into several categories:

- Sociodemographic characteristics: age [1,17,26–30,18–25], sex [18,20,21,23,24,30], ethnicity/race [17,20,21,23,25,29,30], education [20,22,23,30], income [17,19,20,22,28,30] , deprivation/poverty [19,22,31] insurance status [20,21,23,25–27], living arrangement [20,21,23,29,32]
- Morbidity: acute illness [21,23,25–27,31], underlying chronic diseases [23,32], physical and functional limitations [23]
- Personal patient characteristics: health beliefs [23], perception of illness [23]
- Infrastructure: care alternatives (e.g. access to primary care) [20,23,30,32], access to communication [32], commuters by automobile [17], resident population [19], highway miles [19]
- System: pricing [27], risk-averse triage [1]

In summary, the studies report higher age, lower income, deprivation/poverty, worse physical function, acute illness, chronic conditions and lack of knowledge about cost of ambulance transport as predictors of utilization of EMS. No impact or mixed results were observed for sex, ethnicity/race, education, insurance coverage of EMS services, having a primary care physician, living arrangement, health beliefs, the number of highway miles in a community, access to means of communication and time of day. However, most studies were conducted in the USA and results may therefore not be transferable to European EMS systems.

Varying temporal or regional patterns and trends of use are the result of varying influencing factors. Information about these patterns and trends is essential to allocate resources and optimize the planning of emergency care structures. Although EMS is used for various conditions, few studies characterize temporal and regional EMS use of large and diverse EMS patient populations. Literature that summarizes trends in pre-hospital EMS use is also scarce. There is evidence that utilization of pre-hospital EMS has been increasing in recent decades. A review of increasing utilization of pre-hospital EMS reports an average annual growth of patient transports, ambulance arrivals or incidents between 3% and 12.5% in England, the USA, Canada, New Zealand and Australia over different time periods between 1977 and 2008 [1]. A 40% increase in the number of pre-hospital EMS interventions between 2001 and 2010 was reported in the Swiss Canton of Vaud [33]. A 105 % increase in the number of dispatches of patients insured under a statutory insurance plan since 2000 is reported in official German statistics [2].

A review by Lowthian et al. attempts to determine major drivers behind increasing utilization [1]. Population growth and ageing are seemingly obvious drivers, and the review identifies several studies that support the association of age and utilization. However, the increase most likely cannot be explained by demographic changes alone [1,24,34], hence other factors make a substantial contribution [1,35]. Decreased social support in the form of an increasing number of people living alone and the decreasing capacity to care for older relatives, leaving the elderly with limited access to health care alternatives, makes social support a plausible driver for increasing EMS utilization, at least in Australia [1]. The review concludes that the relative contribution of individual factors to the continuing rise in transportations has not been well studied and major causes of rising demand have to be further investigated [1]. The literature search for this dissertation did not identify studies that investigate social support as a contributing factor. This was also the case for literature about the impact of changes in pricing, changes in access to primary care services or changes in awareness about the appropriate use of emergency health resources, which are also plausible drivers behind utilization.

1.3.3 Appropriateness and medical necessity of emergency medical services utilization

A part of increasing utilization might be attributed to the increasing provision of care for patients with conditions that are not life-threatening or time-critical. Consequently, debates around the appropriateness of EMS utilization have emerged. Data for both articles in this dissertation was collected in the German Federal State of Bavaria. The Bavarian Law on EMS defines pre-hospital emergency patients as injured or sick persons whose life is in danger or who are likely to suffer serious health damages in case of delayed necessary

medical care. Pre-hospital EMS therefore should provide immediate medical care in life-threatening or time-critical situations.

Research has focused on the appropriateness of health services use for many years, though most articles concerning EMS focus on ED and not pre-hospital EMS use. Also, definitions used in literature are still not very consistent. This is apparent in the variety of expressions used to describe this phenomenon which include "inappropriate", "unnecessary", "avoidable", "non-urgent" or "low-acuity". A semi-structured literature search on inappropriate or avoidable use of urgent and emergency care services in the UK shows that a significant number of articles did not establish how appropriateness was measured [36].

Different methods are used to assess the appropriateness of emergency care use. They include the identification of treatments subsequently given [37,38], review against protocol [37], (retrospective) comparison with doctors' opinions [36,37], or the pre-definition of criteria that appear appropriate to assess the need for an EMS response [38–40].

Many criteria that define medical necessity or appropriateness of emergency care use have been suggested. They include: situations perceived as non-accidents and non-emergencies [39], symptoms pre-existing for more than 24 hours [39], conditions which could be adequately managed by the general practitioner (GP) [39], specific presenting complaints and conditions [38], or ambulatory or primary care sensitive conditions (ACSCs) [40], clinical features and field findings [38], pre-hospital interventions (e.g. airway interventions or advanced life support (ALS) interventions) [38], treatment in ED (e.g. requiring surgery, computed tomography (CT)) [38]. All of these criteria have been discussed by experts or summarized in reviews. However, common understanding about adequate criteria to define medical necessity or appropriateness of emergency care seems difficult. Surveys among American and New Zealand experts focusing on ED attendance show that agreement can be reached regarding the definition of several outcome measures, and about patients groups that can be treated outside of the ED, yet there was still a range of opinions regarding many other aspects [38,41].

Even though definitions of appropriateness vary and are not always well explained, literature has been reviewed in order to identify causes of inappropriate or avoidable use of emergency care services. A review of research conducted in the UK [36] and a study in England funded by the National Institute for Health Research (NIHR) [42] identify the following categories and sub-themes:

- Patient or population related factors: perception of illness, interpersonal factors, culture, patient demographics, socioeconomic factors, geography.

- Service related factors: access to community care and primary or social services, provision of acute beds, EDs, ability of ambulance to treat people at home or refer them to alternatives to the ED, coding practice.
- System level factors and healthcare frameworks: convenience of EMS, EMS as easy option, triage and clinical decision-making, proactive admission avoidance, multidisciplinary collaboration, integration, out of hours services, resource availability, specialized roles, service management.

Risk-averse behaviors of patients and carers, social deprivation as well as the fragmentation of healthcare services and perceived barriers to health care alternatives seem to especially contribute to inappropriate use [36]. Variations in potentially avoidable emergency admissions in England could also mainly be explained by high levels of deprivation, probably associated with high levels of illness and high expectations around service access in this group [42].

1.4 Use of routinely collected data for the analysis of emergency medical services utilization

Routinely collected health data is obtained for administrative and clinical purposes without specific a priori research goals [43]. Data used in this dissertation comes from four different sources and was collected for different purposes.

All analyses include dispatch information. Dispatch data are generated when handling emergency calls and dispatching vehicles. Electronic records are automatically created for each 112 call. In the federal state of Bavaria, processing of dispatch data for purposes other than operative and administrative tasks in the dispatch center was initiated to keep records of EMS infrastructure and the number of emergencies. For this purpose, all 26 Bavarian dispatch centers transfer their EMS dispatch records to a central relational database on a monthly basis, where the data is combined and prepared for analysis. Dispatch data includes information about dispatch keywords, type of ambulance deployed, time stamps and receiving hospital. Consequently, EMS use can be monitored and trends can be identified, which helps public officials to better understand EMS infrastructure, organization and use. The data provide a basis for infrastructure and funding decisions. The EMS dispatch record dataset lacks information about patient age and gender. As patient age was an essential identifier for the linkage of hospital and dispatch data, a dataset of pre-hospital EMS billing data was used as an intermediate step in the linkage process.

Information about hospital treatment originated from two sources. The first one was a standardized data set that hospitals are required to collect according to paragraph 21 of the Hospital Remuneration Act (KHEntgG) (§21 data). The primary purpose of the §21 data collection is the development and update of the German diagnosis related groups (DRG) system. Yet this data can be used for other purposes, including research, and holds information about almost all German inpatient cases [44]. As DRGs are relevant for the reimbursement of inpatient stays only, the dataset only contains information about patients that are admitted to the hospital. Information about patients that leave the hospital after being seen in the ED was therefore extracted from hospital information systems (HIS). HIS are intended to store information. They can serve many purposes, like simply the retrieval of information, but also system management and problem solving [45]. Even though data stored in HIS is primarily collected for administrative and management purposes, it usually contains patient information and medical data and can be made available for analysis and research. Hospital data included in this dissertation was basic case information (age, sex, admission status) and information about diagnoses (diagnosis codes from the German modification of the 10th revision of the international statistical classification of disease and related health problems (ICD-10-GM) and corresponding ambulatory diagnoses derived from different fee schedules).

The analysis of routine data requires compliance with comprehensive data protection rules [44]. All direct (e.g. name, social security number, sickness insurance number) and indirect (e.g. date of birth) identifiers were deleted from the datasets used in this dissertation before they were transferred for analysis. The data are thus anonymized and linking datasets on an individual patient identity level was not possible. Datasets lacking unique identifiers can still be linked using probabilistic approaches, as applied in this dissertation. This approach however comes with the limitation of potential introduction of bias through false or missed matches [46].

As indicated in the previous paragraphs describing the data used in this dissertation, there are several weaknesses to using routine data that are not explicitly collected for research purposes which impact the analysis of pre-hospital EMS utilization. Not all variables of interest are included in routine data collections. The correctness and completeness of the data collected is even less within the control of the researcher, which results in observational errors and missing data. This is especially true if data collection is not required by law. The preparation of routinely collected data for analysis requires time to clean, check and link the data, especially if different sources are used. Yet routinely collected data comes with several strengths, which is why it constitutes an increasingly important data source for health research. Sample size is usually large and entire

populations can often be studied. Data is usually updated on a regular basis and covers long time periods. It is easily accessible electronically and costs and effort of data collection are minimal for the researcher. This makes those data potentially suited to answer research questions, particularly in research fields where it is challenging to undertake studies. This applies to pre-hospital emergency care, where research capacity and expertise are limited, randomized controlled trials (RCT) are difficult to conduct and research is therefore often small scale [47].

The data used in this dissertation was not collected for research purposes and therefore is not suited to answer certain questions about the use of EMS. This particularly applies to the explanation of variations and the assessment of medical necessity or appropriateness. It can, however, be used to describe utilization of pre-hospital EMS of large populations over a long time period and thus support the planning and adaption of EMS infrastructure and EMS system development. The data are also suitable for hypothesis generation.

1.5 Objectives of the dissertation and brief overview of the methods

Pre-hospital EMS research mostly focuses on groups defined by specific morbidity, such as stroke, ST-elevation myocardial infarction (STEMI), cardiac arrest or severe trauma. There is however a lack of knowledge regarding the entire spectrum of pre-hospital EMS patients. Using routinely collected data, the objectives of this dissertation are to describe characteristics and trends of EMS use of a large and diverse population of pre-hospital EMS patients, to investigate effects of changing utilization, and to compare patients that are discharged from the ED to those that are admitted to the hospital. The results of this work are intended to contribute to a better understanding of patterns and trends of pre-hospital EMS use and effects of changing utilization. They can also potentially be used to identify groups that might be of particular interest for future research and resource allocation.

The dissertation is based on two publication manuscripts that address these objectives. The first manuscript investigates long-term trends of EMS use. It is a retrospective observational study based on routinely collected ambulance dispatch data in the German federal state of Bavaria between 2007 and 2016. Emergency rates are described and predicted using negative binomial mixed effects regression and graphical representation. Furthermore, differences in emergency rates, transport rates, utilization trends and temporal trends are investigated. This study provides evidence on utilization patterns over a ten year period. It illustrates differences in utilization patterns as well as differing increases in emergency rates for emergencies with and without physician and urban and rural municipalities.

The second manuscript is a retrospective observational study based on linked hospital, dispatch and EMS billing data. The analysis identifies differences between patients that

were discharged from the ED and those that were admitted to hospital for treatment. Logistic regression is used to estimate the adjusted likelihood of discharge. Cross-tabulated tables are used to compare dispatch keyword groups and hospital diagnoses, and to investigate differences between dispatch keywords and hospital diagnoses.

The doctoral candidate is the first author of both manuscripts. Under the guidance of her supervisors, she developed the research questions and determined the focus of the manuscripts. Data handling and analysis was performed by the doctoral candidate. Results were interpreted with support from the co-authors. The doctoral candidate wrote all parts of the manuscripts' drafts, created tables and figures and edited the manuscripts according to the co-author's comments. She responded to reviewers' comments and manuscripts were revised accordingly in consultation with the co-authors, to finalize the manuscripts for publication. The doctoral candidate accompanied the publication process of both manuscripts as corresponding author.

