Acute admissions to internal medicine departments in Denmark

- studies on admission rate, diagnosis, and prognosis

PhD Dissertation

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Preface

This PhD thesis is based on studies carried out during my employment at the Department of Clinical Epidemiology, Aarhus University Hospital, Denmark.

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Vest-Hansen B, Riis AH, Sørensen HT, Christiansen CF. Acute admission to medical departments in Denmark: Diagnoses and patient characteristics. European Journal of Internal Medicine. 2014; 25:639-45.

Vest-Hansen B, Riis AH, Sørensen HT, Christiansen CF. Off Hours and Weekend Admissions to Danish Medical Departments: Admission rates and 30-day mortality for 20 common medical conditions. Submitted.

List of abbreviations:

CI: Confidence Interval

CRS: Civil Registration System

CPR: Central Personal Registration

DNRP: Danish National Registry of Patients

GP: General Practitioners

ICD-10: The International Classification of Diseases, 10^{th}edition.

ICU: Intensive Care Unit

MeSH: Medical Subject Headings

MRR: Medical Record Review

NPV: negative predictive value

OR: Odds ratio

PPV: positive predictive value

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1. Introduction

1.1 Acute hospital care in Denmark

The World Health Organization (WHO) defines acute care as "*a range of clinical health-care functions, including emergency medicine, trauma care, pre-hospital emergency care, acute care surgery, critical care, urgent care, and short-term inpatient stabilization".*[1] The focus of this thesis is the medical patient that requires acute admission to the hospital, which indicates severe illness or an urgent need for specialized treatment. A 'medical patient' is defined as a patient that requires care in the specialty of internal medicine.[2] The overall aim is to examine these patients in terms of important patient characteristics, admission rates, main reasons for admission, and prognosis after a short-term follow-up.

The acute care initiated upon arrival at the hospital is termed 'acute hospital care' or 'acute care' in this thesis. The components of acute hospital care involve the initial assessment of the illness, initiation of treatment, establishment of a diagnosis, observation, and discharge or transfer to an appropriate setting.[3,4] The major proportion of patients that require acute hospital care are medical patients; more than 80% of these medical patients present with an acute illness; in contrast, only approximately 60% of surgical patients present with an acute illness.[5] Every year approximately one million acute admissions to medical departments are registered in the Danish National Registry of Patients (DNRP) covering all Danish hospitals, including first-time admissions, transfers, and re-admissions (Flowchart in Appendix I). Worldwide, the absolute number of acute admissions has increased, and this increase has challenged the structure of acute hospital care.[6-10]

In Denmark, medical patients that require acute admission are cared for by physicians specialized in internal medicine.[11] Currently, the practice of internal medicine has evolved into separate subspecialties, for example, cardiology, pulmonology, and hematology.[12,13] In contrast, the responsibility for acute hospital care in the US is placed on physicians specialized in emergency medicine.[3] Emergency medicine has not been introduced as an independent specialty in Denmark.[14]

The Danish Society of Internal Medicine defines nine subspecialties affiliated under the term "Internal Medicine".[15] The specialty "General Internal Medicine" ceased to exist in 2004.[16] In 2007, major changes in Danish acute hospital care were initiated.[17] One of the main changes was the establishment of acute admission units in hospitals. Overall, the Danish acute admission unit has been, to a large extent, modeled after the US emergency department.[18] Accordingly, fewer, larger, more centralized hospitals should receive patients that require acute care.[17,19]

Although the changes in acute hospital care were inspired by the US system, there are some differences. In Denmark, general practitioners (GPs) play a key role in acute care, because the majority of admissions to hospitals are referred by a GP.[20] Virtually all Danish residents are affiliated with a personal GP, and during regular office hours, the GPs refer their patients. However, during off-hours, a GP-run cooperative is responsible for the referrals.[21] Acute hospital care is also available through a 1-1-2 emergency call, which provides ambulance service to the patient.[22] Finally, patients can present themselves to an emergency room on a 24-hour basis.[23] However, in many emergency rooms a preadmission assessment based on a telephone call before arrival is mandatory. In contrast to this system in Denmark, patients in the US are allowed to seek acute hospital care without prior referral. Therefore, the patients in a US emergency department correspond to a mixture of patients in Denmark that were referred by a GP, admitted to the emergency room and ward patients.

The overall aim of the changes made in acute hospital care was to provide higher quality care to all patients. However, the increasing number of patients that require acute care and the highly specialized skills of acute-care physicians have complicated the solution. Consequently, this problem has warranted more in-depth research to guide clinical governance, support health care planning, allocate resources, improve prognosis, and inform physicians that provide acute hospital care.

In Denmark, the unique population-based medical registries allow for epidemiologic investigation of the acute hospital care.[24,25] For example, the characteristics and prognosis of the population of medical patients that require acute care can be examined. The registries hold both administrative and clinical data collected routinely, which reduces the probability of biases in the selection process and in information retrieval. In addition, the population-based design is a unique feature for the registries in the Nordic countries.[26]

Before conducting epidemiological studies in a new area, it is essential to investigate the validity of the data that one intends to use to explore or describe this area. In the research area of medical patients that require acute care, the validity of the registration of a case as 'acute' is crucial, because this one variable describes inclusion into the cohort. Therefore, the first study in this thesis aimed to evaluate the accuracy of the registered acute admission type for medical patients.

Overall, both descriptive and prognostic studies that focus on medical patients that require acute care are important for several reasons.[27-29] First, they improve our understanding of clinical pathways. Second, they are important when defining groups at high risk of adverse outcomes. Third, they may help guide clinical decision-making. Fourth, they are important when comparing treatment efficiency. Finally, they may help in planning tertiary prophylaxis. Therefore, the second and third study in this thesis aimed to describe some important determinants of outcome for medical patients that require acute care.

2. Background and existing literature

2.1 Validity of the registration of the acute admission type in the DNRP (Study I)

2.1.1 Background

DNRP is one of the largest and most extensively used national medical databases in Denmark.[30] It includes individual-based data on all contacts with hospitals. Comparable databases are found in our neighboring Scandinavian countries.[31,32] The DNRP includes a variable that describes the admission type. All admissions are one of two distinct types, acute or elective. A distinction between these two types is often used in studies on the prognosis of individual diseases or in defining patient populations.[33,34] In health care quality surveys or in health care cost surveys, admission types are primarily used to indicate trends.[5,35] Valid administrative data, including the type of admission, is pertinent, both from the viewpoint of health care planning and from the viewpoint of establishing reliable clinical databases.

2.1.2 Existing literature

We searched the existing literature for studies that investigated the validity of the variable “admission type”. MEDLINE had no Medical Subject Headings (MeSH) for this term; therefore, we performed searches based on text words. All searches were restricted to ‘humans’ and to ‘English and Danish languages’. The following query was used;

```
"admission type" [text words] OR "admission method" [text words] OR
“arrival mode” [text words]
```

This query yielded a total of 128 papers, but none of the titles were relevant. Another search was conducted with the following query;

```
("Registries/standards"[Mesh]) AND (“validity” [text word] OR “accuracy”
[text word])
```

This query yielded a total of 244 papers, and 44 of these had data on Danish registries. A total of 34 abstracts were reviewed that mostly concerned diagnostic accuracy, coverage, and completeness. A total of 11 papers were reviewed, and two were relevant, because they concerned administrative data.[36,37] From these papers, we identified a reference to a Danish report published in 1993 that described the validity of "admission type" in the DNRP.[38] Upon retrieving the report from the publisher´s website, we identified another, more recent report.[39] Both of the relevant papers found in our search contained a summary of the report from 1993. Therefore, the main references were national reports initiated by the National Board of Health to analyze the overall data quality of both administrative data and clinical data in the DNRP (Table 2.1).

Table 2.1 Studies examining the validity of administrative data in DNRP

Author/year	Titel/Settings/Aim	Study Population/Exposure	Outcome/Statistical analysis	Results and comments
National Board of Health 1993[38]	**Country:** Denmark **Setting:** National sample **Study period:** 1990 **Aim:** Evaluation of administrative and clinical data from the Danish National Registry of Patients	**Study population:** Representative sample of inpatients from medical, surgical, gynecologic, orthopedic and pediatric departments **Study size:** 1231 admissions 1094 medical records review 137 missing medical records **Exposure:**Information on administrative and clinical data in DNRP	**Outcome:** Information on administrative and clinical data in the medical records **Statistical analysis:** Missing data were assumed correct classified. Word ranked higher than codes	No blinding for the coding in DNRP Admission type: Correct classified in 98.6% No information on the review process
National Board of Health and CF Møller, health care planning department. 2004[39]	**Country:** Denmark **Setting:** National sample (14 departments) **Study period:** 2003 **Aim:** Evaluation of administrative and clinical data from the Danish National Registry of Patients	**Study population:** Representative sample of inpatients surgical and gynecologic departments **Study size:** 280 admissions **Exposure** Information on administrative and clinical data in DNRP	**Outcome:** Information on administrative and clinical data in the medical records **Statistical analysis:** Admission type: No information on missing data	No information on blinding for the coding in DNRP Admission type: Correct classified in 97% No information on the review process

Thus, our search showed that the existing literature on admission type was sparse, and no peer-reviewed papers have described the validity of the variable "admission type" in an administrative database. Furthermore, we found no studies that evaluated data on admission type in the registries of our neighboring Scandinavian countries.

2.1.3 Limitations of the existing literature

The report from 1993 analyzed the registration of admission type in an overall analysis, but it did not stratify the different patient types.[38] The admission type was correctly classified for 98.6% of patients. Patients with missing data on admission type were assumed to be correctly classified; this may have resulted in an optimistic evaluation of data quality. A second report from 2004 did not analyze data on patients admitted to departments of internal medicine.[39] An overall analysis showed that the admission type was correctly classified for 97%. No information on missing data was included. Both reports used a medical record review (MRR) as reference, but they did not describe the method for determining whether an admission was correctly classified. Consequently, our search indicated that no study had specifically examined the validity of the admission types recorded for medical patients. To compare the PPV, sensitivity and specificity of an acute admission in the two reports, data were abstracted and analyzed. The results are provided in Table 2.2.

Table 2.2 Evaluation of the ´acute´ admission type

Registration in DNRP	**Medical record review**		
	Acute	**Non-acute**	
First report (1993)			
Acute	769	12	781
Non-acute	1	279	280
Total	770	291	1061
		Results (95% CI)	
	PPV	98.5% (97.4%-99.2%)	
	Sensitivity	99.9% (99.4%-100.0%)	
	Specificity	95.9% (93.1%-97.7 %)	
Second report (2004)			
Acute	137	3	140
Non-acute	5	135	140
Total	142	138	280
		Results (95% CI)	
	PPV	97.9% (94.4%-99.4%)	
	Sensitivity	96.5% (92.5%-98.6%)	
	Specificity	97.8% (94.3%-99.4%)	

2.2 Reasons for acute medical admissions (Study II)

2.2.1 Background

The ongoing changes in the demographics of Denmark due to the ageing population have challenged the departments of internal medicine. In 2030, the proportion of people over age 60 is estimated to grow from the current 24% to an estimated 29% of the total population.[40] In European studies, the reported median age of medical patients that require acute care ranged from 58-75 years.[41-47] Hospitalized patients in southern Europe tend to be older than those in northern Europe, which may reflect differences in the health care structures. For example, there are differences in the extent of care the patients receive from the GP before admission to the hospital, and there are differences in health care insurance systems. Knowledge of the distribution of ages in specific subgroups of medical patients that require acute care is important, because age is a major determinant for prognosis.[44,46]

As patients become older, they have more chronic diseases; thus, the prevalence of chronic disease increases with age.[48] The number of chronic diseases that occur or exist in addition to the index disease of interest defines the extent of comorbidity.[49,50] Note that comorbidity is distinct from multimorbidity, which is the co-occurrence of two or more conditions in the same patient, without distinguishing which condition is primary. A frequently used index to measure comorbidity is the Charlson Comorbidity Index (CCI).[51] However, the definition of a comorbid condition varies, which complicates comparison.

It is estimated that approximately one-third of the adult Danish population has one or more chronic conditions, and the highest prevalence is found in the older age groups.[52,53] Other Western countries have reported a similar prevalence of chronic conditions.[48,54] Among medical patients that require acute care, 40-76% have a CCI score >0.[44,46,47] Apart from having chronic diseases, patients in the departments of internal medicine comprise a complex population, due to the varying degrees of disease severity and functional impairment.[55] A few studies have indicated that the presence of chronic diseases increases the risk of an acute hospital admission.[56,57]

In recent decades, research in populations of medical patients that required acute hospital admissions has focused on individual diseases, like acute myocardial infarction (AMI) or stroke. Indeed, research in populations with AMI has been essential for advancements in treatment and in identifying prevention strategies.[58,59] Those studies have contributed to the reduced incidence and mortality in that particular group of patients.[60-63] However, studies that examine the risk or prognosis of individual diseases must restrict the study populations to patients with a confirmed diagnosis. When the disease is suspected, but not confirmed, the patient is not included. The latter patients are given R- or Z- diagnoses, based on the *International Classification of Diseases, 10th edition* (ICD-10); in this thesis, these diagnoses are termed 'non-specific diagnoses'.[64] The R diagnoses include *"Symptoms and abnormal findings, not elsewhere classified",* and the Z-diagnoses include *"Factors influencing health status and contact with health services"*. In many countries, these diagnoses are highly prevalent, and the rate of occurrence has increased, particularly among patients admitted for acute care.[44,65-67]

A study from the US found that the primary reason for going to an emergency department was classified as a non-specific R-diagnosis (ICD-10) in 26.5% of patients.[68] After that, the most frequent reasons included lesions and poisonings (20.0%), musculo-skeletal diseases (6.8%), and respiratory diseases (6.6%). That study population had a median age of 46.5 years. Another US study found that most patients were discharged from the emergency department without a diagnosis that explained the likely cause of their symptoms.[69] Similarly, another study found that the discharge diagnoses for patients that visited an emergency department in Iceland were most frequently classified as a non-specific R-diagnosis, followed by diseases of the circulatory system.[70]

Previous studies from the UK on patients discharged with non-specific R-diagnoses have suggested that social and organizational factors, such as admission through the emergency department or admission out of normal GP hours, had a high impact on the probability of being discharged with non-specific diagnoses.[71,72] When we conducted a search to describe the trend in these diagnoses, we found no studies on non-specific Z-diagnoses. Therefore, with a population-based approach, this thesis aimed to describe the overall disease burden among medical patients that required acute care, including specific and non-specific diagnoses; i.e. the primary reasons for admission and their age, gender, and comorbidity.

2.2.2 Existing literature

Due to recent advancements in medical treatments and the consequent changes in the patterns of the reasons for admissions to internal medicine, we decided to limit the literature search to papers published within the preceding ten years in adult populations. MEDLINE was searched for English- and Danish-language literature with the following query:

```
"Internal Medicine/diagnosis"[Mesh] OR "Internal Medicine/statistics and
numerical data"[Mesh] OR "Acute Disease/diagnosis"[Mesh] OR "Acute
Disease/statistics and numerical data"[Mesh] OR
"Emergencies/diagnosis"[Mesh] OR "Emergencies/statistics and numerical
data"[Mesh] OR "Acute admission unit" [text word] OR "Acute medical
unit" [text word] OR "acute medical patients" [text word]
```

This query yielded a total of 849 papers. Based on the titles, only 39 papers were selected for a review of the abstract. Three papers were found to be relevant, because the study populations comprised patients with an admission to departments of internal medicine or patients from acute admission units. Excluded papers concerned specific diseases, internist training and education, medical errors, a specific specialty, aged individuals, risk scoring systems, or readmissions. One additional paper identified in the reference list of one of the papers was found to be relevant. Thus, a total of four papers were relevant to the aim of this study.

Despite the growing body of literature on individual diseases, it was difficult to identify studies on the reasons for admission in cohorts of medical patients that required acute care. One described common discharge diagnoses in Internal Medicine in Europe in 2009.[42] A second study described the association between the primary discharge diagnosis and the total number of diagnoses (primary and secondary) and mortality.[41] A third study included admissions to an acute medical unit.[43] In that study, the patients were stratified into major clinical categories, and the associated median age and gender distribution were described. A fourth study from Denmark, which described the prognosis of acute medical admissions, was included in this study, because it provided an overall description of the primary diagnostic groups.[44] Table 2.3 describes the four studies.

Table 2.3 Studies examining reasons for admission to departments of internal medicine or acute admission units

Author/year	Settings/Design	Study Population/Exposure	Outcome/Statistical analysis	Results
Kellett J 2007[41]	**Country:** Ireland **Setting:** One hospital (60,000) **Study period:** 2000-2004 **Design:** Cohort study **Data source:** Database	**Study population:** Medical patients (>=14 years) **Study size:** 11,124 admissions 9,214 with complete data ("almost all of which is unplanned emergencies") **Exposure:** Number of ICD-9 diagnoses	**Outcome:** 30-day mortality **Statistical analysis:** Students t-test and chi-square test	Age: Median 68 years Number of diagnoses: Median 4.0 Increased nr. of diagnoses associate with increased age, mortality and LOS Prevalence of individual diseases estimated with both primary and secondary diagnoses 30-day mortality: 4.9%
Duckitt R 2010[42]	**Country:** 18 European countries **Setting:** 31 physicians **Study period:** 2009 (2 months) **Design:** Cross-sectional study **Data source:** Questionnaire	**Study population:** Patients admitted to internal medicine or acute medicine wards (>=15 years) **Study size:** 1,501 patients (emergency and elective) 138 patients excluded	**Outcome:** Medical diagnoses **Statistical analysis:** Descriptive statistics	Age: Median 67 years Comorbidity: Mean 3 (secondary diagnoses?) LOS: 6 days Discharge diagnoses: Cardiovascular and infectious diseases most prevalent. Concordance between diagnoses on admission and at discharge
Schmidt M 2010[44]	**Country:** Denmark **Setting:** One medical department **Study period:** 2008 (12 months) **Design:** Cohort study **Data source:** Administrative Database	**Study population:** First-time acute admission to a medical admission unit (>=15 years) **Study size:** 3,727 patients	**Outcome:** 1-month, 3-months, and 6-months mortality **Statistical analysis:** Kaplan Meier estimator Cox regression analysis	Age: Median 63(female), Median 60 (male) Comorbidity: 56.4% Primary diagnoses: Z-diagnoses: 17.9% Respiratory diseases incl. pneumonia:15.4% R-diagnoses: 14.0 %
James NJ 2012[43]	**Country:** England **Setting:** One acute medical unit **Study period:** 2010-11 (16 months) **Design:** Cross-sectional study **Data source:** Ward register	**Study population:** Patients referred from GP and ED to an acute medical unit (>=16 years) **Study size:** 16,001 admissions	**Outcome:** Primary reason as referred by GP or ED Admission stratified on major clinical categories and associated age and gender **Statistical analysis:** Descriptive statistics	Age and gender according to major clinical categories Major clinical categories: Cardiovascular: 24.9%, Age: Median 69 years Respiratory diseases (incl. pneumonia) : 19.8%, Age : Median 74 years

Abbreviations: LOS= length of stay, GP=general practitioner, ED=Emergency department

2.2.3 Limitations of the existing literature

The primary limitation of all identified studies was the lack of a description of the age, gender, and prevalence of comorbidity in the primary diagnostic groups. In the pan-European study, the prevalence of chronic conditions was only analyzed at an overall level, and no description was included of the method for selecting chronic conditions.[42] The paper from Ireland used secondary diagnoses to assess comorbidity.[41] Data were abstracted from a database with a maximum registration of six diagnoses. When the estimation of chronic diseases is restricted to secondary diagnoses assigned after the index admission, conclusions about prevalence are limited. [73,74] Also, the validity may be questioned, because secondary diagnoses could be complications to the primary disease, rather than a different chronic disease. [49,50] In the paper from England, no data on comorbidity were included from the acute medical admission unit.[43] No description of age, gender or comorbidity in the diagnostic groups was available in the Danish study.[44]

2.3 Variation in timing of admissions and mortality (Study III)

2.3.1 Background

A few studies have examined the 24-h variation in admissions. Despite the different reasons for admissions, the overall admission pattern forms a curve with two peaks, one during the mid-morning hours and one during the late afternoon hours.[75-77] It is not known whether these peaks are associated with a biological explanation or with GP availability. A Danish study found that chronic diseases were associated with a high rate of out-of-hours primary health care services and, in particular, patients with heart failure had a high out-of-hours admission rate to the hospital.[78] There is a paucity of data associated with acute out-of-hours care in Denmark.[79-83]

Across health care systems in the Western world, an acute admission during the weekend has been associated with a 3-42% increase in in-hospital mortality, with an adjusted odds ratio (OR) of 1.03-1.42.[47,80,84-97] This trend has been termed "the weekend effect". One recent Danish study demonstrated a doubling in in-hospital mortality for patients admitted during the weekend.[80] However, the weekend effect is poorly understood, and further investigation is warranted. The effect may be explained by differences in the reasons for admission or in the severity of illnesses. One study from the UK found that the number of times GPs were contacted increased during weekends; another study from the UK found that referral rates from GPs increased outside office hours.[98,99]

The Danish health care system, which assures equal access to acute hospital care, is an ideal setting for analyzing the weekend effect, and together with the comprehensive data in the Danish medical registries about reasons for admissions, comorbidity and complete follow-up, it may provide a better understanding. Therefore, the third study aims to examine an association between time of admission and admission rates and 30-day mortality rates for common conditions among medical patients that required acute care.