1.6 Conclusion and future perspectives

The results of this dissertation show a substantial increase in emergency rates. They also reveal differing emergency rates as well as varying increases of emergency rates in municipalities of different size. These differences were also observed between emergencies with and without physician dispatch. Emergency rates were highest in urban municipalities. The yearly increase in utilization was similar between municipalities of different size, except for large cities, where the yearly increase was smaller. The increase of emergencies that did not require an emergency physician on scene was much higher than the increase in emergencies with emergency physician attendance. The increase in utilization did not impact on transport rates or temporal patterns. Furthermore, the results show that patients that are discharged from the ED differ from patients that are admitted to the hospital after EMS transport. Young age and dispatch for accident or trauma or unspecified emergencies were strong predictors of discharge from the ED. Differences in distribution of ICD 10 diagnosis chapters between admitted and discharged patients were often observed even if they were assigned the same dispatch keyword category. Some diagnoses (e.g. alcohol intoxication, concussion and syncope) were, however, frequently assigned in both groups. Whether the observed increases in emergency rates indicate changing needs or changing appropriateness remains unclear and should be assessed by further studies. Also, discharge from the ED cannot be considered an adequate indicator for initial urgency of a response. Yet patients with characteristics that are frequently associated with discharge from the ED could be of particular interest regarding the urgency of their condition. This dissertation illustrates that routinely collected dispatch and hospital data were not suited to answer

specific research questions with regard to reasons behind increasing utilization and the appropriateness of utilization, but can be used to describe the utilization of pre-hospital EMS and to generate hypotheses. The results point to groups that are of particular interest for future research and for the improvement of patient allocation.

Recently initiated policy measures to improve cross-sectoral emergency care and patient allocation in Germany comprise integrated emergency centers in hospitals and integrated control centers that coordinate both emergency and urgent outpatient services. Systematic reviews focusing on the reduction of ED use indicate that telephone triage [48,49] and GP posts co-located to ED [49] impact on overall and inappropriate attendances. These findings indicate that the initiated policy measures could be promising approaches. Patients and carers turning to emergency care often do not know exactly what type of help they need [50], where and how quickly their medical problem should ideally managed [41], and which resources are required for treatment [51]. Professional assessment at an early stage would therefore contribute to aligning patient's perspective and objective assessment. However, the mere existence of integrated centers does not automatically imply efficient standardized assessment. Even though dispatch decisions are the focus of many studies in the pre-hospital field, a systematic review from 2018 concludes that the overall level of evidence for the accuracy of medical dispatching systems is low [52]. There is currently no established standardized protocol for the assessment of emergency calls to match response resources with patient needs in Germany. Only an effective structured assessment of the initial condition at the time of the emergency call would contribute to better understanding initial urgency of emergencies, and thus improve resource allocation. Further evidence to support well accepted criteria for medical necessity of EMS response and the safety and effectiveness of triage is therefore needed.

Standardized assessment also only contributes to better patient allocation when dispatchers are able to dispatch resources that match the different nature and urgency of emergencies. A several-tiered system should thus not only include emergency ambulances with and without physician support, but responses such as adequate urgent services for conditions that are not life threatening, but still require immediate (medical) attention. In addition, hospitals may still be the first entry point for thorough assessment of unclear medical complaints and conditions after EMS dispatch, and should be geographically well distributed. Yet a several-tiered system could also comprise transport destinations other than hospitals. Difficult triage decisions and fear of legal implications might still lead paramedic crews and even emergency physicians to always transport patients to a hospital. Evidence about clinically safe approaches to identify patients who call for an emergency ambulance but do not need transportation to ED is scarce [53]. More research is therefore

needed to develop protocols that help ambulance crews choose safe alternatives to transport to hospital.

As long as the type of care and pathways through the healthcare system in case of emergencies is not stipulated, patients are able to choose from different types of care. In order to achieve a better match of health care needs and emergency medical resources, intended pathways through the EMS system and access to alternative services must therefore be well accepted by the patients. More research is needed to determine patient preferences, to understand decision processes regarding urgent care and to identify which barriers are associated with use of EMS for conditions that could be managed in other settings.

2 Summary

The provision of care for patients that require immediate help on site makes pre-hospital emergency medical services (EMS) an integral part of the EMS system and an important part of the planning of emergency care structures. Increasing utilization of pre-hospital EMS has been reported in many developed countries. Yet literature on long-term utilization trends and potential effects of changing utilization is still limited. There is also a lack of knowledge regarding the entire spectrum and larger populations of pre-hospital EMS patients. Although data that has not primarily been collected for research purposes comes with several limitations, routinely collected data are potentially suited to answer research questions and allow for the study of entire populations. Based on routinely collected data, this thesis describes characteristics and trends of EMS use in a large sample of pre-hospital patients, investigates effects of changing utilization, and compares pre-hospital EMS patients discharged from the emergency department (ED) to those admitted to hospital. The quantitative analyses in this dissertation are intended to contribute to a better understanding of pre-hospital EMS use and effects of changing utilization. They also help narrow down groups that might be of particular interest for future research and resource allocation.

The first study in this thesis focuses on long-term utilization trends of pre-hospital EMS. Using data from the German federal state of Bavaria, it examines EMS use and effects of changing utilization on transport rates and the temporal distribution of emergencies in municipalities differentiated by five levels of rurality. The results show an annual increase in the number of emergencies per 1000 population (emergency rate) between the years 2007 and 2016, in particular for emergencies without dispatch of an emergency physician. The annual increase in the emergency rate without physician dispatch was between 5.7% (CI 4.3-7.1) in large cities and 7.8% (CI 7.6–7.9) in the most rural areas. Depending on the level of rurality, the emergency rate with physician attendance only increased between 1.3% and 2.4% annually. Emergency rates were higher in urban municipalities, whereas the average proportion of patients transported to a hospital was lower. Despite a 50% absolute increase in emergencies within the period, transport rates and temporal patterns of utilization remained largely unchanged. The data are suited to describe utilization patterns and long-term trends. However, many important explanatory variables are not part of consistent, long-term data collections and could not be included in the analyses. The analyses therefore can't provide explanations for differing emergency rates between municipalities of different rurality and with and without physician dispatch, and can't provide insights about factors contributing to the increases in utilization. The observed

differences could indicate differing and changing needs. However, differing and changing appropriateness of resource allocation has moved into the focus, as it is hypothesized that more and more patients transported by pre-hospital EMS would not have needed an urgent pre-hospital EMS intervention.

The second study in this thesis therefore compares characteristics of pre-hospital patients that receive out-patient treatment in an ED and patients that are hospitalized. The analysis of linked hospital and dispatch data collected in 14 ED in the City of Munich, Germany, and in the surrounding dispatch centers shows that 40% of EMS patients transported to a hospital ED by EMS are subsequently discharged. Patients discharged from the ED differ from patients that are admitted to the hospital in several respects. Discharge was particularly more likely if patients were younger, the dispatch keyword indicated "accident/trauma" or "other/unspecified emergency", when an ambulance without additional emergency physician support was dispatched, and when patients arrived during the day. Many underlying hospital diagnoses were observed within dispatch categories. The distribution of diagnoses differed between admitted and discharged patients even when the same dispatch keyword category was assigned, indicating a differing spectrum of disease. Some diagnoses (e.g. alcohol intoxication, concussion and syncope) were, however, frequently observed in both groups. Interpreting the results of the second study reveals that discharge from the ED after EMS transport and hospital diagnoses are not good criteria to assess the initial need for a pre-hospital EMS response. Quick transport to and assessment in an ED might have been necessary to evaluate worrisome complaints, and patients with non-urgent complaints can still require hospitalization. Patients frequently discharged from the ED are nevertheless particularly relevant for future research, as they could be allocated to hospitals with low inpatient bed capacities and the initial urgency of their condition is of particular interest.

The organization of EMS systems is complex and differs between and even within countries. This dissertation suggests that their organization and planning has to be targeted to characteristics of the existing system as well as to regional peculiarities, such as the degree of rurality. It also illustrates that the routinely collected dispatch and hospital data were not suited to answer specific research questions with regard to the appropriateness of utilization of EMS. Yet they give insights into the utilization of pre-hospital EMS, a setting where studies are difficult to conduct. These insights are a foundation for the improvement of the planning and organization of EMS and for future research. The studies highlight the necessity to further investigate initial urgency of emergencies without physician dispatch and of patients that are young or call EMS because of accidents or trauma. Subsequently, standardized protocols should be developed to support the choice of appropriate responses

and the choice of safe alternatives to transport to hospital and resources that match different kinds of medical emergencies should be provided.

3 Zusammenfassung

Die schnelle medizinische Versorgung von Patienten vor Ort macht die prähospitale Notfallversorgung zum integralen Bestandteil der Notfallmedizin und zu einem wichtigen Teil der Planung notfallmedizinischer Versorgungsstrukturen. In vielen entwickelten Ländern wird eine zunehmende Inanspruchnahme der rettungsdienstlichen Versorgung beobachtet. Es existieren jedoch nur wenige Studien zu langfristigen Trends und möglichen Auswirkungen der veränderten Nutzung. Außerdem fehlen Erkenntnisse zum kompletten Spektrum und zu großen Populationen von Notfallpatienten. Auch wenn Daten, die nicht in erster Linie für Forschungszwecke erhoben wurden, mit Einschränkungen verbunden sind, eignen sie sich potenziell zur Beantwortung von Forschungsfragen. Zudem ermöglichen sie oft die Untersuchung großer Patientenpopulationen. Basierend auf Routinedaten stellt die Dissertation Informationen zu Inanspruchnahmemustern und -trends der prähospitalen Versorgung einer großen Stichprobe von Notfallpatienten bereit, untersucht die Auswirkungen sich verändernder Nutzung und vergleicht Patienten die nach einem Transport aus der Notaufnahme entlassen werden mit Patienten die ins Krankenhaus aufgenommen werden. Die im Rahmen der Arbeit durchgeführten quantitativen Analysen sollen zu einem besseren Verständnis der prähospitalen Notfallversorgung sowie den Auswirkungen einer veränderten Nutzung beitragen. Außerdem sollen Gruppen herausgearbeitet werden, die für die zukünftige Forschung und eine bessere Allokation von Ressourcen von besonderem Interesse sein könnten.

Die erste Studie in dieser Arbeit beschäftigt sich mit langfristigen Trends und Mustern der Inanspruchnahme des Rettungsdienstes, basierend auf Daten aus dem Bundesland Bayern. Zudem werden Auswirkungen sich verändernder Nutzung auf Transportraten und zeitliche Verteilungen in nach fünf Gruppen differenzierten städtischen und ländlichen Gemeinden untersucht. Es zeigt sich ein kontinuierlicher jährlicher Anstieg der Notfälle je 1000 Einwohner (Notfallrate) zwischen 2007 und 2016, insbesondere bei Notfällen ohne Disposition eines Notarztes. Der jährliche Anstieg der Notfallrate ohne Beteiligung eines Notarztes lag zwischen 5.7% (CI 4.3-7.1) in Großstädten und 7.8% (CI 7.6–7.9) in den ländlichsten Gemeinden, während der Anstieg der Notfallrate mit Notarzt, abhängig vom Gemeindetyp, zwischen 1.3% und 2.4% jährlich lag. Die Notfallraten in Städten waren im Vergleich zu kleineren Gemeinden höher, während der durchschnittliche Anteil an Patienten die zu einem Krankenhaus transportiert wurden dort niedriger war. Trotz eines absoluten Anstiegs der Notfallereignisse um 50% innerhalb des gesamten Zeitraums blieben die Transportraten und die zeitliche Verteilung der Notfälle weitgehend unverändert. Die Daten sind geeignet um Nutzungsmuster und langfristige Trends

darzustellen. Viele wesentliche erklärende Variablen sind jedoch nicht Teil einer langfristigen, konsistenten Datenerfassung und konnten nicht in die Analysen mit einbezogen werden. Die Analysen liefern somit keine Erklärung warum sich Notfallraten abhängig von der Notarztbeteiligung und der Gemeindegröße unterscheiden und welche Faktoren besonders zum Anstieg des Notfallaufkommens beitrugen. Ein Erklärungsansatz für die beobachteten Unterschiede und den Anstieg könnte ein unterschiedlicher und sich über die Jahre verändernder Versorgungsbedarf sein. Zunehmend gibt es jedoch auch Diskussionen über die Angemessenheit der Versorgung, unter der Annahme dass immer mehr Patienten versorgt werden die keine dringende prähospitale Intervention benötigt hätten.

Die zweite Studie in dieser Arbeit vergleicht daher vom Rettungsdienst eingelieferte Notfallpatienten die ins Krankenhaus aufgenommen werden mit denjenigen die ambulant in der Notaufnahme behandelt werden. Die Analyse von verknüpften Krankenhaus- und Leitstellendaten aus 14 Münchner Notaufnahmen und den umliegenden Leitstellen zeigt, dass 40% der vom Rettungsdienst zu einer Notaufnahme transportierten Fälle aus dieser entlassen wurden. Die ambulant behandelten Patienten unterschieden sich in mehrerer Hinsicht von Patienten die aufgenommen wurden. Eine Entlassung war insbesondere dann wahrscheinlicher, wenn Patienten jung waren, das Meldebild auf „Unfall/Verletzung" oder einen „Sonstigen Notfall" hindeutete, wenn kein Notarzt disponiert wurde und die Einlieferung tagsüber erfolgte. Für ein von der Leitstelle ausgewähltes Meldebild ergaben sich im Nachhinein viele unterschiedliche Krankenhausdiagnosen. Die Verteilung der Krankenhausdiagnosen unterschied sich zwischen aufgenommenen und entlassenen Patienten. Dies war auch dann der Fall, wenn die Leitstelle den Patienten initial dieselbe Meldebild-Kategorie zugeordnet hatte, was ein unterschiedliches Krankheitsspektrum unterstreicht. Einige Diagnosen (Alkoholvergiftung, Gehirnerschütterung und Synkope) wurden jedoch in beiden Gruppen häufig beobachtet. Die Interpretation der Ergebnisse der zweiten Studie macht deutlich, dass die Entlassung aus der Notaufnahme und gestellte Diagnosen nach einem rettungsdienstlichen Transport keine ausreichend guten Kriterien sind um die ursprüngliche Notwendigkeit der prähospitalen Ressource zu beurteilen. So kann ein schneller Transport in die Notaufnahme notwendig gewesen sein, um besorgniserregende, unklare Beschwerden abzuklären. Zudem können auch Patienten mit weniger dringlichen Beschwerden eine Krankenhausaufnahme benötigen. Notfallpatienten die nach der Einlieferung durch den Rettungsdienst häufig aus der Notaufnahme entlassen werden sind dennoch für die zukünftige Forschung von besonderem Interesse, um die Allokation bei geringen stationären Bettenkapazitäten zu verbessern und die ursprüngliche Dringlichkeit der Beschwerden detaillierter einzuschätzen.