2.3.2 Existing literature

All searches were restricted to the English language and adult populations. The following query was performed in MEDLINE in an attempt to retrieve relevant literature on admission rates associated with time of admission.

```
("After-Hours Care"[MeSH] OR “weekend” [text word] OR "out of hours"
[text word] OR "off hours" [text word]) AND ("patient admission"[MeSH])
```

A total of 113 papers were identified. From these, 8 abstracts were reviewed, but no papers included information on the admission rates. The majority of papers focused on specific diseases and the association between weekend admission and mortality. Another query was used.

```
"Patient Admission"[Mesh] AND “hourly” [text word]
```

In this search, a total of 11 papers were identified. Five abstracts were reviewed, but no relevant papers were found.

In an attempt to search the existing literature for studies that examined an association between weekend or off-hour admissions and mortality, we performed the following query in MEDLINE:

```
("After-Hours Care"[Mesh]) OR “weekend” [text word] OR "out of hours"
[text word] OR "off hours" [text word]) AND ("Mortality"[Mesh] OR
“mortality” [text word])
```

This query resulted in 324 hits. After examining the titles, 23 abstracts were reviewed. Finally, 15 articles were selected for a full review. Of these articles, 14 were relevant. After a search through the reference list of these articles, two additional articles were found to be relevant. The articles considered relevant are shown in Table 2.4

Table 2.4 Studies examining the association between weekend or out-of-hours admission and mortality

Author/year	Settings/Design	Study Population/Exposure	Outcome/Statistical analysis	Results
Bell C M 2001[84]	**Country:** Canada **Study Design:** Observational study **Setting:** One state **Study period:** 1988- 1997 **Data sources:** Administrative databases	**Study Population:** All acute care admission through ED (all ages) **Exclusions:** Elective admissions, urgent transferals, elective transfers and births **Study Size:** 3,789,917 admissions **Exposure:** Weekend FS	**Outcome:** Two-day and In-hospital mortality **Statistical Analysis:** Logistic regression **Adjustment:** age, sex and CCI **Diagnosis groups:** 6 diseases (3 +3 controls) and 100 diseases associated with highest mortality	**Characteristics:** Age: mean 51 years Weekend admissions: 26.5% **In hospital mortality:** Control diseases: no weekend effect Weekend: 23/100 conditions had increased mortality Adj. OR 1.06-1.72) **Two-day mortality:** Weekend: 26/100 conditions had increased mortality
Cram Peter 2004[85]	**Country:** US **Study Design:** Observational study **Setting:** One state **Study period:** 1998 (12 months) **Data sources:** Administrative database	**Study Population:** All hospital admission through ED (all ages) **Study size:** 3,725,373 admissions (all) 641,860 admissions through ED with 50 diagnoses associated to mortality **Exclusions:** Scheduled admissions **Exposure:** Weekend FS	**Outcome:** In-hospital mortality **Statistical Analysis:** Multiple Logistic regression, Chi square **Adjustments:** Age, sex, race, comorbidity (CCI) **Diagnosis groups:** Top 50 cause of death	**Characteristics:** Age: Mean 67 years Weekend admissions: 180,758 (28%) **In-hospital mortality:** ED patients: Weekend Adj. OR 1.03 (1.01-1.06) Major teaching hospital: Weekend Adj. OR= 1.13 (1.04-1.22) Minor teaching hospitals: Weekend Adj. OR =1.05 (1.00-1.09) **Diagnoses:** 3/50 (6%) of diagnoses had weekend effect
Schmulewitz L 2005[86]	**Country:** Scotland **Study Design:** Observational study **Setting:** One hospital **Study period:** 2001 (12 months) **Data sources:** Administrative database	**Study Population:** All emergency admission with 6 diagnoses (age>=13 years) **Study size:** 3,244 admissions **Exposure:** Weekend FS Public holidays = weekend	**Outcome:** Total in-hospital mortality 2-day in-hospital mortality Readmissions within 6 months **Statistical Analysis:** Multiple Logistic regression, Chi square **Adjustments:** Age, sex **Diagnosis groups:** 6 diagnoses	**Characteristics:** Age: Mean 67.7 years Weekend admissions: 28.9% **In-hospital mortality:** 10.2% Pneumonia: Adj. weekend OR 0.50 (0.27-0.88) Other: no differences **2-day in-hospital mortality:** 2.8% (no weekend effect) **Readmission:** 34.1 % Weekend: No difference
Barba R 2006[87]	**Country:** Spain **Study Design:** Observational study **Setting:** One hospital **Study period:** 1999-2003 **Data sources:** Administrative database	**Study Population:** All acute admissions via ED (age >=14 years) **Exclusions:** elective admissions, critical care patients, births. **Study size:** 35,993 admissions **Exposure:** Weekend FS	**Outcome:** Global and 48 h in-hospital mortality **Statistical Analysis:** Multiple Logistic regression, Chi square **Adjustments:** Age, sex, DRG and CCI (secondary diagnoses) **Diagnosis groups:** ICD-9 (one primary and 12 secondary), DRG group	**Characteristics:** Age: Median 52.59 years Weekend admissions: 23.4 % **Global mortality**: 6 % Weekend: Adj. OR 1.08 (0.97-1.21) **48-hour mortality**: 1.9% Weekend: OR 1.40 (1.18-1.62) **Diagnoses:** No data on diagnoses

Clarke MS 2010[88]	**Country:** Australia **Study Design:** Observational study **Setting:** One state **Study period:** 2002-2007 **Data sources:** Administrative database	**Study Population:** All acute admissions through ED with 4 diagnoses (all ages) **Exclusions:** transferals **Study size:** 54,396 admissions **Exposure:** Weekend FS	**Outcome:** 30-day in-hospital mortality 2-day in-hospital mortality **Statistical Analysis:** Multiple Logistic regression **Adjustments:** Age, sex, indigenous status, remote residence, SES, comorbidity **Diagnosis groups:** 4 diagnoses	**Characteristics:** Age: ? Weekend admissions: 26.9% **30-day in-hospital mortality:** AMI: Weekend Adj. RR 1.15 (1.03-1.26) Other: no differences **2-day in-hospital mortality:** AMI: Adjusted weekend RR 1.23 (1.08-1.38) Other: no differences
Aylin P 2010[89]	**Country:** England **Study Design:** Observational study **Setting:** Population of England **Study period:** 2005-6 (12 months) **Data sources:** Administrative database	**Study Population:** Emergency inpatient admissions (all ages) **Exclusions:** day surgery, non-acute trusts. **Study size:** 4,317,866 admissions (total) **Exposure:** Weekend FS	**Outcome:** In-hospital mortality **Statistical Analysis:** Multiple Logistic regression, Chi square, Risk model **Adjustments:** Age, sex, socioeconomic deprivation, CCI (secondary diagnoses) and diagnoses **Diagnosis groups:** CCS Top 50 cause of death (ICD-9)	**Characteristics:** Age: ? Weekend admissions: 23.1 % **In-hospital mortality**: 5.0% Weekend: Adj. OR 1.10 (1.08-1.11) **Diagnoses:** Top 50 (41.3% admissions and 81.8% deaths) CCS: 28/50 higher mortality in weekend CCS: 8/32 medical groups had higher mortality
Marco J 2010[47]	**Country:** Spain **Study Design:** Observational study **Setting:** Population of Spain (90%) **Study period:** 2005 (12 months) **Data sources:** Administrative database + data abstraction on-site	**Study Population:** Admissions to internal medicine from ED (> 14 years) **Exclusions:** elective admissions, elective transfers **Study size:** 429,880 patients **Exposure:** Weekend FS	**Outcome:** Overall in-hospital mortality 48-hours in-hospital mortality **Statistical Analysis:** Multiple Logistic regression, Chi square **Adjustments:** Age, sex, DRG weights, CCI score, hospital size, seasonality, area **Diagnosis groups:** DRG	**Characteristics:** Age: Median 70.9 years Weekend admissions: 23.2 % **Overall in-hospital mortality:** 10.3% Weekend: Crude OR 1.1 (1.08-1.14), Adj OR 1.07 (1.046-1.097) Public holidays: Adj. OR 1.067 (1.001-1.139) **48-hours in-hospital mortality:** 2.5% Weekend: Unadj. OR 1.28 (1.22-1.33), Adj. OR 1.57 (1.48-1.67) **Diagnoses:** No data on diagnoses
Maggs F 2010[90]	**Country:** England **Study Design:** Observational study **Setting:** One hospital **Study period:** 2007-2008 (12 months) **Data sources:** Administrative database	**Study Population:** Non-elective admissions (adults) **Exclusions:** observation unit patient **Study size:** 15,594 patients **Exposure:** Time of the day (night vs day, out-of-hours vs in-hours), Weekend FS Holidays = normal days	**Outcome:** Overall in-hospital mortality >7-day in-hospital mortality **Statistical Analysis:** Multiple Logistic regression Chi square **Adjustments:** Age, sex **Diagnosis groups:** No definition	**Characteristics:** Age: Median 72 years Weekend admissions: 20.6 % **In-hospital mortality:** 7.96% Weekend: Unadj. OR 1.19, Adj. OR 1.11 (0.97-1.25) Night vs day: Adj. OR 1.33 (1.16-1.49) Out of hours vs in hours: Adj.OR 1.40 (1.22-1.58) **Diagnoses:** No data on diagnoses