Die Organisation der Notfallversorgung ist komplex und unterscheidet sich zwischen Ländern und oft sogar innerhalb desselben Landes. Die Dissertation zeigt, dass die Organisation und Planung auf Besonderheiten des jeweiligen Systems sowie auf regionale Gegebenheiten, wie z.B. städtische und ländliche Räume, ausgerichtet sein muss. Sie zeigt auch, dass spezifische Fragestellungen zur Angemessenheit der Versorgung mit den verwendeten, routinemäßig erhobene Leitstellen- und Krankenhausdaten, nicht hinreichend beantworten werden können. Dennoch geben die Analysen Einblicke in die Inanspruchnahme der prähospitalen Notfallversorgung, ein Setting in dem Studien schwierig durchzuführen sind. Die Erkenntnisse bilden eine Grundlage für zukünftige Forschung zur Verbesserung der Planung und Organisation der Notfallversorgung. Die Arbeit unterstreicht die Notwendigkeit die initiale Dringlichkeit von Notfällen ohne Notarzt und mit Beteiligung von jungen, verletzen oder verunfallten Patienten genauer zu untersuchen. Daran anknüpfend könnten standardisierte Protokolle zur Disposition geeigneter Rettungsmittel und zur Wahl alternativer Transportziele entwickelt und auf verschiedene Arten medizinischer Notfälle abgestimmte Ressourcen bereitgestellt werden.

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5 Publications

5.1 Use of pre-hospital emergency medical services in urban and rural municipalities over a 10 year period: an observational study based on routinely collected dispatch data

Authors: Kathrin Hegenberg, Heiko Trentzsch, Stefan Gross, Stephan Prückner

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ORIGINAL RESEARCH Open Access

Use of pre-hospital emergency medical services in urban and rural municipalities over a 10 year period: an observational study based on routinely collected dispatch data

Kathrin Hegenberg*, Heiko Trentzsch, Stefan Gross and Stephan Prückner

Abstract

Background: Pre-hospital emergency medical services (EMS) are an integral part of emergency medical care. EMS planning can be achieved by analyzing patterns of use. However, long-term time trends of EMS use have rarely been studied. The objective of this retrospective study was to investigate utilization patterns over a ten year period, and to compare utilization trends between urban and rural municipalities and between events with and without prehospital emergency physician (PEP) dispatch.

Methods: Routine data collected by 26 dispatch centers in the federal state of Bavaria, Germany, from 2007 to 2016 was analyzed. Emergency locations were classified into five levels of rurality. Negative binomial mixed effects regression models were fitted to predict emergency rates and to investigate differences in rates and utilization trends. Graphical representation methods were used to compare distribution of transport rates and distribution across daytime and weekday.

Results: Twelve million two hundred thousand one hundred fifty-five dispatches assigned to 7,725,636 single emergencies were included. The mean number of emergencies per year and 1000 population (emergency rate) was 42.8 (±16.0) in rural municipalities and 80.7 (±9.3) in large cities. Compared to rural municipalities, cities had higher emergency rates without (IRR = 3.0, CI 2.2–4.0) and with pre-hospital physicians (IRR = 1.5, CI 1.2–2.0). Between 2007 and 2016, the absolute number of emergencies increased by 49.1%. Estimated annual percent change of emergency rates without physician activation ranged from 5.7% (CI 4.3–7.1) in cities to 7.8% (CI 7.6–7.9) in rural areas. Changes in emergency rates with physician attendance were lower, with estimated increases between 1.3 and 2.4%. The average proportion of patients transported to a hospital was lower in cities and remained unchanged. There were no considerable differences or changes in the distribution across daytime and weekdays.

Conclusion: Differences between cities and other areas suggest that the planning of EMS should be targeted to regional characteristics. A substantial increase in emergency rates was observed across all areas of Bavaria, but did not impact transport rates or temporal distributions. Further research is needed to better understand the urgency of emergency events and reasons behind increasing EMS utilization.

Keywords: Pre-hospital emergency medical services, Emergency medical dispatch, Epidemiology, Health services use

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Introduction

Emergency medical services (EMS) are an integral part of emergency care and crucial for the provision of immediate medical care in the pre-hospital setting. To assure an appropriate response, proper planning of EMS infrastructure is paramount. An increasing year-on-year utilization of emergency ambulances over the past 20 years has been reported in many developed countries [1]. In order to provide an adequate number of mobile EMS units it is important to monitor the use of pre-hospital EMS and to respond to changing patterns. It is also important that adequate care is delivered in both, urban and rural regions.

Many factors influence the utilization of EMS. They include individual patient characteristic like age [2, 3], socioeconomic status and medical conditions [4, 5], patient preferences [6] and perceived priority [7] as well as system factors like the organization of primary care [8]. Urban-rural differences of ambulance use over time have not been investigated. Yet the use of health and emergency services and thus utilization trends likely differ between rural and urban regions, due to different patient preferences and healthcare infrastructure and different characteristics of patients.

The aim of this explorative study was therefore to describe the use of pre-hospital emergency medical services over a 10 year period and to compare urban and rural municipalities and emergencies with and without dispatch of emergency physicians. We investigate rates of pre-hospital EMS use, temporal distributions and transport rates.

Methods

Setting

The analyses in this retrospective observational study are based on ambulance dispatch data routinely collected between 2007 and 2016 in the German federal state of Bavaria. Any request for emergency medical assistance is made through the national emergency telephone number 112. For urgent but non-emergency conditions, on-call doctor services can be accessed through 116,117. 112 calls are managed by 26 regional dispatch centers which are run by different operators. Between 2007 and 2013, centers were gradually transformed to integrated centers which coordinate emergency and non-emergency ambulances as well as the fire brigade. Dispatchers are paramedics or firefighters who underwent additional dispatch training. EMS are organized as a two-tiered rescue system that consists of paramedic staffed ambulances and rapid response cars staffed with prehospital emergency physicians (PEP). Response decisions are made by the dispatcher who uses a non-standardized, keyword based dispatch protocol and a computer aided dispatch system. Emergencies that require PEPs are usually more complex and have a higher probability of unstable vital signs and/or for invasive interventions. PEP activation is triggered by one or more of the following criteria:

- loss of or severely impaired vital functions
- severe injuries, intoxication, massive blood loss, critical body temperature with suspected loss of vital functions
- fire, severe burns or scalding
- electrical or chemical accidents
- suspected danger to human life (e.g. shootings)
- psychiatric conditions that endanger the self or others
- accidents in water/ice
- imminent delivery

Activation of PEP can also be initiated at the discretion of the dispatch controller when a situation is unclear of for tactical reasons. This may be the case when transport times are expected to be long or when the response time would be long in case the PEP is not initially dispatched, but subsequently requested by the paramedics on site.

Data source and sample

An electronic record is automatically created for each 112 call. 26 Bavarian dispatch centers transfer their EMS dispatch records to a central relational database on a monthly basis. The database contains a complete collection of every EMS dispatch record generated in Bavarian dispatch centers. Information about dispatches between the years 2007 and 2016 was extracted from the database if a dispatch met the following inclusion criteria: A dispatch had to be classified as a primary emergency that lead to the activation of a paramedic staffed ambulance, with or without support from a PEP. For those dispatches, regional location, time stamps and destination of the transport were extracted. If multiple dispatches were related to the same event, they were assigned to this event and analyzed as one single emergency. Multiple dispatches for the same event usually occur when an emergency physician is dispatched in addition to the paramedic staffed ambulance, or when more than one patient is involved or additional units are required for tactical support. Except for transport rates, all analyses in this paper refer to single emergency events, not corresponding dispatches.

Based on the location of the emergency, every emergency was assigned to one of the 2056 Bavarian municipalities. As geographic distances and infrastructure gradually vary between municipalities, we chose to compare five different levels of rurality. According to a classification by the Federal Institute for Research on Building, Urban Affairs and Spatial Development, each municipality was assigned to the respective level The assigned level depends on the size of the community and its regional importance. The regional importance of a community is stipulated in the regional development

program and differentiates communities that can provide basic goods and services (e.g. doctor, pharmacy, bank branch, basic primary school, police station, train station), extended basic goods and services (e.g. secondary school, hospital, district authority) and specialized goods and services (e.g. specialized hospital, university, district court).

Levels are stratified as follows:

Rural community: less than 5000 inhabitants, no provision of basic goods or services.
Small town: minimum 5000 inhabitants and/or provision of basic goods and services.
Large town: minimum 10,000 inhabitants and provision of basic goods and services.
Medium-sized city: minimum 20,000 inhabitants and provision of extended basic goods and services.
Large city: minimum 100,000 inhabitants and provision of specialized goods and services.

Data on the population of Bavaria was obtained from the Bavarian State Office for Statistics. 0.2% of emergencies occurred in areas that are not assigned to municipalities (e.g. forest areas). Since population figures are not available for these areas, dispatches to these areas were excluded from the analysis.

Analysis

Emergency events are reported as absolute numbers and mean rates ± standard deviation (SD). To account for population growth, utilization is usually reported as annual rate per 1000 population (emergency rate). Analyses are usually stratified by municipality type and involvement of PEP (with PEP or without PEP).

A model was specified to assess the effect of year and municipality type on the emergency rate. It includes the number of emergencies in a municipality as the dependent variable and year and assigned municipality type as independent variables. To correct the number of events for population size, an offset variable was added to the model. Because of an over-dispersed count outcome variable, a negative binomial generalized linear model with logit link function was chosen [9] and fitted using the free R package lme4 [10]. To account for repeated measures on the same municipality over time [11], the model was extended to a mixed effects regression model with random intercept for each municipality. To assess whether the time trend in utilization was modified by municipality type, an interaction term between year and municipality type was included. We tested for statistical significance of the interaction effect by performing a likelihood ratio test. Separate analyses were run for emergencies with and without PEP. Regression coefficients from the fixed part of the model were exponentiated to obtain incidence rate ratios (IRR) and percent changes with 95% confidence intervals (CI).

Temporal distributions of emergencies and transport rates after dispatch were stratified by municipality type and PEP attendance. Transport was defined as an emergency event that led to dispatch of EMS units and that ultimately resulted in a transport of a patient to a hospital. Only vehicles equipped for patient transport were included in the analysis of transport rates. Boxplots, medians and interquartile ranges (IQR) describe the distribution of transport rates by municipality type, physician attendance and year. Statistical analysis was performed using R statistical software (R Foundation for Statistical Computing, Vienna, AT).

Ethical aspects

The study was approved by the ethics committee of the medical faculty of the University of Munich (Project-No 17–813).

Results

Utilization and utilization trends

The total sample included 7,725,636 emergencies with 12,200,155 corresponding dispatches. Throughout the observed period, the overall minimum emergency rate at the municipality level was 1.7, the maximum rate was 330.6. Absolute numbers of emergencies and the mean emergency rate during the study period are shown in Table 1.

IRRs are shown in Table 2. For both, emergencies with and without PEP, the estimated average emergency rate was statistically significantly higher the larger the assigned municipality type, using rural communities as a reference. Yet differences in estimated average emergency rates between municipalities were smaller when PEPs were dispatched: Compared to rural communities, the emergency rate without PEP was three times higher in large cities (CI 2.2–4.0, $p < 0.001$), whereas with PEP, the rate was 1.5 times higher (CI 1.2–2.0, $p < 0.001$).

In a 10-years-period of time, there was a 49.1% absolute increase in emergencies and a 51.2% absolute increase in dispatches. While the average overall emergency rate in 2007 was 37.2 (± 15.2), it increased to 56.4 (± 22.9) in 2016 (+ 51.9%). The increase was smaller for emergencies with PEP (from 22.9 ± 9.6 to 28.3 ± 11.9) as compared to emergencies without PEP (from 14.3 ± 8.1 to 28.1 ± 13.6). Figure 1 shows time trends of emergency rates by municipality type and PEP attendance. The mean rate was higher the larger a municipality in all years, except for emergencies with PEP located in medium-sized and large cities, which show event rates comparable to each other. Mean rates of emergencies were more similar across small and large municipalities if PEPs were engaged into a rescue missions. An increase in rates between the years 2007 and

Table 1 Number of emergencies and mean emergency rate, 2007–2016

	overall		without PEP		with PEP	
	n	mean emergency rate (SD)	n	mean emergency rate (SD)	n	mean emergency rate (SD)
Total	7,725,636	46.6 (17.5)	3,993,450	20.0 (9.7)	3.732.186	26.6 (9.8)
Rural ($n = 1371$)	1,412,989	42.8 (16.0)	589,129	17.5 (8.0)	823,860	25.2 (9.4)
Small town ($n = 458$)	1,275,160	49.0 (17.1)	565,913	21.3 (9.5)	709,247	27.7 (9.8)
Large town ($n = 161$)	1,335,647	60.9 (13.2)	650,602	29.4 (9.8)	685,045	31.5 (8.9)
Medium-sized city ($n = 58$)	1,48,4817	73.1 (13.1)	769,047	37.3 (9.7)	715,770	35.9 (8.0)
Large city ($n = 8$)	2,217,023	80.7 (9.3)	1,418,759	44.4 (8.4)	798,264	36.4 (9.1)

PEP: pre-hospital emergency physician

2016 was observed across all municipalities and for both, emergencies with and without PEP.

Estimated average annual percentage change is shown in Table 3.

In rural communities (reference), the increase by one year leads to an increase of the emergency rate by 7.8% (CI 7.6–7.9 $p < 0.001$). The interaction terms show that this effect was barely modified by municipality type, meaning that the increase was similar between municipalities of different size. Large cities were the exception. Only large cities experienced a statistically significant ($p < 0.001$) lower increase of 5.7% (CI 4.3–7.1). When PEPs were dispatched, the estimated annual increase in rural communities was 2.4% (CI 2.3–2.5, $p < 0.001$). A statistically significant difference in change of rates was only observed in medium-sized cities, where the estimated annual increase was only 1.7%. The increase in large cities was even lower. However, the confidence interval was large.

Temporal distribution of emergencies

Figure 2 shows that emergency rates picked up at 6 am and peaked around midday. Another peak was observed around 5 pm. Peaks were more pronounced in emergencies with PEP. Between 2007 and 2016, the distribution slightly shifted from nighttime to daytime, with a slightly smaller proportion of emergencies happening between 10 pm and 6 am in recent years (21.8 ± 5.6%) in 2007 vs 20.5 ± 5.1%) in 2016).

Figure 3 shows the proportion of emergencies for each day of the week in 2007 and 2016. The comparison between municipalities of different size shows that, the smaller a municipality, the higher the mean proportion of emergencies at weekends (large cities: mean 29.2% (± 0.5); rural communities 33.0% (± 3.1)). Over the years, a small shift from weekends towards weekdays was observed: The overall mean proportion of emergencies at weekends fell from 33.6% (± 6.7) in 2007 to 31.3% (± 6.0) in 2016.

Table 2 Incidence rate ratios for emergency rate, 2007–2016

	Without PEP	With PEP
	IRR (CI)	IRR (CI)
Rural (reference)	1	1
Small town	1.2 (1.2–1.3)*	1.1 (1.1–1.2)*
Large town	1.8 (1.6–1.9)*	1.3 (1.2–1.3)*
Medium-sized city	2.2 (2.0–2.5)*	1.5 (1.4–1.7)*
Large city	3.0 (2.2–4.0)*	1.5 (1.2–2.0)*

*$p < 0.001$
PEP: pre-hospital emergency physician

Transport rates

Figure 4 shows boxplots of the proportion of dispatches to a municipality that actually led to the transport of a patient to a hospital for the years 2007 and 2016. Overall transport rates were higher for emergencies without PEP as compared to emergencies with PEP (with PEP: 80.0% (IQR: 9.8); without PEP: 82.8% (IQR: 11.5)). For emergencies without PEP, transport rates decreased with increasing size of a municipality. The median rate for rural municipalities in 2016 was 82.8% (IQR: 10.6), compared to a median transport rate of 68.6% (IQR: 3.1) in large cities. For missions with PEP, differences in transport rates with respect to rurality were less evident. However, with median transport rates of 71.6% in 2007 and 77.5% in 2016 transport rates in large cities were still lower than in all other areas. Compared to 2007, slightly lower median transport rates were observed when there was no additional physician dispatch (median of 84.1% in 2007 and 81.8% in 2016), whereas median transport rates for emergencies with PEP were slightly higher in 2016 compared to 2007 (median of 78.6% in 2007 and 81.0% in 2016).

Discussion

Emergency rates differed between rural and urban regions, with higher rates in urban municipalities. Over a period of ten years, a substantial increase in the number of emergencies was observed. The increase of emergencies that did not require an emergency physician on scene was much higher than the increase in emergencies with emergency physician attendance. Time trends of utilization were similar between municipalities of different size, except for cities, where the yearly increase was

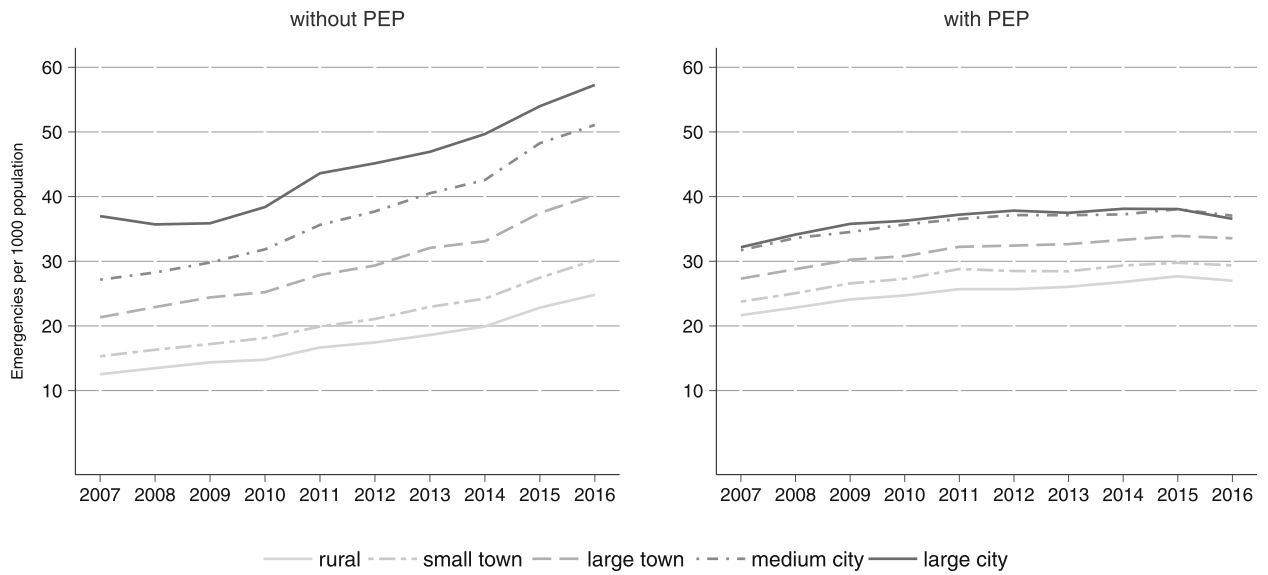

Fig. 1 Time trends of mean emergency rate, 2007–2016

smaller. Transport rates were similar between rural and urban regions when a physician was dispatched and higher in smaller municipalities when an emergency physician was not present, but did not change over time. Temporal patterns of pre-hospital utilization were similar between urban and rural regions and over time.

Emergency rates and differences between urban and rural communities

The number of emergencies per 1000 population was higher the larger a municipality. Comparison with other studies is made difficult by the heterogeneous organization of pre-hospital EMS and definition of urban and rural regions. Few other studies report urban-rural differences in EMS use and find identical incidence of emergency transports to emergency departments in urban and rural areas [12] as well as a higher incidence of low-urgency emergencies in rural areas [13].

Coordinated planning of EMS structures in Bavaria has been initiated in 1999 to prevent both large gaps in provision of EMS and extreme clustering of EMS structures [14]. It is therefore unlikely that differing emergency rates are the result of an unbalanced distribution of pre-hospital EMS infrastructure. An obvious cause of higher emergency rates in larger municipalities is that daytime population density is higher in urban regions, mostly because of inbound commuters. Another cause would be a worse health status of urban citizens, which we could not control for in our study. Health status is associated with age and there is evidence that a large proportion of EMS use can be attributed to the elderly [3, 2]. According to official statistics the average proportion of people aged 75 years and older ranged between 8 and 10%. This difference however, does not seem big enough to fully explain varying rates. Health status is also associated with socioeconomic deprivation. Deprivation was associated with higher emergency call rates in England [15], and the observed association between population density and deprivation could explain higher rates cities. Another cause may be that people in larger municipalities have different preferences regarding emergency care alternatives. Connection to a general practitioner [16], a stronger sense of 'relationship' and more complex decision-making in emergency situations [17] distinguish rural from urban patients. Citizens of urban areas might more often choose to call for an ambulance, whereas rural citizens consider other options first, especially in situations that do not seem life threatening. Rural areas are dealing with a higher share of emergencies with PEP. This could reflect differences in decision making or disease spectrum, but could also be due to an

Table 3 Estimated average annual percentage change of emergency rates with corresponding confidence intervals, 2007–2016

	Rural	Small town	Large town	Medium-sized city	Large City
Without PEP	7.8 (7.6–7.9)	7.8 (7.4–8.2)	7.5 (7.0–8.0)	7.8 (7.2–8.5)	5.7 (4.3–7.1)*
With PEP	2.4 (2.3–2.5)	2.2 (1.8–2.6)	2.4 (1.9–2.9)	1.7 (1.0–2.4)*	1.3 (− 0.2–2.8)

p value for interaction of year and municipality type (rural = reference), * $p < 0.001$
PEP pre-hospital emergency physician

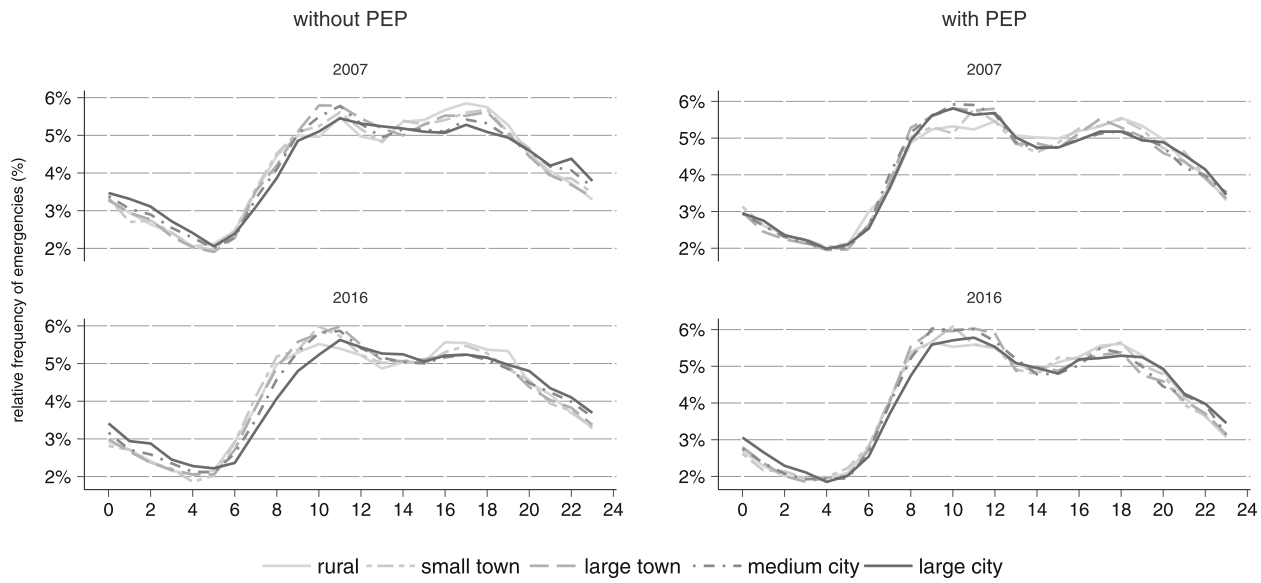

Fig. 2 Distribution of emergencies across daytime, 2007 and 2016

adapted dispatch strategy in areas where times to get to the scene and transport times to hospital are long.