Khanna R 2011[91]	**Country:** US **Study Design:** Observational study **Setting:** One hospital **Study period:** 2008 (9 months) **Data sources:** Retrospective medical record review	**Study Population:** Admissions to the general medicine service from the ED (adults) **Exclusions:** Admission to other departments, patients with missing data, admissions not from ED **Study size:** 824 patients **Exposure:** Daytime: 0700-0659	**Outcome:** LOS, hospital charges, ICU transfer, 30 day repeat ED visit, 30-day readmission, poor outcome<=24 hours (transfer to ICU, cardiac arrest, death) **Statistical Analysis:** Inter-rater reliability Multiple Logistic regression, Chi square **Adjustments:** Age, sex, race, ethnicity, insurance class, hospitalist/teaching service, MDC category, CCI **Diagnosis groups:** Major diagnostic groups	**Characteristics:** Age: ? Weekend admissions: 22 % **ICU transfer:** Weekend: OR 0.20 (0.05-0.88) **Diagnoses:** No data on diagnoses
Mikulich O 2011[92]	**Country:** Ireland **Study Design:** Retrospective cohort study **Setting:** **Study period:** 2002-2009 **Data sources:** Administrative database	**Study Population:** Emergency medical admissions (all ages) **Study size:** 49,337 admissions in 25,883 patients **Exposure:** Weekend FS	**Outcome:** 30-day in-hospital mortality **Statistical Analysis:** Multivariate Logistic regression, Chi square **Adjustments:** Illness severity score, CCI, O2 saturation, troponin status, albumin **Diagnosis groups:** CCS (ICD-9)	**Characteristics:** Age: Median 56.6 years Weekend admissions: 20.6 % **30-day in-hospital mortality:** 9.2% Weekend: Unadj. OR 1.11 (0.99-1.23) Adj. OR 1.05 (0.88-1.24) **Diagnoses:** No data on diagnoses
Handel Adam E 2012[93]	**Country:** Scotland **Study Design:** Observational study **Setting:** Population of Scotland **Study period:** 1999-2009 **Data sources:** Administrative database	**Study Population:** All admission through ED (all ages) **Study size:** 5,343,906 admissions (total) 5,271,327 admitted to the ED (no missing data) **Exposure:** Weekend - no definition	**Outcome:** In-hospital mortality **Statistical Analysis:** Multiple Logistic regression, Chi square **Adjustments:** Year, age group, sex, deprivation quintile, number of comorbidities (no definition) **Diagnosis groups:** Top 50 causes of death	**Characteristics:** Age: ? Weekend admissions: 23.6% **Absolute mortality:** 5.03% **Relative mortality:** 5.96% vs 4.77% Weekend: Unadj. OR: 1.27 (1.26-1.28), Adj. OR: 1.42 (1.40-1.43) Inverse relationship with number of comorbidities **Diagnoses:** No data on diagnoses
Mohammed A Mohammed 2012[97]	**Country:** England **Study Design:** Retrospective observational study **Setting:** 328 hospitals **Study period:** 2008-9 (12 months) **Data sources:** Administrative databases	**Study Population:** All acute hospitals (age>= 16 years) **Exclusions:** admissions discharged alive with LOS=0, day cases, maternity cases, mental health episodes (not dementia) **Study size:** 1,535,267 elective admissions, 3,105,249 emergency **Exposure:** Weekend FS	**Outcome:** In-hospital mortality **Statistical Analysis:** Multiple Logistic regression, Chi square **Adjustments:** Age groups, complex elderly, gender, HRG with cc, interaction weekend-HRG, seasonality, zero day stay (elective) **Diagnosis groups:** HRG groups	**Elective admissions:** (33.08%) Weekend: 127,562 (8.3%) Weekend: Deaths (0.77% vs 0.52%) Adj. OR = 1.32 (1.23-1.41) **Emergency admissions:** (66.92%) Weekend: 735,933 (23.7%) Weekend: Deaths (7.06% vs 6.53%) Weekend: Adj.OR= 1.09 (1.05-1.13) **Diagnoses:** HRG profile weekend and weekday

Adam L Sharp 2013[95]	**Country:** US **Study Design:** Retrospectiv cohort study **Setting:** Population of US (**Study period:** 2008 **Data sources:** Administrative database	**Study Population:** Emergency department visit (adults) **Study size:** 4,225,973 admitted through the ED (20% representative sample) **Exposure:** Weekend admission - no definition	**Outcome:** In-hospital mortality in the ED **Statistical Analysis:** Logistic regression Interaction examined **Adjustments:** Age, sex, income, comorbidities (Chronic Indicator), **Diagnosis groups:** Top 10 primary diagnosis (ICD-9)	**Characteristics:** Age: Mean 61.7 years Weekend admissions: 25.5% **In-hospital mortality:** 4.03% Weekend: Deaths: 4.23% vs 3.96% Weekend: Unadj. OR: 1.073 (1.061-1.084) Adj OR: 1.026 (1.005-1.048) (Only higher risk after hospital admission not in the ED) No variation between diagnoses, No interactions
Oscar Perez Concha 2013[96]	**Country:** Australia **Study Design:** Cohort study **Setting:** One region (501 hospitals) **Study period:** 2000-2007 **Data sources:** Administrative databases	**Study Population:** All ED visit (all ages) **Study size:** 3,381,962 admissions for 539,122 patients **Exposure:** Weekend FS Temporal risk pattern:Early care effect, care effect washout, patient effect, mixed	**Outcome:** In-hospital and 7-day mortality **Statistical Analysis:** Direct standardisation Mantel Haenszel and Cox: DRG groups **Adjustments:** Charlson comorbidity index, age, sex and diagnostic group **Diagnosis groups:** DRG codes	**Characteristics:** Age: Median 52.4 years Weekend admissions: 27.1% **7-day Mortality:** 12.0% (64,789) Weekend: 2.03 % (18,282) Standardized 2.12% Weekday: 1.92 %(46,507) Standardized 1.85% **Diagnoses**: 16/430 increased mortality Temporal pattern analyzed in these 16 groups.
Stacy Smith 2014[94]	**Country:** Scotland **Study Design:** Observational study **Setting:** One hospital **Study period:** 2008-2010 **Data sources:** Administrative database	**Study Population:** All emergency medical admission – 11 specialties (adults) **Exclusions:** dead on arrival or in ED **Study size:** 20,072 admissions (total) **Exposure:** Weekend - no definition Public holiday	**Outcome:** 7-day in-hospital mortality 30-day in-hospital mortality **Statistical Analysis:** Multiple Logistic regression, Chi square, Interaction between weekend and public holiday **Adjustments:** Age, sex, comorbidity, deprivation, diagnosis, year **Diagnosis groups:** Top 50 cause of death	**Characteristics:** Age: ? Weekend admissions: 22.9% Public holiday: 5.6% **7-day in-hospital:** 3.8% Weekend: Adj.OR 1.10 (0.92-1.31) Adjusted public holiday: OR 1.48 (1.12-1.95) **30-day in-hospital mortality:** 8.9% Weekend: Adjusted OR 1.07 (0.94-1.21) Adjusted public holiday: OR 1.27 (1.02-1.57) No interaction, No data on diagnoses
Madsen F 2014[80]	**Country:** Denmark **Study Design:** Cohort study **Setting:** Population of Denmark (322 medical departments – 11 specialties) **Study period:** 1995-2012 **Data sources:** Administrative databases	**Study Population:** All admissions to departments of internal medicine using a specialty code (age >=16 years) **Study size:** 2,651,021 admissions for 1,123,959 patients **Exposure:** Weekend admission – no definition	**Outcome:** In-hospital and 30-day mortality **Statistical Analysis:** Poisson regression **Adjustments:** Age, sex, month, admission during working hours, Elixhausers comorbidity index, period	**Characteristics:** Age: Mean 66 years Weekend admissions: 9% (person-time) **In-hospital Mortality:** 4.2 % (111,172 deaths) Weekend: 35,209 deaths (31.7%) Weekend/holidays: MRR 2.23 **30-day Mortality:** 6.4 % (170,413 deaths) Weekend: 42,141 deaths (24.7%) Weekend/holidays: MRR 1.77

No previous studies could be identified that examined hourly admission rates to internal medicine departments. All previous studies that described an association between admission during the weekend and mortality were based on administrative databases from different healthcare systems, including Canada, the US, Australia, and several European countries.[47,80,84-97] Among all admissions, 20.6% to 27.0% were found to be weekend admissions, except in one Danish study based on a study population of patients admitted to departments of internal medicine; that found that only 9% of patients were admitted during the weekend (based on person-time).[80] Only two studies considered mortality associated with off-hour admissions.[90,91] However, in those studies, the off-hour admissions were a combination of patients admitted during weekday off-hours and those admitted during the weekend.

All studies, except the Danish study, defined mortality as all-cause, in-hospital mortality. The Danish study examined both in-hospital mortality and 30-day mortality.[80] No long-term follow-up studies were identified. Six of the studies were conducted within a population-based setting.[47,80,89,93,95,97] Three studies described mortality associated with weekend admissions, within a predefined range of diagnoses. [84,86,88] Due to differences in inclusion criteria (all ages versus adults), a comparison of age distributions among the studies was inconclusive. In the ten studies with estimated overall OR for in-hospital mortality during weekend compared to during the week, the adjusted OR varied between 1.03 and 1.42.[47,85,87,89-90,92-95,97] The Danish study estimated a mortality rate ratio of 2.23 for in-hospital mortality during weekend compared to during the week.[80]

2.3.3 Limitations of existing literature

A few important limitations were identified. When exposure was defined as the time of admission, all studies defined the weekend as the time from midnight Friday to midnight Sunday. This raised questions about the appropriate definition for the weekend, based on knowledge gained from the organization of acute hospital care during the weekend. For example, when the “weekend” is defined by the quality and extent of care delivered, then optimally, the time from Sunday midnight to Monday morning should have been included. Thus, the classification of exposure in those studies may have biased the associations.

No studies have examined the mortality in refined time periods, where weekday off-hours were examined separately from the weekend. Only one Danish study examined mortality in a short-term follow-up period that obviated loss to follow-up due to discharge.[80] In this Danish study the estimated "weekend effect" was higher compared to all other studies. No absolute measures were available and no confidence intervals for the estimate were provided. In addition, no disease-specific estimates were provided. The identification of the study population in the Danish study was based on a specialty-code for the departments of medicine registered in the DNRP, but the validity of the codes is unknown.

Due to the limitations identified in the existing literature, this thesis aimed to examine disease-specific admission rates and mortality rates among medical patients that required acute care in categories of time of admission, where weekday off-hours were separated from the weekend.

3. Aims of the thesis

Study 1: The aim was to evaluate the validity of the registration of the acute admission type among medical patients in the Danish National Registry of Patients (DNRP), using a medical record review as the reference.

Study 2: The aim was to examine the reasons for acute medical admission and the associated age, gender and Charlson Comorbidity Index score. In addition, within the primary diagnostic groups, we examined the individual conditions specified in the Charlson Comorbidity Index and the length of hospital stay.

Study 3: The aim was within groups of medical patients that required acute care for common medical conditions to examine the association between time of admission and admission rates and 30-day mortality rates.

4. Methods

4.1 Setting

We conducted population-based observational studies in Denmark. Denmark has a free, tax supported health care system, which assures that the Danish population (5,535,000 million people as of 1 January 2010), in both rural and urban areas, has unrestricted, equal access to specialized treatment in primary and secondary health care systems.[20] Every Danish citizen is assigned a unique central personal registration number (CPR number) at birth or immigration, which contains embedded information on birth date and sex. This unique CPR-number permits unambiguous individual-level linkage among all Danish population-based registries.