Time trends of emergency rates and differences between urban and rural communities

With an increase of 49.1%, the absolute number of emergencies changed substantially during the 10 year period. The mean number of emergencies per 1000 population in Bavarian municipalities increased from 37 to 56. Thus the increase in emergencies was much higher than population growth. Rather uniform increases were observed across municipalities of different size, with the exception of large and medium-sized cities, where increases were lower. Large confidence intervals for large cities are probably due to the smaller sample of large cities. There are numerous possible explanations behind increasing utilization and the contribution of different factors is unclear. Differences might partly be due to differing age structures. Official population data show that, depending on the municipality type, the number of people aged 75 years or older increased between 28 and 36%, with urban areas facing the smallest increases. However, a backward projection with Bavarian dispatch data has already shown that only a small proportion of the total increase in EMS use between 2004 and 2011 can be

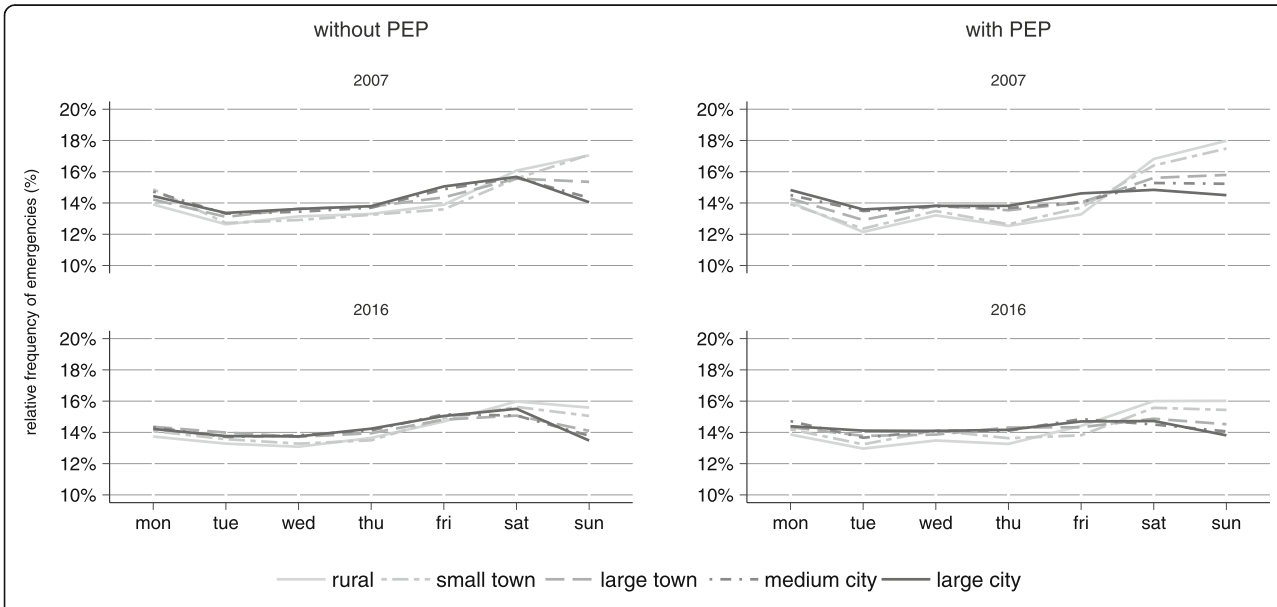

Fig. 3 Distribution of emergencies across weekday, 2007 and 2016

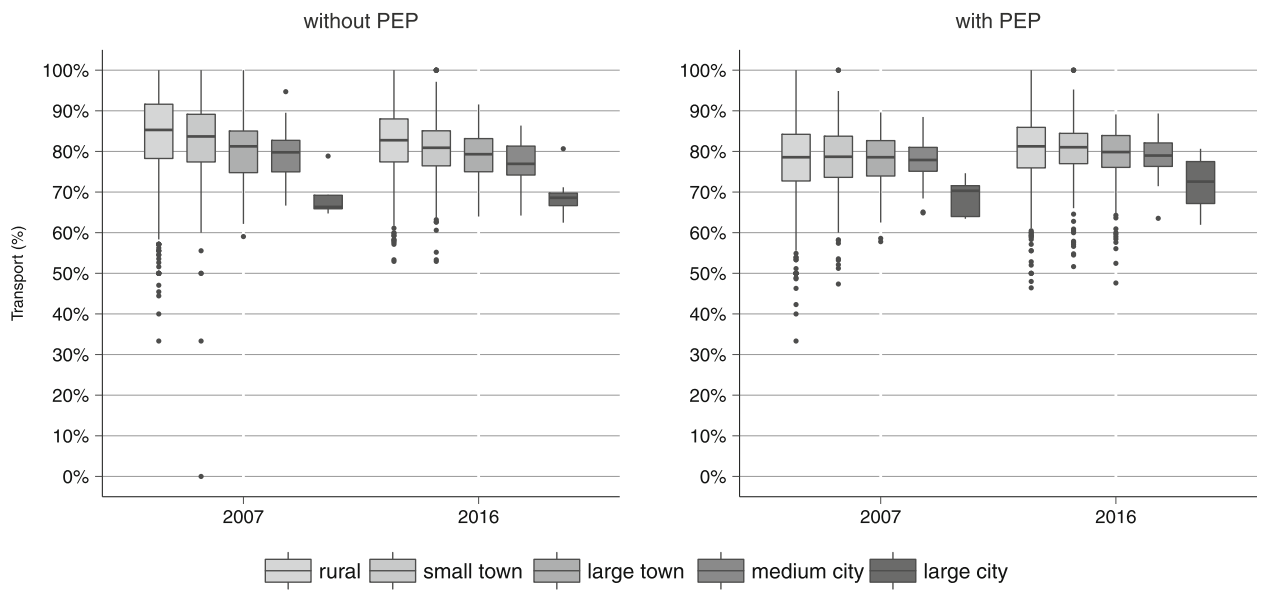

Fig. 4 Distribution of transport rates, 2007 and 2016

attributed to demographic change [3]. A part of the total demand for emergency medical services in cities might be absorbed by alternative health services.

Time trends of emergency rates and differences between emergencies with and without physician dispatch

The increase in emergency rates was higher for emergencies that did not require the additional dispatch of a physician, regardless of the size of a municipality. This could indicate changing needs, with a shift towards conditions that do not require PEP activation. It could also indicate that dispatchers are not able to match calls with an appropriate response. The supply and the adequate regional distribution of ambulances and PEPs are coordinated according to legal requirements. If a patient requires PEP treatment according to the dispatch catalogue, the nearest PEP will be dispatched. PEP shortage might therefore lead to longer response intervals, but is unlikely to put a cap on the rate of emergencies with physicians. Compared to criteria for PEP dispatch, criteria for dispatch of paramedic staffed ambulances are less clearly defined. Appropriateness of utilization of emergency services has been questioned by different authors in different countries [18–20], and an increase of non-specific diagnoses has been reported [21]. A part of increase in missions where the presence of a physician is not required could be attributed to the fact that dispatchers are not able to match unspecific and less urgent calls with a response other than a paramedic staffed ambulance. Dispatch for non-specific complaints and non-urgent diseases would be a problem for ambulance crews, as they seem to have difficulties in dealing with patients with non-serious clinical needs [22].

Time trends of transport rates and differences between urban and rural regions and emergencies with and without physician dispatch

There are different reasons for non-transport. Some emergencies turn out to be a false alarm, some patients are already dead on arrival or refuse transport, or on-scene care was sufficient enough to decline the state of emergency. PEP are usually confronted with more serious conditions thus chances are higher that a patient is pronounced dead on scene and does not undergo transportation. PEP may also find it easier to decide if a patient needs transport to a hospital or can be left at home. Lower transport rates in urban areas, especially large cities, indicates that surrounding infrastructure might play a role, but could also be explained by a higher amount of "false alarms" and alarms for conditions involving patients refusing to be transported. There was no considerable change in transport rates over time.

Time trends of temporal patterns and differences between urban and rural regions

Time of day patterns show a typical bimodal distribution with peaks in the morning and evening and less activity at night [23, 24], which was also present in our data and did not vary by the size of a municipality or year. A higher demand on Fridays [25] and weekends has been found by other authors, especially for alcohol-related and trauma cases [24]. We also observed a slightly higher proportion of emergencies on weekends. This was

especially true for smaller municipalities, which are probably less affected by commuter flows to cities on weekends, or which are recreational areas and are therefore more crowded on weekends. In spite of the strong increase in the number of emergencies, patterns remained almost unchanged.

Future perspectives

Further research is needed to better understand the urgency of emergency events and to identify non-emergency situations. This should be followed by improving triage mechanisms at dispatch and by defining multiple levels of response that best match patients' needs. Difficult triage decisions and fear of legal implications might lead paramedic crews to always convey patients to a hospital. The development of protocols could help ambulance crews choose save alternatives to transport to hospital. New concepts should also take patients' perspectives and preferences regarding the access to emergency care into account. To better predict future utilization and explain observed trends there is also a need for a more extensive, uniform and consistent data collection that includes patient-specific medical and sociodemographic data and information about access to healthcare infrastructure.

Limitations

Data were routinely collected. As dispatch records are created automatically, the documentation of a dispatch is a reliable measure for the activation of an EMS unit and we believe that the number of registered emergencies is accurate. Yet there is some degree of uncertainty regarding the correctness and completeness of time stamps and the destination of transport due to data entry errors. We believe that bias from data entry errors and missing data is small, as the database holds every dispatch record generated in a Bavaria dispatch center and time stamps and transport destinations are important in the subsequent dispatch process and therefore usually well documented. Because of the lack of standardized dispatch algorithms, the choice of type of ambulance and frequency of additional PEP dispatch might vary between the 26 dispatch centers. We believe that potentially different dispatch strategies do not bias the results, as emergencies assigned to the same level of rurality were handled by many different centers. Our study fails to provide explanations for causes of trends. Many explanatory variables of interest were not included in our model, because they are not part of a consistent routine data collection. Insights in pre-hospital EMS utilization and urban rural differences from our study may be applicable for Bavaria only and might not be transferable to other regions with different population composition and healthcare infrastructure.

Conclusion

A substantial increase in emergency rates in Bavaria was observed across all areas over the past 10 years. However, transport rates and temporal distributions remained unchanged. Reasons behind differing emergency rates in urban and rural communities and reasons behind increasing utilization remain unclear. However, EMS use differs between rural and urban areas and regional characteristics should be taken into account when planning pre-hospital emergency medical infrastructure.

Abbreviations

CI: Confidence interval; EMS: Emergency medical services; PEP: Prehospital emergency physician; SD: Standard deviation

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Availability of data and materials

The data used in this paper was a combination of population data, spatial data and dispatch data. Dispatch data are third party data analyzed with permission of the Bavarian State Ministry of the Interior, Sport and Integration and the Bavarian social insurance agencies that the authors do not have the permission to distribute. Population data are publicly available from the Bavarian State Office for Statistics. Spatial data are publicly available from the German Federal Institute for Research on Building, Urban Affairs and Spatial Development.

Authors' contributions

KH and SP conceived the study. KH managed the data, performed the analyses and interpreted the data. HT, SP and SG provided input for interpretation of results. KH drafted the manuscript. All authors contributed to the critical revision of the manuscript and approved its final version.

Ethics approval and consent to participate

The study was approved by the ethics committee of the medical faculty of the University of Munich (Project-No 17–813). Consent to participate was not required as data were anonymized.

Consent for publication

Not applicable

Competing interests

The authors declare that they have no competing interests.

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5.2 Differences between cases admitted to hospital and discharged from the emergency department after emergency medical services transport

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ABSTRACT

Objective Rising emergency medical services (EMS) utilisation increases transport to hospital emergency departments (ED). However, some patients receive outpatient treatment (discharged) while others are hospitalised (admitted). The aims of this analysis were to compare admitted and discharged cases, to assess whether cases that were discharged from the ED could be identified using dispatch data and to compare dispatch keyword categories and hospital diagnoses.

Design Retrospective observational study using linked secondary data.

Setting and participants 78 303 cases brought to 1 of 14 ED in the city of Munich, Germany, by EMS between 1 July 2013 and 30 June 2014.

Main outcome measures Characteristics of admitted and discharged cases were assessed. Logistic regression was used to estimate the association between discharge and age, sex, time of day, ambulance type and dispatch keyword category. Keyword categories were compared to hospital diagnoses.

Results 39.4% of cases were discharged. They were especially likely to be young (OR 10.53 (CI 9.31 to 11.92), comparing <15-year-olds to >70-year-olds) and to fall under the categories 'accidents/trauma' (OR 2.87 (CI 2.74 to 3.01)) or 'other emergencies (unspecified)' (OR 1.23 (CI 1.12 to 1.34) (compared with 'cardiovascular'). Most frequent diagnoses came from chapter 'injury and poisoning' (30.1%) of the 10th revision of the international statistical classification of disease and related health problems (ICD-10), yet these diagnoses were more frequent at discharge (42.7 vs 22.0%) whereas circulatory system disease was less frequent (2.6 vs 21.8%). Except for accidents/trauma and intoxication/poisoning many underlying diagnoses were observed for the same dispatch keyword.

Conclusion Young age and dispatch for accidents or trauma were the strongest predictors of discharge. Even within the same dispatch keyword category the distribution of diagnoses differed between admitted and discharged cases. Discharge from the ED does not indicate that urgent response was unnecessary. However, these cases could be suitable for allocation to hospitals with low inpatient bed capacities and are of particular interest for future studies regarding the urgency of their condition.

Strengths and limitations of this study

- Large sample which includes 78 303 cases brought to the emergency department by emergency medical services after emergency calls in an urban region.
- Linkage of dispatch data with hospital data made it possible to identify which cases were in need of subsequent admission and to study hospital diagnoses of prehospital cases.
- Main limitations are that 30% of dispatches could not be linked to hospital records, and that diagnosis information was missing for 20% of discharged cases.