4.2 Data Sources

4.2.1 The Danish National Registry of Patients (DNRP) (studies I-III)

The DNRP has recorded all non-psychiatric admissions to hospitals since 1977. In addition, starting from 1995, it has recorded all hospital visits, including emergency rooms and hospital specialist clinics.[30] Hospital specialist clinics provide specialist outpatient services in all specialties of medicine. The record of each admission or visit is linked to the unique CPR-number. In addition, each record contains the unique code of each hospital and department, the date of admission and discharge, the admission type (acute or non-acute), and the major procedures performed, which includes care provided in an intensive care unit (ICU). Information on ICU admission and treatment, e.g., mechanical ventilation, non-invasive ventilation, dialysis, and vasopressors, has been registered with high accuracy since 2005.[100]

In the DNRP, each record can contain one primary diagnosis and up to 19 secondary diagnoses, coded according to the *International Classification of Diseases*, 10th edition (ICD-10). The diagnoses are assigned by the discharging physician. Therefore, when a hospital stay includes more than one department, the patient can have more than one primary diagnosis registered. The first department that admits the patient is considered the index admission. According to Danish guidelines and those of the WHO, the primary diagnosis assigned at hospital discharge should be the main reason for hospitalization.[64,101] The primary purpose of data in the DNRP is to provide accurate accounting for governmental financial reimbursements to the hospitals. Due to this financial incentive to report detailed data, the completeness of the registry data is considered high. No recent studies on the completeness of registry data are available, but a study from 1980 suggested that all hospital admissions were included in the registry.[102] Furthermore, reporting to the DNRP is mandatory, both for financial accounting and for monitoring the quality of healthcare service. Thus, the DNRP is a valuable resource for medical research.

4.2.2 The Civil Registration System (studies II-III)

The CRS is a central registry established in 1968 that archives information on vital statistics, marital status, residency, and migration for all residents in Denmark. The registry contains complete follow-up data on all patients, and it is updated electronically on a daily basis.[103]

4.3 Study Populations

4.3.1 Study I

We sampled a study population of 160 medical patients admitted to the hospital in the North Denmark Region during 2009. Medical patients were defined as patients with an admission to any department of internal medicine in the study area. Only inpatients were included. The medical patients were admitted to 15 different departments; of these, nine were highly specialized.

For the purpose of this study, the departments of oncology were not included, because we did not include patients that required surgery, and these departments admit all patients with cancer, regardless of whether they require surgery.

4.3.2 Study II

Nationwide, we included all adult (defined as age ≥ 15 years) medical inpatients that required an acute hospital admission between 1 January and 31 December 2010. In this study, we examined records of only first acute admissions to an internal medicine department during the study period. We identified eligible medical patients through the DNRP, based on the unique code for each internal medicine department. We decided to include patients from the departments of general internal medicine, and the departments of the subspecialties of neurology, cardiology, pulmonology, gastroenterology, nephrology, rheumatology, hematology, endocrinology, geriatric medicine, and infectious diseases. In addition, we included medical patients admitted through the acute admission units. In total, 178 departments admitted medical patients that required acute care in 2010, and of these departments, 14 were acute admission units.

4.3.3 Study III

Study III included a subpopulation of patients from study II. Patients were excluded when they were transferred or readmitted within 30 days preceding the index date or on the day of admission. The exclusion was based on the consensus that these patients typically had different risk factors, including complications to surgery, which were associated with a worse prognosis. Moreover, the referral from a hospital department may skew distribution of times of admission, and may lead to a biased result. Finally, we only included patients with a residence in Denmark on the day of admission to assure complete follow-up.

4.4 Exposure and outcomes

4.4.1 Validity of the registration of the acute admission type in the DNRP (Study I)

In study I, the main variable was the admission type registered in the DNRP. Either a secretary or a nurse can register the admission type upon patient admission. Nurses carry the primary responsibility for patient registration, in the absence of a secretary; for example, the secretary is not available outside office hours. For reference, we conducted a medical record review (MRR). Therefore, concordance between the registered admission type and the admission type specified in the medical record was our outcome of interest. However, from the MMR, we only extracted the specification for the type of admission for each patient; i.e., acute or non-acute. Scheduled admissions were considered non-acute. No diagnostic criteria concerning the acuteness of the illness were used. Therefore, we did not evaluate the appropriateness of the specifications for acute admissions.

4.4.2 Reasons for acute medical admissions (Study II)

In study II, the primary diagnosis assigned upon discharge from the index admission was considered the main reason for admission. These diagnoses were grouped based on a single ICD-10 chapter, except for the infectious diseases. For the latter diagnosis, we combined chapters A and B of the ICD-10 and other infectious disease diagnoses that appear in the remaining organ-specific chapters. This resulted in a total of fourteen diagnostic groups. The diagnoses from the remaining chapters were grouped as "*Other*". These fifteen diagnostic groups were considered the exposure in study II (ICD-10 codes in Appendix II). Within these groups, different outcomes were examined, including the distributions of age, gender and comorbidity, the individual conditions specified in the Charlson Comorbidity Index and length of hospital stay.

We used the Charlson Comorbidity Index (CCI) score to examine the comorbidities associated with each diagnostic group.[51] The CCI score included 19 conditions, and we extracted data on each of these conditions from the DNRP.[104] The validity of the index conditions extracted from the DNRP is high.[105] We included all primary and secondary diagnoses recorded for the patient during previous visits to emergency rooms, outpatient specialist clinics, and inpatient stays over a five year period preceding the index date. The five year period was chosen to capture clinically significant chronic diseases. Additionally, we included all secondary diagnoses recorded for the patient during the index admission to capture newly diagnosed chronic diseases. The main limitation in the use of secondary diagnoses is that they may represent either a chronic condition present before admission, or a complication that occurred during the current hospital stay. See section 2.2.3 for discussion of this limitation. We computed CCI scores based on the weights assigned to each condition, and the scores were divided into three levels: low level (Index score 0), moderate level (Index score 1-2) and high level (Index score 3+) (ICD-10 codes of the CCI conditions in Appendix III).

The length of hospital stay was defined as the number of days between the index date and final discharge, including intra- and inter-hospital transfers.

4.4.3 Variation in timing of admissions and mortality (Study III)

In study III, the exposure was the time of admission. We defined four time periods; weekday office hours, weekday off-hours, weekend daytime hours, and weekend night-time hours. Weekday office hours were from Monday to Friday from 8:00 am to 4:59 pm. Weekday off-hours were from Monday to Friday from 5:00 pm to 7:59 am, except Friday night from 10:00 pm-11:59 pm and Monday morning from 12:00 am to 7.59 am, which were considered part of the weekend. Weekend daytime hours were Saturday and Sunday from 9:00 am to 9:59 pm. Weekend night-time hours were Saturday and Sunday from 10:00 pm to 11:59 pm, and from 12:00 am to 8:59 am plus Friday night from 10:00 pm to 11:59 pm, and Monday morning from 12:00 am to 7:59 am. Public holidays, *e.g.*, Easter and Christmas, were considered weekend days.

The outcomes in study III were the admission rate and the all-cause, 30-day mortality rate. Admission rates were computed hourly according to the time of admission. Only 30-day mortality rates were examined, because we assumed that the time of admission would be most strongly associated with short-term mortality. To address the inherent heterogeneity of the cohort, we stratified the cohort by the common conditions among medical patients that required acute care. The 20 most common conditions were: pneumonia, erysipelas, bacteremia/sepsis, urinary tract infection, anemia, diabetes, dehydration, alcohol intoxication, transient ischemic attack, angina, acute myocardial infarction, atrial fibrillation, heart failure, hypertension, stroke, chronic obstructive pulmonary disorder, respiratory failure, gastroenteritis, syncope, and suspected acute myocardial infarction (ICD-10 codes in Appendix IV).

As a proxy for the severity of the diseases, we included an ICU admission as an outcome. However, this approximation had a limitation, because an ICU admission also depended on the availability of an ICU bed.

4.5 Statistical analysis

Data were analyzed with the statistical software package STATA (version 11, Stata Corp., College Station, Texas, USA). Study I was approved by The Danish Data Protection Agency (record number 2006-53-1396). Studies II and III were also approved by the Danish Data Protection Agency (record number 1-16-02-1-08). Because these studies were based solely on data from administrative and medical databases, no further approval from the Ethics Committee was required.

4.5.1 Validity of the registration of the acute admission type in the DNRP (Study I)

A contingency table with the patient characteristics extracted from both the DNRP and the MRR were constructed. The concordance between the acute admission type in the DNPR and in the medical records was analyzed with estimates of the positive predictive value (PPV), sensitivity, and specificity with corresponding 95% confidence intervals

(CI).[106,107] We estimated the 95% CIs with Jeffrey´s method for a binomial proportion.[108] Table 4.1 outlines the estimations of PPV, sensitivity, and specificity. A high sensitivity of the variable "acute" was taken as a high probability that a patient acutely hospitalized was accurately registered as an acute admission in the DNRP. The positive predictive value (PPV) was the probability that a patient registered as an acute admission was specified for an acute admission in the medical record. The difference between sensitivity and PPV was the denominator, because the sensitivity is the number of true positives compared to all patients that were truly acutely admitted (thus, the false negatives [FN] were included in the denominator); in contrast, the PPV is the number of true positives compared to all patients that were registered as acute admissions (thus, the false positives [FP] were included in the denominator).[107]

Table 4.1. Estimation of PPV, Sensitivity, and Specificity

	Medical Record Review		
DNPR	Acute	Non-acute	
Acute	True Positive (TP)	False Positive (FP)	TP+FP
Non-acute	False Negative (FN)	True Negative (TN)	TN+FN
	TP+FN	FP+TN	
		PPV = (TP/TP+FP) Sensitivity = (TP/TP+FN) Specificity = (TN/TN+FP)	

In a subgroup analysis, we restricted the analysis to medical patients that arrived through the emergency room, because they were expected to be classified *a priori* as acute admissions. In a sensitivity analysis, we used information from the DNRP on the date of referral and the date of admission, because they were expected to be similar for acute admissions and different for non-acute admissions.

4.5.2 Reasons for acute medical admissions (Study II)

The overall characteristics of the cohort were collected from the DNRP. Within the 15 primary diagnostic groups, we determined the distributions of age, gender, CCI score, each of the individual conditions described by the CCI scores, and the length of hospital stay. Transfers were analyzed separately for those transferred within the first day and those transferred during the entire hospital stay. The transfers were also separated into those transferred from a department of internal medicine and those transferred from acute admission units. The patients with non-specific diagnoses (R- and Z- diagnoses) were described by their individual diagnoses. Furthermore, we identified the transfers in these groups and examined the primary diagnosis assigned in the second department. Finally, the primary diagnostic groups were stratified by the medical department to examine departmental distributions.

4.5.3 Variation in timing of admissions and mortality (Study III)

We computed the proportions of medical patients that required acute care for each admission time. The admission times were grouped as follows: weekday office hours, weekday off-hours, weekend daytime hours, and weekend night-time hours. For each time group, we collected data on age, gender, CCI score, marital status, source of admission, length of hospital stay, and the 20 common conditions. The hourly admission rates were computed over all patients, and for subgroups of patients with each of the 20 common conditions. The patients were followed from the index date to the date of death from any cause, emigration, or 30 days after the index date, whichever came first.