INTRODUCTION

Prehospital emergency medical services (EMS) provide immediate medical care to acutely ill and injured patients. Demand for EMS in Germany is rising, with an increase of 105% since 2001.[1] An increase in EMS activation in both, urban and rural regions of Bavaria was observed over the past 10 years.[2] Rising use of EMS and emergency departments (ED) contributes to ED crowding and scarcity of hospital admission capacities. The negative consequences of ED crowding on patient outcomes are well established.[3] A growing proportion of ED outpatient treatments has been observed in Germany.[4] There is also evidence that emergency care and ambulance services are accessed for primary care and low-urgency health problems.[5 6] Other studies report discharge rates after EMS transport of as high as 70%[7] and classify 16% of EMS patients as potential candidates for primary healthcare.[8] A certain amount of overtriage is accepted and expected to prevent overlooking critically ill patients that in consequence suffer from adverse outcomes, but it also consumes resources and causes unnecessary crowding of specialised resources. Reasons of and therefore solutions for ED crowding lie largely outside of

the ED.[3] Whereas it is difficult to guide patients that walk into the ED, dispatchers and EMS crews are involved in the emergency care processes at an early stage and play a central role for the allocation of resources to patients and of patients to hospitals. Grusd and Kramer-Johansen found that patients who do not need prehospital interventions can be identified at dispatch[9] and Eastwood *et al* suggest that cases not suitable for an ED presentation can be referred to alternative care pathways after secondary telephone triage.[10]

Knowing which caller characteristics are associated with discharge from the ED and whether the dispatchers assessment of the complaints reflect later diagnoses of admitted and discharged cases might help contribute to dispatch and patient allocation decisions in patients that are less likely to need acute care beds, and point to groups that are worth a closer look regarding the suitability for other settings. The aims of this study were therefore to compare admitted and discharged cases, to assess whether information accessible at dispatch can help differentiate between cases who will need subsequent admission to a hospital and those who likely will not and to investigate differences between dispatch keywords and hospitals diagnoses of admitted and discharged cases.

METHODS

Design and setting

This is a retrospective observational study using secondary data gathered for an evaluation of the provision of care by the ED in the city of Munich.[11] In 2014, about 1.5 million people lived in the city of Munich. The Munich dispatch centre covers an area of about 980 km^2 with 1.8 million inhabitants.

The German healthcare system offers different types of emergency care in different environments. Prehospital medical services can be accessed via the national emergency telephone number 112. Calls are managed by regional dispatch centres that operate full time and coordinate emergency and non-emergency ground and air ambulances and the fire brigade. Call-takers and dispatchers are trained paramedics or firefighters who underwent dispatch training. A local, non-standardised, keyword-based dispatch manual which is mainly based on chief complaints and reported events is used to decide on the type and number of prehospital EMS units to be dispatched to the scene of the emergency. Levels of EMS response include ambulances designated to non-emergency transport, paramedic staffed ambulances and rapid response cars and helicopters staffed with prehospital emergency physicians. Prehospital emergency physicians need a specialty board certification for emergency medicine. A physician will be dispatched according to a prespecified catalogue when vital signs are suspected to be unstable or when the condition implicates a high probability of need for invasive interventions. Physicians can also be activated at the discretion of the dispatcher for tactical reasons or when they are requested by the paramedics on site. According to suitability and intake capacity a dispatcher will suggest a hospital to which an EMS patient should be transported to. This suggestion is usually accepted by ambulance crews, although they can, in consultation with the dispatch centre, decide on another destination if special medical considerations prevail. Physicians can decide whether a patient is left on scene. If hospitals temporarily de-register to the dispatch centre from acute care, EMS units have to travel to alternative locations, which usually results in longer transport times and deducts units from their home base.

A dispatcher can refer callers that do not need an EMS response to on-call or ambulatory services provided by the Association of Statutory Health Insurance. On-call doctor services can be accessed directly through 116 117 for urgent but non-emergency conditions. Patients can access all ambulatory emergency care services on their own initiative, or seek care at a hospital's ED.

Data sources and sample

Between 1 July 2013 and 30 June 2014, routinely collected information of all cases presenting to 1 of 14 ED of 14 major hospitals in Munich was pooled into a study data base. Dispatch information was extracted from a database that holds routinely generated data from the computer-assisted dispatch systems of Munich's central dispatch centre and surrounding dispatch centres and billing information. During the study period, 524 716 cases presented to the 14 EDs and 110 484 emergency dispatches where a patient was transported to a destination in the city of Munich were recorded by the dispatch centres, of which 78 307 (71%) could be matched to an ED record. Four emergency dispatches were excluded, as the keywords indicated a non-emergency transport. All data was anonymised and is therefore case-based, not patient-based. Repeated presentation by the same patient or EMS activation for the same patient could not be accounted for.

Hospital data included basic case information (age, sex, admission status) and information about diagnoses (codes from the German version of the 10th revision of the international statistical classification of disease and related health problems (ICD-10-GM)). Dispatch data includes dispatch keywords, type of ambulance deployed, time stamps and receiving hospital. Billing data includes patient age, an essential identifier for the linkage of hospital and dispatch data. A probabilistic approach was used to link billing and dispatch records, and then dispatch and hospital records. Time stamps of dispatch and billing data were compared and patient age could be assigned to 86% of dispatch records. Second, patient age and admission time of dispatch and hospital records were compared. All records with an exact match of patient age and an arrival time within a 20 min interval were linked which was the case for 80% of records. When several records matched, the records with the smallest difference in arrival time were linked. This process was repeated for the remaining records, first through extending the admission time interval to 40 min, and then extending

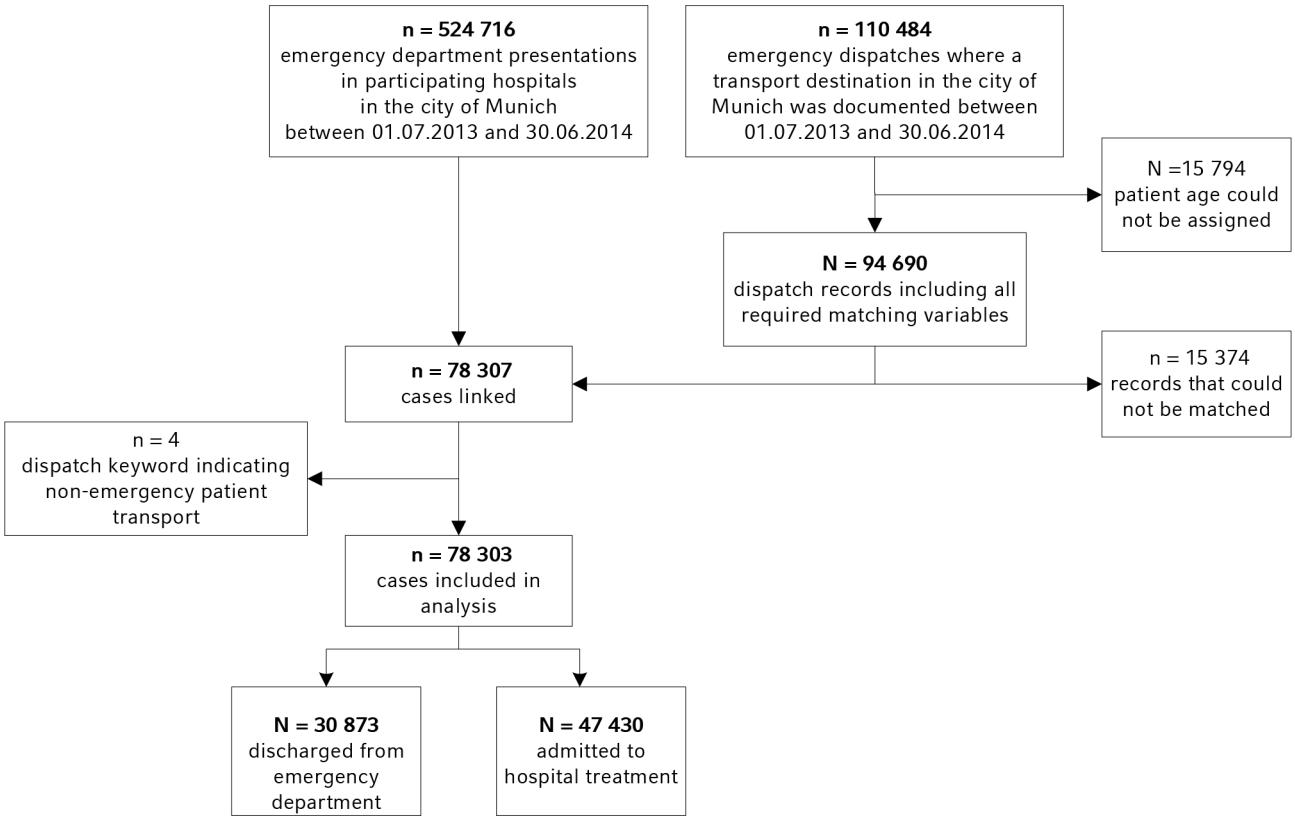

Figure 1 Study design and case selection.

the age criterion to a 5-year range. The study design and case selection are illustrated in figure 1.

Cases were classified as discharged when there was no documentation for admission to the same hospital on the day of ED presentation. Information about admitted cases came from a standardised data set that hospitals are required to collect according to section 21 of the Hospital Remuneration Act (KHEntgG). Participating hospitals provided comparable information about discharged cases from their hospital information system. Records with identical items recorded within the first hour after admission were considered duplicates and removed from the dataset. Recording a primary diagnosis is only mandatory for admitted cases. The amount of missing data is displayed in the results section. More than one diagnosis was recorded for 5.1% of discharged cases. In this case, the diagnosis with the highest estimated resource requirement was chosen as the primary diagnosis. Since dispatch keywords are not standardised, 293 different keywords were condensed and classified into 15 categories (see online supplementary material).

Analysis

The sample was characterised by calculating medians with IQR for continuous variables and frequencies and proportions for categorical variables. Statistical tests (χ^2 test for categorical variables and the Wilcoxon-Mann-Whitney U test for continuous variables) were performed to evaluate differences between admitted and discharged cases. The probability of discharge was calculated for case characteristics. Logistic regression was preformed to estimate the adjusted likelihood of discharge. Covariates were selected based on their availability at dispatch and included age, sex, dispatch keyword category, and day and time of admission at the ED. The nine most frequent dispatch keyword categories and ICD-10 diagnosis chapters are displayed. Remaining diagnosis chapters and keyword categories are summarised as 'other chapters' and 'other keywords'. Age was categorised into five groups. The final model was selected based on Akaike information criterion.[12 13] A subgroup analysis was conducted for age groups and results from the stratified models are displayed. The frequencies of hospital diagnoses stratified by dispatch keyword category are presented in cross-tabulated tables. Analysis was performed using R statistical software (R Foundation for Statistical Computing, Vienna, AT).

Ethics and reporting

Analyses are based on retrospective data that are irreversibly anonymised. The ethical review committee therefore waived obligation to advise according to the law on faculties. The reporting of this study is in accordance with Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for the reporting of observational studies in epidemiology.

Patient and public involvement

Patients or the public were not involved in the design and conduct of this research.

Table 1 Characteristics of ED cases transported by EMS

	Total	Admission status		
	n=78 303	Discharged n=30 873	Admitted n=47 430	P value*
Age, median (IQR)	60.0 (45)	40.0 (41)	70.0 (33)	<0.0001
Sex, n (%)				<0.0001
Male	35 888 (45.8)	14 735 (47.7)	21 153 (44.6)	
Female	35 646 (45.5)	13 249 (42.9)	22 397 (47.2)	
Missing	6769 (8.6)	2889 (9.4)	3880 (8.2)	
Response, n (%)				<0.0001
Ambulance without physician	56 856 (72.6)	25 933 (84.0)	30 923 (65.2)	
Ambulance with physician	21 447 (27.4)	4940 (16.0)	16 507 (34.8)	
Time of admission, n (%)				<0.0001
08:00–18:00 hours	33 787 (43.1)	13 897 (45.0)	19 890 (41.9)	
18:00–08:00 hours	44 516 (56.9)	16 976 (55.0)	27 540 (58.1)	
Day of week n (%)				0.25
Monday–Friday	56 019 (71.5)	22 016 (71.3)	34 003 (71.7)	
Saturday–Sunday	22 284 (28.5)	8857 (28.7)	13 427 (28.3)	
Dispatch keyword category, n (%)				<0.0001
Accident/trauma	23 975 (30.6)	13 810 (44.7)	10 165 (21.4)	
Cardiovascular	18 404 (23.5)	5226 (16.9)	13 178 (27.8)	
Internal disease (unspecified)	7112 (9.1)	2018 (6.5)	5094 (10.7)	
Neurological	5684 (7.3)	1152 (3.7)	4532 (9.6)	
Respiratory	5025 (6.4)	869 (2.8)	4156 (8.8)	
Paediatric	3925 (5.0)	2803 (9.1)	1122 (2.4)	
Gastrointestinal	3856 (4.9)	1178 (3.8)	2678 (5.6)	
Other emergency (unspecified)	3449 (4.4)	1176 (3.8)	2273 (4.8)	
Intoxication/poisoning	2970 (3.8)	1150 (3.7)	1820 (3.8)	
Other keywords	3903 (5.0)	1491 (4.8)	2412 (5.1)	
Primary ICD-10 diagnosis, n (%)				<0.0001
XIX Injury, poisoning	23 592 (30.1)	13 169 (42.7)	10 423 (22.0)	
IX Circulatory system	11 115 (14.2)	792 (2.6)	10 323 (21.8)	
XVIII not elsewhere classified	8625 (11.0)	3695 (12.0)	4930 (10.4)	
V Mental and behavioural disorders	4485 (5.7)	1258 (4.1)	3227 (6.8)	
XI Digestive system	3975 (5.1)	597 (1.9)	3378 (7.1)	
X Respiratory system	3844 (4.9)	505 (1.6)	3339 (7.0)	
VI Nervous system	3620 (4.6)	681 (2.2)	2939 (6.2)	
I Infectious and parasitic	2636 (3.4)	459 (1.5)	2177 (4.6)	
XIII Musculoskeletal system	2442 (3.1)	1232 (4.0)	1210 (2.6)	
Other chapters	7676 (9.8)	2248 (7.3)	5428 (11.4)	
Missing	6393 (8.0)	6237 (20.2)	56 (0.1)	

*P values derived from χ^2 test for distinct variables and from Mann-Whitney U test for continuous variables.
ED, emergency departments; EMS, emergency medical services.

RESULTS

Characteristics of ED cases transported by EMS

47 430 cases (60.6%) were admitted and 30 873 (39.4%) were discharged. Characteristics of both groups are reported and compared in table 1. The comparison of admitted and discharged cases shows that discharged cases were much younger (median of 40 vs 70 years, p<0.0001). The share of males in this group was slightly higher (47.7% vs 44.6%, p<0.0001). Discharged cases were less frequently brought in by an ambulance assisted

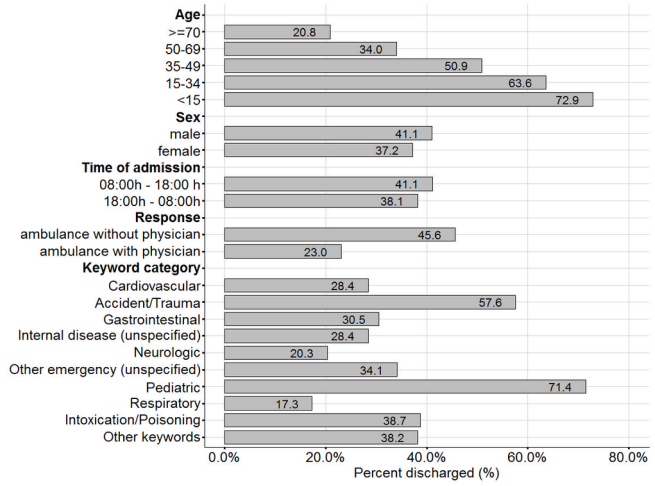

Figure 2 Probability of being discharged from emergency department after emergency medical service transport.

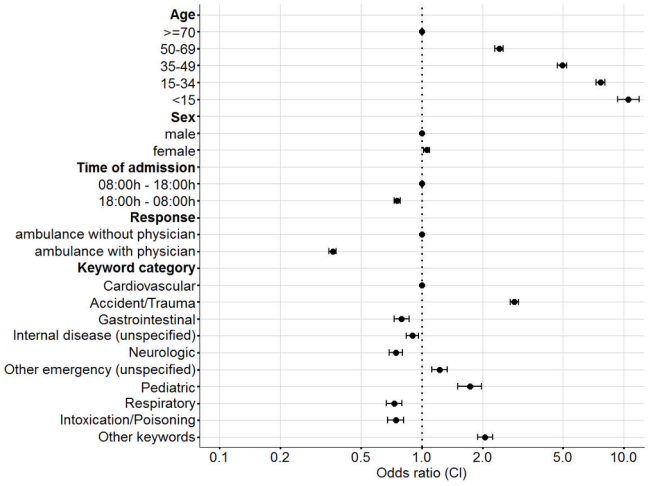

Figure 3 Adjusted ORs and CI (95%) for discharge.

by emergency physicians (16.0% vs 34.8%, p<0.0001). The most common keyword category was "Accident/Trauma" (44.7%) in case of discharge and "Cardiovascular" (27.8%) in case of admission. The most frequent diagnoses were within the main ICD-10 diagnosis chapter XIX (Injury, Poisoning), regardless of admission status.

Factors associated with discharge from ED after EMS transport

Figure 2 displays the proportion of cases discharged for different case characteristics. Whereas only 20.8% of cases over the age of 70 were discharged, 72.9% of cases under the age of 15 left the hospital after being seen in the ED. 45.6% of cases arriving in a paramedic-staffed ambulance were discharged, whereas only 23.0% were discharged when the ambulance crew was supported by an emergency physician. The proportion of discharged cases also varied according to dispatch keyword category, with highest discharge rates for keywords indicating the involvement of children or accidents/trauma and lowest discharge rates for keywords indicating respiratory or neurological problems.

Results from logistic regression analysis adjusting for all included variables are displayed in figure 3. After adjustment, the odds of discharge still increased with age: compared with cases over 70 years of age, cases under 15 years of age had 10 times higher odds of being discharged (OR 10.53, CI 9.31 to 11.92). The adjusted odds of discharge were 6% higher for women compared with men (OR 1.06, CI 1.02 to 1.10). Arrival between 18:00 and 8:00 (nighttime) decreased the odds of discharge by 26% (OR 0.74, CI 0.72 to 0.77). Compared with cases reporting a cardiovascular problem to the dispatcher, dispatch for intoxication or poisoning, respiratory, neurological or gastrointestinal and unspecified internal disease decreased the odds of being discharged, whereas odds of discharge were higher in case of dispatch for accidents or trauma, when children were involved and when the reported problem was not specified by the dispatcher.

When the model was stratified by age group, the strength of the association differed by age category but was reversed only for two keyword categories: Whereas dispatch for respiratory conditions was associated with discharge for cases under the age of 35, cases with respiratory problems aged 35 or older had higher odds of admission. In contrast, intoxication and poisoning led to decreased odds of discharge in younger cases but increased odds of discharge in older cases (table 2).

Hospital diagnoses

Most diagnoses were within chapter XIX, which includes injuries, poisoning and certain other consequences of external causes (table 1). Yet diagnoses from chapter XIX were more common for cases that were discharged (42.7% vs 22.0 %). In contrast, diagnoses from chapter IX (diseases of the circulatory system) were more common when a case was admitted to the hospital (21.8% vs 2.6 %). Diagnoses from chapters XIX (Injury, poisoning), XVIII (not elsewhere classified) and missing diagnosis information covered 75% of all diagnoses for discharged cases, whereas diagnoses of admitted cases were distributed across different diagnosis chapters.

The five most common three-digit ICD-10 codes in case of admission were F10 (mental and behavioural disorders due to use of alcohol), S06 (intracranial injury), I10 (essential (primary) hypertension), R55 (syncope and collapse), I63 (cerebral infarction). In case of discharge, the most common codes were S01 (open wound of head), S06 (intracranial injury), S00 (superficial injury of head), R55 (syncope and collapse), F10 (mental and behavioural disorders due to use of alcohol). These five most common three-digit ICD-10 codes accounted for about 20% of diagnosis codes in each group.

Dispatch keyword categories compared with hospital diagnoses

Tables 3 and 4 show the proportion of diagnoses from each ICD-chapter by dispatch keyword category for admitted and discharged cases. Regardless of the initial dispatch keyword, hospital diagnoses fell into many different

Table 2 Adjusted ORs and CI (95%) for discharge, stratified by age category

	<15 (n=5 075)		15–34 (n=15 346)		35–49 (n=10 859)		50–69 (n=15 995)		>=70 (n=31 028)	
	OR (CI)	P value	OR (CI)	P value	OR (CI)	P value	OR (CI)	P value	OR (CI)	P value
Sex (female)	1.04 (0.91 to 1.19)	0.57	1.01 (0.94 to 1.09)	0.84	1.31 (1.2 to 1.42)	<0.0001	1.17 (1.09 to 1.26)	<0.0001	0.90 (0.85 to 0.96)	<0.0001
Time (18:00–08:00 hours)	0.61 (0.53 to 0.69)	<0.0001	0.74 (0.68 to 0.80)	<0.0001	0.75 (0.69 to 0.82)	<0.0001	0.81 (0.75 to 0.87)	<0.0001	0.77 (0.73 to 0.82)	<0.0001
Response (with physician)	0.32 (0.28 to 0.37)	<0.0001	0.37 (0.34 to 0.4)	<0.0001	0.39 (0.35 to 0.43)	<0.0001	0.38 (0.35 to 0.41)	<0.0001	0.34 (0.31 to 0.37)	<0.0001
Dispatch keyword category										
Cardiovascular	Reference		Reference		Reference		Reference		Reference	
Accident/trauma	1.76 (1.09 to 2.82)	0.02	2.43 (2.19 to 2.71)	<0.0001	3.04 (2.72 to 3.41)	<0.0001	3.36 (3.05 to 3.7)	<0.0001	2.92 (2.69 to 3.18)	<0.0001
Other emergency (unspecified)	1.06 (0.56 to 1.98)	0.86	0.93 (0.77 to 1.12)	0.42	0.99 (0.81 to 1.21)	0.92	1.31 (1.1 to 1.56)	<0.0001	1.59 (1.36 to 1.85)	<0.0001
Gastrointestinal	1.89 (0.84 to 4.25)	0.13	0.73 (0.63 to 0.85)	<0.0001	0.73 (0.61 to 0.87)	<0.0001	0.76 (0.63 to 0.92)	<0.0001	0.87 (0.72 to 1.05)	0.14
Internal disease (unspecified)	1.24 (0.63 to 2.44)	0.53	0.65 (0.56 to 0.75)	<0.0001	0.97 (0.84 to 1.14)	0.74	0.95 (0.83 to 1.09)	0.46	1.03 (0.91 to 1.17)	0.65
Neurological	0.86 (0.37 to 2.01)	0.73	0.76 (0.64 to 0.91)	<0.0001	1.03 (0.86 to 1.24)	0.73	0.75 (0.64 to 0.88)	<0.0001	0.62 (0.53 to 0.71)	<0.0001
Respiratory	1.23 (0.59 to 2.55)	0.58	1.24 (1.01 to 1.53)	0.04	0.95 (0.77 to 1.19)	0.68	0.54 (0.45 to 0.64)	<0.0001	0.60 (0.51 to 0.70)	<0.0001
Intoxication and poisoning	0.86 (0.43 to 1.73)	0.67	0.5 (0.44 to 0.57)	<0.0001	0.88 (0.73 to 1.05)	0.14	1.46 (1.2 to 1.77)	<0.0001	1.23 (0.74 to 2.03)	0.42
Other keywords	1.73 (0.77 to 3.86)	0.18	1.58 (1.34 to 1.86)	<0.0001	1.89 (1.55 to 2.29)	<0.0001	1.83 (1.53 to 2.19)	<0.0001	2.71 (2.36 to 3.12)	<0.0001

Dispatch keyword category ‘pediatric’ is omitted.

Table 3 Distribution of diagnoses within diagnosis Chapters by dispatch keyword category (%), discharged cases

	Diagnosis chapter											
Dispatch keyword category	I	V	VI	IX	X	XI	XIII	XVIII	XIX	Other	Missing	Total
Accident/trauma	0.2	0.7	0.5	0.6	0.2	0.5	3.0	2.7	**65.5**	3.4	22.6	100
Cardiovascular	1.7	6.0	3.1	7.4	1.4	2.4	4.3	**28.3**	14.3	9.5	21.6	100
Internal disease (unspecified)	2.0	6.8	4.3	5.4	1.1	3.6	10.3	**19.5**	16.4	13.6	17.1	100
Neurological	1.1	6.6	**21.5**	4.4	1.0	1.6	3.5	17.7	11.5	12.3	18.7	100
Respiratory	1.6	6.4	3.0	3.9	12.3	1.8	5.6	19.1	16.2	8.6	**21.3**	100
Other emergency (unspecified)	1.6	3.1	2.6	4.7	1.1	2.3	10.7	15.0	**29.9**	13.2	15.8	100
Paediatric	5.9	0.2	0.5	0.3	7.8	2.4	1.8	4.5	**57.4**	6.8	12.4	100
Gastrointestinal	4.9	1.0	0.8	1.4	0.5	15.1	3.4	**31.0**	8.4	17.9	15.5	100
Intoxication/poisoning	0.4	**38.4**	0.3	0.4	0.3	0.3	1.8	5.4	27.7	5.7	19.1	100
Other keywords	1.7	5.7	2.3	2.6	1.1	1.6	3.4	23.2	**26.2**	11.5	20.7	100

The most common diagnosis chapter is highlighted in bold.

chapters. Exceptions were dispatch for 'accident/trauma' and 'intoxication or poisoning', where the majority of diagnoses (accident/trauma: chapter XIX diagnoses for 65.5% of cases when discharged, 71.6% when admitted; intoxication/poisoning: chapter XIX plus chapter V diagnoses for 66.1% of cases when discharged, 85.5% when admitted) came from compatible chapters. Diagnoses for admitted cases did match the initial dispatch keyword category more often than diagnoses for discharged cases, but still fell into different chapters. The distribution of diagnosis chapters differed between admitted and discharged cases, even within the same keyword category. With the exception of dispatch for neurological or respiratory problems, the most common hospital diagnosis for discharged cases came from either chapter XIX (injury, poisoning) or XVIII (not elsewhere classified), regardless of dispatch keyword category. The most common ICD-codes within chapter XVIII were R55 (syncope and collapse), R07 (pain in throat and chest) R10 (Abdominal and pelvic pain) and R42 (dizziness and giddiness).