To compute comparable 30-day mortality rates for different times of admission, we used direct standardization.[109] As our standard population we used the patients admitted during weekday office hours. That is, for each of the times of admission, we estimated what would have been the 30-day mortality rate in our standard population if the age-sex specific rates equaled those of the time period of interest. The age- and sex standardized mortality rate was estimated in each subgroup of common conditions. In addition, we examined the standardized 30-day mortality rate for each of the three levels of comorbidity for each time of admission. A sensitivity analysis examined the association between time of admission and mortality rate without the exclusion of the patients with an inpatient stay on the index date or the 30 days preceding the index date.

Associations were examined between the time of admission and the number of admissions to the ICU within three days of the index date or during the whole hospital stay. In a competing risk model analyzing the cumulative incidence of ICU admissions within three days and 30 days after the index date, death was included as a competing risk. In a subgroup analysis of the medical patients admitted through the emergency room, the hourly admission rate, the standardized 30-day mortality rate, and the proportion of patients admitted to the ICU were analyzed according to the time of admission.

5. Results

5.1 Validity of the registration of the acute admission type in the DNRP (Study I)

5.1.1 Characteristics

All 160 sampled inpatients were registered as either an acute or a non-acute admission in the DNPR. Of these, 128 (80.0%) were registered as acute. The medical records of two patients could not be located. These patients were excluded in the computation of PPV, sensitivity, and specificity. The medical patients that required acute admission were slightly younger and the proportion of females was higher compared to those admitted non-acutely. (Table 5.1)

Table 5.1 Characteristics of 158 medical hospital admissions in the North Denmark Region in 2009

	Acute (n=127)	Non-acute (n=31)
	no (% of group)	
Gender		
Women	64 (50.4)	10 (32.3)
Men	63 (49.6)	21 (67.7)
Age, years		
Median (IQR)	62 (49-80)	63 (52-69)
Smoking		
Never	46 (36.2)	11 (35.5)
Current	32 (25.2)	6 (19.4)
Former	32 (25.2)	9 (29.0)
Unknown	17 (13.4)	5 (16.1)
Alcohol Abuse		
Never	86 (67.7)	14 (45.2)
Current	9 (7.1)	0 (0.0)
Former	2 (1.6)	1 (3.2)
Unknown	30 (23.6)	16 (51.6)
Body Mass Index		
<18.5	3 (2.4)	0 (0.0)
>=18.5 and <25	25 (19.7)	6 (19.4)
>=25 and <30	16 (12.6)	7 (22.6)
>=30	23 (18.1)	7 (22.5)
Unknown	60 (47.2)	11 (35.4)

5.1.2 PPV, sensitivity, and specificity

Of the 127 medical patients registered as an acute admission, we confirmed that 124 were acutely admitted. Of the three non-confirmed acute admissions, one was rescheduled for the following day and two were scheduled admissions. Of the 31 medical patients registered as a non-acute admission in the DNPR, three should have been registered as an acute admission. All three were referred for an acute admission by their GPs. Table 5.2 displays the results of PPV, sensitivity, and specificity analyses.

Table 5.2. Estimation of PPV, Sensitivity, and Specificity

	Medical Record Review		
DNPR	Acute	Non-acute	In total
Acute	124	3	127
Non-acute	3	28	31
In total	127	31	158

	Results (95% Confidence Intervals)
PPV	97.6% (93.8%-99.3%)
Sensitivity	97.6% (93.8%-99.3%)
Specificity	90.3% (76.4%-97.2%)

5.1.3 Subgroup and sensitivity analysis

All 21 patients that arrived to the emergency room were correctly registered with an acute admission in the DNRP. The sensitivity analysis confirmed the results, except for one patient. In the medical record review, that patient was classified as non-acute, but the sensitivity analysis classified the record as acute, due to the concordance between the date of referral and the date of admission.

5.2 Reasons for acute medical admissions (Study II)

5.2.1 Characteristics

The study included 264,265 medical patients that required acute care. There were slightly more females than males (51.3%). The median age was 64 years (IQR: 47-77 years) (Table 5.3). As shown in Figure 5.1, the median age varied among the primary diagnostic groups. Half of the patients were referred directly to the departments, primarily by GPs. Forty-five percent of the patients had a moderate or high CCI score. The most prevalent CCI conditions were chronic pulmonary diseases (11.7%) and cerebrovascular diseases (9.9%). Two-thirds of the patients were distributed among four diagnostic groups: cardiovascular diseases (19.3%), non-specific Z-diagnoses (16.9%), infectious diseases (15.5%), and non-specific R-diagnoses (11.8 %). The single most frequent diagnosis among the 52,056 patients with cardiovascular diseases was atrial fibrillation (n=9,344). In the diagnostic group of infectious diseases, pneumonia was the most frequent diagnosis (n=14,563).

Table 5.3 Patient characteristics of medical patients that required acute care in 2010

Characteristics	Overall n=264,265
	n (%)
Gender	
Female	135,457 (51.3)
Male	128,808 (48.7)
Age group, years	
15 – 39	43,864 (16.6)
40 – 59	66,043 (25.0)
60 – 79	100,016 (37.9)
80+	54,342 (20.5)
Charlson Comorbidity Index (CCI) score	
Low (0)	145,156 (54.9)
Moderate (1-2)	83,987 (31.8)
High (3+)	35,122 (13.3)
Primary diagnosis	
Infectious diseases incl. pneumonia	40,865 (15.5)
Neoplasm	3,483 (1.3)
Hematological diseases	5,214 (2.0)
Endocrine, nutritional and metabolic disorders	12,925 (4.9)
Mental and behavioral disorders	7,755 (2.9)
Diseases of the nervous system	11,192 (4.2)
Diseases of the circulatory system	51,056 (19.3)
Diseases of the respiratory system	12,719 (4.8)
Diseases of the digestive system	10,186 (3.9)
Diseases of the musculo-skeletal system	9,560 (3.6)
Diseases of the genitourinary system	3,886 (1.5)
Injury and poisoning	16,508 (6.3)
Factors influencing health status and contact with health service	44,570 (16.9)
Symptoms and abnormal findings, not elsewhere classified	31,200 (11.8)
Other	3,146 (1.2)
Source of admission[a]	
Hospital departments	81,130 (30.7)
Outpatient clinics	14,172 (5.4)
Emergency rooms	64,397 (24.4)
Direct (e.g., referred from a GP)	132,119 (50.0)
Diseases in the Charlson Comorbidity Index	
Myocardial infarction	9,981 (3.8)
Congestive heart failure	17,616 (6.7)
Peripheral vascular disease	13,090 (5.0)
Cerebrovascular disease	26,204 (9.9)
Dementia	6,841 (2.6)
Chronic pulmonary disease	30,982 (11.7)
Connective tissue disease	8,286 (3.1)
Ulcer disease	7,326 (2.8)
Mild liver disease	7,843 (1.8)
Diabetes without end organ damage	23,526 (8.9)
Diabetes with end organ damage	13,895 (5.3)
Hemiplegia	1,060 (0.4)
Moderate to severe renal disease	9,723 (3.7)
Non-metastatic solid tumor	22,958 (8.7)
Leukemia	1,466 (0.6)
Lymphoma	2,698 (1.0)
Moderate to severe liver disease	1,713 (0.7)
Metastatic cancer	3,814 (1.4)
AIDS	473 (0.2)

[a]Sum is over 100%, because patients were recorded in more than one hospital location on the index date.

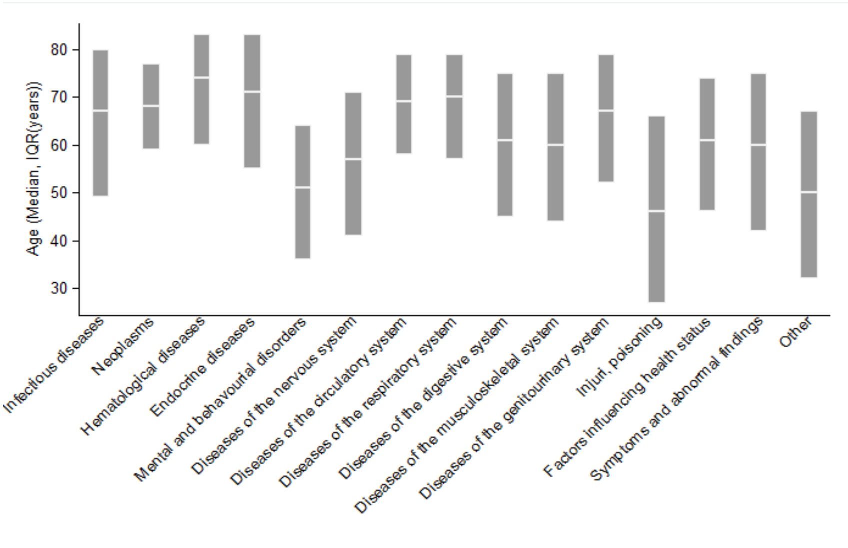

Figure 5.1 Median age and IQR in the primary diagnostic groups

5.2.2 Primary diagnostic groups

Gender, age group, and the CCI score distributions in the primary diagnostic groups are presented in Table 5.4. In only four primary diagnostic groups there was a male predominance, that is, neoplasms, mental and behavioral disorders, cardiovascular diseases, and genitourinary diseases. For patients with neoplasm, cardiovascular diseases, and respiratory diseases approximately 50% were in the 60-79-year age group. For eleven out of the fifteen primary diagnostic groups the majority of the patients had a low CCI score. We observed a high degree of correspondence between the primary diagnostic groups and the individual CCI conditions (Appendix V).

When examining the individual diagnoses among patients with R and Z diagnoses, we found that more than 85% of the non-specific Z-diagnoses were classified as Z03 diagnoses: "*Medical observation and evaluation for suspected diseases and conditions"* (n=38,010). Among the non-specific R-diagnoses, "Syncope and collapse" was the most frequent symptom (n=6,027). Appendix VI shows the primary diagnoses assigned after a transfer for patients with non-specific diagnoses. A surprisingly high proportion of patients were assigned a non-specific diagnosis again. Appendix VII shows that infectious diseases and non-specific diagnoses are prevalent in all type of departments of internal medicine.

5.2.3 Length of hospital stay and transfers

The overall median length of hospital stay was 2 days (IQR: 1-6 days), but this increased to 5 days (IQR: 2-12 days) among the 14% (n=37,299) of patients with an intra-hospital or inter-hospital transfer. The length of hospital stay increased with increasing age and increasing CCI score and varied for the type of departments of internal medicine (Table 5.5) A higher transfer rate was found for the patients admitted to acute admission units (37%) compared to the patients admitted to other hospital departments (8%). In total, 24,586 patients were transferred to a second department within the first day of admission, but only 7937 patients (3%) were transferred to a surgical department.

Table 5.4 Characteristics of the medical patients that required acute care in 2010 according to primary diagnostic group.