DISCUSSION

Principal findings

Discharge on the same day following EMS transport to an ED was associated with young age, dispatch of an ambulance without additional emergency physician support and arrival during the day. Discharge also was dependent on the dispatch keyword, with particularly high discharge rates for emergencies related to accidents or trauma and unspecified emergencies. A broad range of underlying diagnoses was observed for almost all dispatch keyword categories.

Table 4 Distribution of diagnoses within diagnosis Chapters by dispatch keyword category (%), admitted cases

	Diagnosis chapter											
Dispatch keyword category	I	V	VI	IX	X	XI	XIII	XVIII	XIX	Other	Missing	Total
Accident/trauma	1.4	3.6	2.0	6.0	1.3	1.8	3.2	4.2	**71.6**	4.8	0.2	100
Cardiovascular	5.0	4.5	4.4	**38.4**	4.5	5.4	2.2	17.6	6.7	11.1	0.1	100
Internal disease (unspecified)	9.1	5.9	5.1	19.3	6.0	10.8	5.0	9.1	6.2	**23.2**	0.1	100
Neurological	3.8	4.9	30.6	**31.2**	3.6	2.0	1.2	8.7	3.0	10.9	0.1	100
Respiratory	5.6	2.2	2.2	28.2	**38.6**	3.6	1.5	6.0	3.1	9.0	0.2	100
Other emergency (unspecified)	5,2	5,2	5,3	**19.4**	5.0	9,2	6,6	8,2	17,3	18,5	0,2	100
Paediatric	6.6	1.2	3.8	0.5	21.4	2.5	1.0	9.1	**46.4**	7.3	0.1	100
Gastrointestinal	7.8	1.5	0.8	3.7	1.8	**50.2**	0.8	10.5	1.8	21.0	0.0	100
Intoxication/poisoning	0.7	**69.3**	0.9	1.7	0.9	1.5	0.3	6.2	16.2	2.1	0.2	100
Other keywords	4.0	9.2	9.2	**20.8**	4.7	3.4	1.0	16.4	17.9	13.2	0.1	100

The most common diagnosis chapter is highlighted in bold.
I Infectious and parasitic IX Circulatory system V Mental and behavioural VI Nervous system X Respiratory system XI Digestive system XIII Musculoskeletal system XIX Injury, poisoning XVIII not elsewhere classified Other chapters include: VII Eye IV Endocrine, nutritional and metabolic XVII Congenital malformations, Blood and blood-forming organs XII Skin VIII Ear II Neoplasms XVI Originating in perinatal period XV Pregnancy, childbirth XXI Factors influencing health XX External cause.

Keywords and diagnoses were more similar when a condition seemed easily recognisable, like accidents or trauma and intoxication or poisoning. The distribution of diagnosis chapters differed between admitted and discharged cases, usually even within the same keyword category. Compared with admitted cases, a larger proportion of discharged cases were diagnosed with injuries or poisoning, whereas the proportion of circulatory system diseases was smaller in this group. Some diagnoses (alcohol intoxication, concussion and syncope) were frequently assigned to both, admitted and discharged cases.

Strengths and weaknesses of the study

Even though it allows a more complete investigation of the rescue chain, few studies link dispatch and hospital data. The use of routinely collected data comes along with several potential sources for bias. One of them is that 30% of dispatch records could not be linked to a hospital record because common identifiers (time stamps or patient age) were documented incorrectly or not at all. We believe that missing identifiers are due to input errors which are likely to be completely random, but we cannot rule out that lack of documentation might indicate that these cases were either less or more critically ill. We consider an overlap of time stamps together with an overlap of transport destination and patient age as suitable criteria to achieve adequate matches. Yet we can't rule out that false matches introduced some noise to the analyses. Another major weakness is that diagnosis information was missing for one out of five discharged cases because it is not relevant for reimbursement of these cases and not all hospitals ensure that diagnosis information of patients discharged from the ED is routinely documented. We therefore report the amount of missing data in all analyses and did not include hospital diagnoses in the regression model. Discharged cases are misclassified when they are admitted on another day, to another hospital or if they die in the ED. Comparison of ICD-10 diagnosis with dispatch keyword categories implies some degree of imprecision, since dispatch keywords often describe emergency situations or medical conditions rather than suspected diagnoses. We could not study patient factors which are likely to be associated with the outcome or other variables, like socioeconomic status or access to care and could not capture comorbid conditions, which are known to increase the risk of short-term adverse outcomes for time-critical 112 callers with the same complaint.[14] The study area is a metropolitan area and results might be different in rural regions or even in metropolitan areas with different prehospital treatment or admission practices.

Interpretations and comparison with other studies

40% of cases transported to the ED by EMS were not admitted to the hospital. Our results can't be transferred to areas with different population composition and healthcare infrastructure. This might explain why even higher discharge rates of 70% were observed in a mixed urban, suburban and rural area in the USA,[7] where alternatives to hospital emergency care are different. Another study from the USA reports a 50% discharge rate of ambulance patients in an urban area.[15] Studies in the prehospital setting in Sweden and Australia have assessed more than one third of patients as not being in need of prehospital interventions or ambulance transport, despite of ambulance dispatch.[16 17]

Age was the strongest predictor of discharge even after adjustment for other patient and dispatch characteristics. Particularly young adults and children were more likely to be discharged than older cases. Other studies have found younger patients to be candidates for primary healthcare[8] and less likely to need paramedic treatment.[17] The decision to access ambulance and urgent care services is influenced by access to primary care, individual circumstances, perceived urgency and beliefs that resources can only be provided by a particular healthcare provider.[5 6] These reasons were mentioned, along with a need for reassurance, the desire for a second opinion and lack of insurance, by parents who bring their child to the ED for minor illnesses. In these cases a 'wait and see' approach seems especially undesirable and the accurate assessment of the child's condition proves difficult to parents.[18] These factors may also be important for EMS missions involving children. Conversely, elderly patients usually bear a higher amount of morbidity and a higher degree of frailty. An increased probability of admission or death after transport to ED was observed for a number of dispatch codes for cases over the age of 65.[7] The lack of safe discharge arrangements for geriatric patients[19] might make hospital admission the best option, even if the acute emergency situation is resolved. Age did modify the estimates, but rather impacted on the strength than the direction of the association, especially when looking at dispatch keyword categories. This might be because the spectrum of disease behind the same category is probably broad. If diseases behind the same keyword category vary by age group ORs of discharge between keywords categories subsequently shift.

Odds of discharge were lower when emergency physicians were dispatched. We expected the presence of a physician to be a marker of severity and thus decreased likelihood of hospital discharge, as physician dispatch is triggered by a higher probability of critically ill/injured patients and invasive interventions on scene.

Arrival at night also decreased the odds of discharge. Such cases could be of higher acuity. There may also be fewer alternatives to admission available, or decision-making may be postponed due to limited diagnostic availability or absence of senior physicians at the ED at night.

We hypothesised that certain dispatch keyword groups would clearly mark situations or health problems that usually do not lead to subsequent hospital admission. Other studies have identified a number of situations that were less likely to lead to hospital admissions or EMS transport or were considered suitable for referral to other levels of care. They include assaults and unconsciousness or fainting in younger patients,[7] paediatric cases, psychiatric conditions, patients with low pain scores,[17]

nausea/vomiting/diarrhoea, seizures/epilepsy, back pain, pain during urination/haematuria, mental illness and unspecified disease.[8] Low-acuity dispatch codes included abdominal pain, assault, back pain, pregnancy and childbirth, injuries and psychiatric conditions[20] and were validated in the same area,[21] but did not turn out to be low-acuity in another community.[22] Non-transport after EMS dispatch was especially more common after assault/sexual assault, unknown problem/man down, traffic/transportation accidents, unconscious/fainting[23] and mental, behavioural and neurodevelopmental disorders.[24] Our analysis shows that, compared with dispatch for cardiovascular problems, odds of discharge were especially high for cases transported after accidents or trauma, emergencies involving children and emergencies where dispatchers did not specify the reason for dispatch. We already discussed reasons why young age might increase the odds of discharge. Higher odds of discharge after accidents and injuries might be because diagnostic resources that are only available in a hospital setting are required for a thorough examination of these cases, after which they can frequently be cleared. Injury severity and whether these patients were readmitted for elective surgery remains unknown. However, that they could initially be discharged suggests that, overall, injury severity was presumably low. A need of hospital-specific resources could also apply to emergencies where the problem can't be specified by the dispatcher. Determining the priority level of unclear calls is particularly difficult, and they are therefore often provided with a either lower or higher response than needed.[25 26]

The spectrum of disease differed between discharged and admitted cases, with a higher proportion of chapter XIX (Injury, poisoning) diagnoses in discharged and more ICD-10 chapter IX (circulatory system) diagnoses in admitted cases. Except for two keyword categories (accident/trauma and intoxication/poisoning), a broad range of underlying diagnoses was reflected by the same initial complaint for both admitted and discharged patients. Keyword category and hospital diagnosis were more similar when a condition seemed easily recognisable, like accidents or trauma and intoxication or poisoning. These situations might be more intuitive for patients and bystanders to describe. Discrepancies between keyword and diagnosis might point to patient groups that are probably more difficult to manage and were observed slightly more frequently for discharged cases. The distribution of cases across diagnosis chapters differed between admitted and discharged cases, even within the same keyword category. This suggests that the disease spectrum of both groups differs, even if similar complaints are initially expressed.

At dispatch, the correct assessment of urgency is more important than diagnostic accuracy. Still, complaints influence patient management. Prehospital emergency conditions usually do not present themselves as 'textbook examples'.[26] Especially non-surgical emergency patients often lack diagnosis-specific symptoms.[27] The analyses show that some conditions are very common in both groups. They included alcohol intoxication, concussion and syncope. Standard operating procedures have been defined to handle these conditions in the ED[28] to safely identify patients with high risk of adverse outcomes and might be useful for a standardised assessment of emergency calls as well.

The dispatch centre is the earliest point of time in the rescue chain at which triage might occur, but due to limited information it is also one of the most difficult ones.[29] Most emergency response systems accept a certain level of over-triage as a safety margin[16 30] but over-triage is also costly and can result in resources not being available to someone who needs them. The dispatcher allocates ambulances and specialised prehospital units[31] and plays a key role in identifying the best resources for the caller or patient,[30] which mostly depends on an accurate assessment of the urgency and acute symptoms, and not on the overlap of dispatch data with later confirmed diagnosis or discharge from the ED. Odds of discharge and overlap with diagnosis are therefore not suitable to assess the quality of response decisions and not good criteria to base response decisions on. Yet, patient groups that are frequently discharged could be of particular interest or further more detailed analyses with regard to the urgency of their conditions. Information about the probability of discharge may furthermore be helpful to allocate patients to hospitals when hospital beds are congested.

There are other variables that probably impact on discharge or distort the relationship between included variables and discharge, and not considering them has consequences for the interpretation of estimates. They were not included in the analysis as they are not available at dispatch and not part of the routine data collection, and they are usually not available at the point where a response decision is made. Two important factors are morbidity and socioeconomic status. Socioeconomic status brings a higher burden of disease, and patients with low socioeconomic status are more likely to use acute and hospital care.[32] Socioeconomic differences between chronic diseases seem to vary, with larger disparities for stroke, diseases of the nervous system, diabetes mellitus and arthritis.[33] Socioeconomic status is therefore likely linked with certain dispatch keyword categories and for instance low odds of discharge for neurological keywords might partially be masked by socioeconomic status. Regardless of the initial complaint, previous illness and comorbid conditions might always complicate treatment and therefore also decrease the odds of discharge. As morbidity increases with age, a part of the effect of age might actually be traced back to comorbid conditions.

CONCLUSION

Discharge was especially likely when patients were young or after dispatch for accidents/trauma. Except for accidents/trauma and intoxication/poisoning many underlying diagnoses were observed within dispatch categories. Even within the same dispatch keyword category, the

distribution of hospital diagnoses differed between admitted and discharged cases, indicating a differing spectrum of disease. Discharge from the ED after EMS transport can't be equated with low potential for critical illness or injury or no need for prehospital resources. Rapid transport may be necessary to exclude worrisome differential diagnoses or to treat conditions using resources that are not available outside of a hospital setting. Yet, the findings could guide allocation of ambulances to hospitals when hospital bed capacities are low, so that transport capacities are quickly available again. Frequently discharged patients are also worth a closer look regarding the urgency of their condition to manage the growing demand for emergency medical resources. To accurately identify patients that are not severely ill or injured and for a better evaluation of resource allocation, acuity should be assessed in addition to symptom keywords at dispatch.

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Keyword categories and examples of assigned keywords

Accident/Trauma	Fall, traffic and other accidents
Cardiovascular	Myocardial infarction, collapse, heart complaints
Internal disease (unspecified)	Undefined problem (internal medicine)
Neurologic	Stroke, Seizure
Respiratory	Respiratory distress, asthma
Pediatric	Child sick or injured
Gastrointestinal	Abdomen, gastro-intestinal bleed
Other emergency (unspecified)	Other emergency (undefined problem)
Intoxication/Poisoning	Alcohol, drugs, medication
Other keywords	Consciousness (unconsciousness, patient without signs of life), Obstetrical/Gynecological (gynecological bleed, parturition), Person in danger (Person in need of assistance, entrapped in residence, stand by in case of fire), Suicide (Suicide and attempted suicide), Bleeding

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