	Total	**Gender**		**Age groups (years)**				**CCI score**		
		Female	Male	15-39	40-59	60-79	80+	Low	Moderate	High
	n=264,265	n=135,457 (51.3 %)	n=128,808 (48.7 %)	n=43,864 (16.6 %)	n=66,043 (25.0 %)	n=100,016 (37.9 %)	n=54,342 (20.5 %)	n=145,156 (54.9 %)	n=83,987 (31.8 %)	n=35,122 (13.3 %)
Primary diagnosis	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Infectious diseases incl. pneumonia	40,865 (15.5)	21,238 (52.0)	19,627 (48.0)	6,792 (16.6)	8,189 (20.0)	15,075 (36.9)	10,809 (26.5)	19,289 (47.2)	14,644 (35.8)	6,932 (17.0)
Neoplasms	3,483 (1.3)	1,683 (48.3)	1,800 (51.7)	185 (5.3)	688 (19.8)	1,982 (56.9)	628 (8.0)	1,118 (32.1)	1,361 (39.1)	1,004 (28.8)
Hematological Diseases	5.214 (2.0)	2,994 (57.4)	2,220 (42.6)	449 (8.6)	843 (16.2)	2,047 (39.3)	1,875 (36.0)	2,044 (39.2)	1,994 (38.2)	1,176 (22.6)
Endocrine, nutritional, and metabolic disorders	12.925 (4.9)	7,224 (55.9)	5,701 (44.1)	1,498 (11.6)	2,425 (18.8)	4,729 (36.6)	4,273 (33.1)	4,845 (37.5)	5,282 (40.9)	2,798 (21.7)
Mental and behavioral disorders	7,755 (2.9)	3,180 (41.0)	4,575 (59.0)	2,219 (28.6)	3,027 (39.0)	1,734 (22.4)	775 (10.0)	5,325 (68.7)	1,899 (24.5)	531 (6.9)
Diseases of the nervous system	11,192 (4.2)	5,691 (50,9)	5,501 (49.1)	2,565 (22.9)	3,403 (30.4)	3,971 (35.5)	1,253 (11.2)	7,325 (65.5)	2,980 (26.6)	887 (7.9)
Diseases of the circulatory system	51,056 (19.3)	22,829 (44.7)	28,227 (55.3)	2,610 (5.1)	11,438 (22.4)	24,520 (48.0)	12,488 (24.5)	27,347 (53.6)	17,317 (33.9)	6,392 (12.5)
Diseases of the respiratory system	12,719 (4.8)	7,169 (56.4)	5,550 (43.6)	1,281 (10.1)	2,331 (18.3)	6,128 (48.2)	2,979 (23.4)	3,552 (27.9)	6,616 (52.1)	2,551 (20.1)
Diseases of the digestive system	10,186 (3.9)	5,384 (52.9)	4,802 (47.1)	1,829 (18.0)	2,941 (28.9)	3,676 (36.1)	1,740 (7.1)	5,553 (54.6)	2,982 (29.4)	1,651 (16.2)
Diseases of the musculo-skeletal system	9,560 (3.6)	5,529 (57.8)	4,031 (42.2)	1,779 (18.6)	2,883 (30.2)	3,164 (33.1)	1,734 (18.1)	6,262 (65.5)	2,481 (26.0)	817 (8.6)
Diseases of the genitourinary system	3,886 (1.5)	1,796 (46.2)	2,090 (53.8)	536 (13.8)	810 (20.8)	1,588 (40.9)	952 (24.5)	1,311 (33.7)	1,236 (31.8)	1,339 (34.6)
Injury, poisoning, and external causes	16,508 (6.3)	9,001 (54.5)	7,507 (45.5)	6,641 (40.2)	4,407 (6.7)	3,649 (22.2)	1,811 (11.0)	12,270 (74.3)	3,212 (19.6)	1,026 (6.2)
Factors influencing health status	44,570 (16.9)	23,057 (51.7)	21,513 (48.3)	7,250 (16.3)	13,55 (30.4)	16,433 (36.9)	7,330 (16.5)	26,952 (60.6)	12,980 (29.2)	4,638 (10.4)
Symptoms and abnormal findings	31,200 (11.8)	16,702 (53.5)	14,498 (46.5)	7,093 (22.7)	8,257 (26.5)	10,450 (33.5)	5,400 (17.3)	19,624 (62.9)	8,390 (26.9)	3,186 (10.2)
Other	3,146 (1.2)	1,980 (62.9)	1,166 (37.1)	1,137 (6.1)	844 (26.8)	870 (27.7)	295 (9.4)	2,339 (74.4)	613 (19.5)	194 (6.2)

Table 5.5 Length of hospital stay according to patient characteristics

Characteristics	Length of hospital stay, days Median (IQR)
Gender	
Female	2 (1-6)
Male	2 (1-6)
Age group, years	
15 – 39	1 (0.5-2)
40 – 59	1 (1-4)
60 – 79	3 (1-7)
80+	5 (1-10)
CCI-score	
Low (0)	1 (1-4)
Moderate (1-2)	3 (1-7)
High (3+)	4 (1-9)
Department type	
Department of neurology	3 (1-7)
Department of cardiology	1 (1-5)
Department of pulmonology	3 (1-7)
Department of gastroenterology	3 (1-7)
Department of nephrology	4 (1-9)
Department of rheumatology	2 (0.5-8)
Department of hematology	4 (1-8)
Department of endocrinology	2 (1-7)
Department of infectious diseases	2 (1-6)
Department of geriatric medicine	9 (7-16)
Department of general medicine	2 (1-6)
Acute medical admission unit	1 (0.5-5)
Source of admission*	
Non-medical hospital departments	0.5 (0.5-3)
Outpatient clinics	2 (1-7)
Emergency rooms	1 (1-5)
Direct (e.g. from general practitioner)	3 (1-7)
Primary diagnosis	
Infectious diseases incl. pneumonia	4 (2-8)
Neoplasm	7 (2-15)
Hematological diseases	2 (1-6)
Endocrine and nutritional diseases	3 (1-8)
Mental and behavioral disorders	1 (0.5-2)
Diseases of the nervous system	1 (1-4)
Diseases of the circulatory system	3 (1-7)
Diseases of the respiratory system	3 (1-7)
Diseases of the digestive system	3 (1-7)
Diseases of the musculo-skeletal system	2 (0.5-6)
Diseases of the genitourinary system	4 (1-9)
Injury, poisoning and other external causes	1 (0.5-2)
Factors influencing health status	1 (0.5-4)
Symptom, signs and abnormal findings	1 (0.5-3)
Other	1 (0.5-3)

o5.3 Variation in timing of admissions and mortality (Study III)

5.3.1 Characteristics

The study included 174,192 medical patients that required acute care, after exclusions. Table 5.6 shows the distribution and characteristics of the 174,192 patients at the time of admission. Patients admitted during weekday office hours tended to be older and had slightly higher CCI scores than patients admitted at other times. Weekend night-time was the only time period where more males (50.8%) than females were admitted. Outside of weekday office hours, the proportion of patients that arrived through the emergency room doubled.

5.3.2 Hourly admission rates

The hourly admission rates (patients per hour) were 38.7 (95% CI: 38.4-38.9) during weekday office hours, 13.3 (95% CI: 13.2-13.5) during weekday off-hours, 19.8 (95% CI: 19.6-20.1) during weekend daytime hours, and 7.9 (95% CI: 7.8-8.0) during weekend night-time hours (Table 5.7). Table 5.7 displays the admission rates in each of the common conditions, stratified by the time of admission. The admission rate was highest for patients with pneumonia in all four time periods. The admission rates for patients with anemia, diabetes, atrial fibrillation, and heart failure showed the largest decrease from weekday office hours to the other time periods. Some conditions, like alcohol intoxication, were associated with more consistent admission rates.

Table 5.6 Demographic and clinical characteristics by time of admission

	Weekday		Weekend	
	Office hours 8:00am-4:59 pm	Off-hours 5:00 pm-7:59 am	Day 9:00 am-9:59 pm	Night 10:00pm-8:59am plus Friday 10:00-11:59 pm and Monday 0:00-7:59 am
Overall	87,764 (50.4%)	43,312 (24.9%)	29,140 (16.7%)	13,976 (8.0%)
Age groups				
15-39	9,291 (10.6)	7,246 (16.7)	3,960 (13.6)	2,528 (18.1)
40-59	19,888 (22.7)	10,902 (25.2)	6,764 (23.2)	3,456 (24.7)
60-79	36,722 (41.8)	15,794 (36.5)	11,079 (38.0)	5,146 (36.8)
80+	21,863 (24.9)	9,370 (21.6)	7,337 (25.2)	2,846 (20.4)
Age, Median (years (IQR))	68 (54-79)	64 (47-78)	67 (51-80)	64 (46-77)
Gender				
Female	45,877 (52.3)	22,175 (51.2)	15,073 (51.7)	6,880 (49.2)
Male	41,887 (47.7)	21,1375 (48.8)	14,067 (48.3)	7,096 (50.8)
Charlson Comorbidity Index score				
0	49,384 (56.3)	25,710 (59.4)	16,647 (57.1)	8,055 (57.6)
1-2	27,302 (31.1)	12,687 (29.3)	8,996 (30.9)	4,267 (30.5)
3+	11,078 (12.6)	4,915 (11.4)	3,497 (12.0)	1,654 (11.8)
Marital status				
Married	40,881 (46.6)	18,719 (43.2)	12,794 (43.9)	6,358 (45.5)
Never married	14,140 (16.1)	9,206 (21.3)	5,364 (18.4)	2,981 (21.3)
Divorced	12,414 (14.1)	6,486 (15.0)	4,230 (14.5)	2,064 (14.8)
Widowed	20,325 (23.2)	8,904 (20.6)	6,751 (23.2)	2,573 (18.4)
Unknown	4	0	1	0
Admission source				
Hospital outpatient specialist clinic	5,781 (6.6)	2,251 (5.2)	1,139 (3.9)	541 (3.9)
Emergency room	13,225 (15.1)	14,492 (33.5)	8,810 (30.2)	4,618 (33.0)
Other	69,438 (79.0)	27,343 (63.1)	19,610 (67.3)	8,997 (64.4)
Length of hospital stay (Median (days (IQR)))	3 (1-7)	2 (1-7)	3 (1-7)	3 (1-6)
Common medical conditions				
Pneumonia	5,886 (6.7)	2,797 (6.5)	2,197 (7.5)	978 (7.0)
Erysipelas	991 (1.1)	513 (1.2)	367 (1.3)	125 (0.9)
Bacteremia/Sepsis	1,201 (1.4)	759 (1.8)	563 (1.9)	238 (1.7)
Urinary tract infection	1,944 (2.2)	996 (2.3)	740 (2.5)	300 (2.2)
Anemia	2,384 (2.7)	417 (1.0)	266 (0.9)	93 (0.7)
Diabetes	1,540 (1.8)	507 (1.2)	326 (1.1)	158 (1.1)
Dehydration	2,073 (2.4)	953 (2.2)	697 (2.4)	213 (1.5)
Alcohol intoxication	989 (1.1)	994 (2.3)	556 (1.9)	388 (2.8)
Transient ischemic attack	1,380 (1.6)	811 (1.9)	609 (2.1)	200 (1.4)
Angina	2,191 (2.5)	1,000 (2.3)	616 (2.1)	408 (2.9)
Acute myocardial infarction	2,274 (2.6)	1,317 (3.0)	997 (3.4)	694 (5.0)
Atrial fibrillation	3,707 (4.2)	1,170 (2.7)	889 (3.1)	354 (2.5)
Heart failure	1,645 (1.9)	535 (1.2)	300 (1.0)	207 (1.5)
Hypertension	1,173 (1.3)	487 (1.1)	329 (1.1)	136 (1.0)
Stroke	3,187 (3.6)	1,587 (3.7)	1,407 (4.8)	515 (3.7)
Chronic obstructive pulmonary disorder	2,869 (3.3)	1,273 (2.9)	926 (3.2)	545 (3.9)
Respiratory failure	1,120 (1.3)	559 (1.3)	414 (1.4)	224 (1.6)
Gastroenteritis	1,179 (1.3)	612 (1.4)	466 (1.6)	231 (1.7)
Syncope	1,554 (1.8)	1,195 (2.8)	865 (3.0)	336 (2.4)
Suspected acute myocardial infarction	3,719 (4.2)	2,304 (5.3)	1,455 (5.0)	712 (5.1)
Other	44,758 (51.0)	22,526 (52.0)	14,155 (44.6)	6,921 (49.5)

Abbreviation: IQR= interquartile range

Table 5.7 Hourly admission rates for 20 common medical conditions by time of admission.

	Weekday		Weekend	
	Office hours (8:00am-4:59 pm)	Off-hours (5:00 pm-7:59 am)	Day (9:00 am -9:59 pm)	Night (10:00 pm-8:59 am) plus Friday 10:00-11:59 pm and Monday 0:00-7:59 am
Overall	38.7 (38.4-38.9)	13.3 (13.2-13.5)	19.8 (19.6-20.1)	7.9 (7.8-8.0)
Common medical conditions				
Infectious diseases				
Pneumonia	2.60 (2.53-2.66)	0.86 (0.83-0.89)	1.50 (1.43-1.56)	0.55 (0.52-0.59)
Erysipelas	0.44 (0.41-0.47)	0.16 (0.14-0.17)	0.25 (0.22-0.28)	0.07 (0.06-0.08)
Bacteremia/septicemia	0.53 (0.50-0.56)	0.23 (0.22-0.25)	0.38 (0.35-0.42)	0.13 (0.12-0.15)
Urinary Tract Infection	0.86 (0.82-0.90)	0.31 (0.29-0.33)	0.50 (0.47-0.54)	0.17 (0.15-0.19)
Hematological Diseases				
Anemia	1.05 (1.01-1.09)	0.13 (0.12-0.14)	0.18 (0.16-0.20)	0.05 (0.04-0.06)
Endocrine and nutritional disease				
Diabetes	0.68 (0.65-0.71)	0.16 (0.14-0.17)	0.22 (0.20-0.25)	0.09 (0.08-0.10)
Dehydration	0.91 (0.88-0.95)	0.29 (0.27-0.31)	0.47 (0.44-0.51)	0.12 (0.10-0.14)
Mental and behavioral disorders				
Alcohol intoxication	0.44 (0.41-0.46)	0.31 (0.29-0.33)	0.38 (0.35-0.41)	0.22 (0.20-0.24)
Diseases of the nervous system				
Transient Ischemic Attack	0.61 (0.58-0.64)	0.25 (0.23-0.27)	0.41 (0.38-0.45)	0.11 (0.10-0.13)
Diseases of the circulatory system				
Angina	0.97 (0.93-1.01)	0.31 (0.29-0.33)	0.42 (0.39-0.45)	0.23 (0.21-0.25)
Acute Myocardial Infarction	1.00 (0.96-1.04)	0.41 (0.38-0.43)	0.68 (0.64-0.72)	0.39 (0.36-0.42)
Atrial fibrillation	1.63 (1.58-1.69)	0.36 (0.34-0.38)	0.61 (0.57-0.65)	0.20 (0.18-0.22)
Heart failure	0.73 (0.69-0.76)	0.16 (0.15-0.18)	0.20 (0.18-0.23)	0.12 (0.10-0.13)
Hypertension	0.52 (0.49-0.55)	0.15 (0.14-0.16)	0.22 (0.20-0.25)	0.08 (0.06-0.09)
Stroke	1.41 (1.36-1.45)	0.49 (0.46-0.51)	0.96 (0.91-1.01)	0.29 (0.27-0.32)
Diseases of the respiratory system				
Chronic Obstructive Pulmonary Disorder	1.26 (1.22-1.31)	0.39 (0.37-0.41)	0.63 (0.59-0.67)	0.31 (0.28-0.33)
Respiratory failure	0.49 (0.46-0.52)	0.17 (0.16-0.19)	0.28 (0.26-0.31)	0.13 (0.11-0.14)
Diseases of the digestive system				
Gastroenteritis	0.52 (0.49-0.55)	0.19 (0.17-0.20)	0.32 (0.29-0.35)	0.13 (0.11-0.15)
Symptoms and abnormal findings				
Syncope	0.69 (0.65-0.72)	0.37 (0.35-0.39)	0.59 (0.55-63)	0.19 (0.17-0.21)
Factors influencing health status				
Suspected Acute Myocardial Infarction	1.64 (1.59-1.69)	0.71 (0.68-0.74)	0.99 (0.94-1.04)	0.40 (0.37-0.43)
Other	19.7 (19.6-19.9)	6.93 (6.84-7.02)	9.64 (9.48-9.80)	3.90 (3.81-4.00)

5.3.3 30-day mortality rates

The age- and sex-standardized 30-day mortality rates were 5.1% (95% CI: 5.0-5.3%) for patients admitted during weekday office hours, 5.7% (95% CI: 5.5-6.0%) for patients admitted during weekday off-hours, 6.4% (95% CI: 6.1-6.7%) for patients admitted during weekend daytime hours, and 6.3% (95% CI: 5.9-6.8%) for patients admitted during weekend night-time hours (Table 5.8). For nearly all the common conditions, except urinary tract infection, hypertension and stroke, the highest mortality was associated with an admission during the weekend. The only condition, which had the highest mortality associated with an admission during weekday office hours, was urinary tract infection. For patients admitted with hypertension or stroke, the highest mortality was associated with an admission during weekday off-hours. Notably, for patients with stroke, there was substantially greater mortality associated with admissions during weekday off-hours compared to the mortality associated with weekday office hours (13.4 vs 9.2%). For patients with the conditions associated with the largest decrease in admission rates from weekday office hours to the other time periods, that is, patients with anemia, diabetes, atrial fibrillation, and heart failure, the mortality increased substantially from office hours to weekend hours.

A higher CCI score associated with a higher mortality, but in all three levels of the CCI score, the highest mortality was associated with an admission during weekend daytime hours (Table 5.8).

5.3.4 ICU admission

The proportion of patients admitted to an ICU within the first three days in hospital was highest for those admitted during the weekend night-time hours (4.4%). Lower proportions were observed for those admitted during the weekend daytime hours (3.2%), weekday off-hours (3.1%), and weekday office hours (2.0%) (Table 5.9). In Figure 5.2 the cumulative incidence of an ICU admission within 30 days after admission is illustrated, with death included as a competing risk.

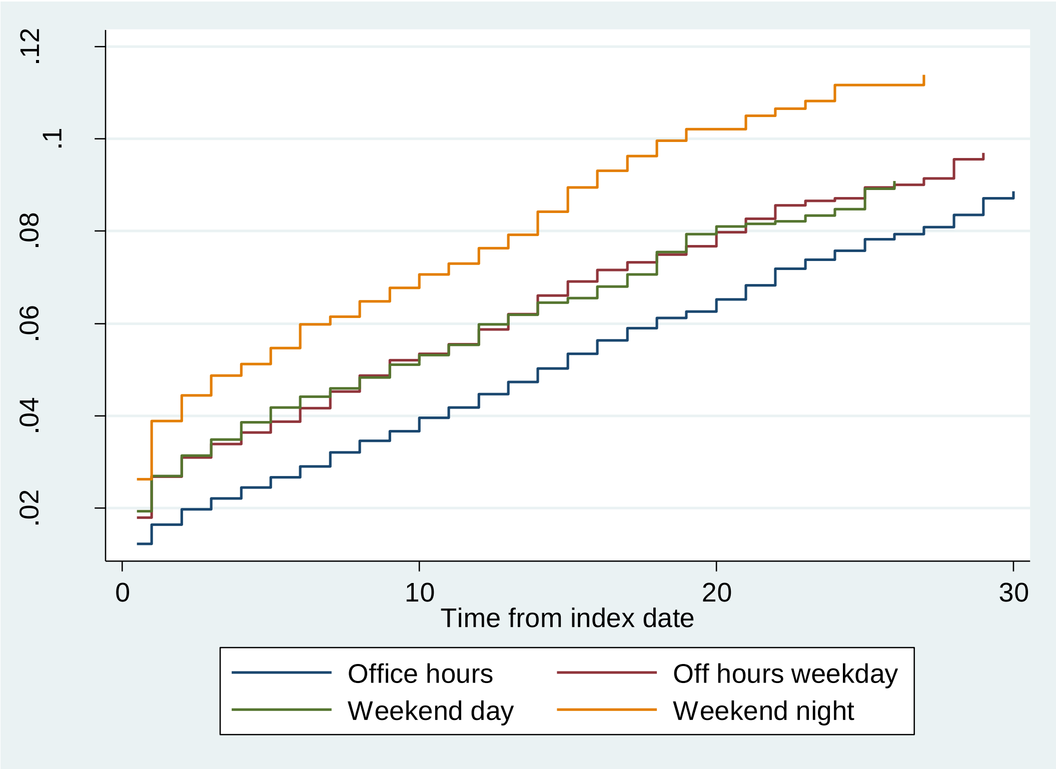

Figure 5.2 Analysis of ICU admissions in a competing risk model

5.3.5 Subgroup analysis and sensitivity analysis

In our subgroup analysis of patients admitted through the emergency room, the time of admission did not have a major effect on mortality or the number of ICU admissions (Appendix VIII).

In the sensitivity analysis where no patients were excluded, the age- and sex-standardized 30-day mortality rates were 5.0% (95% CI: 4.9-5.1%) for patients admitted during weekday office hours, 5.7% (95% CI: 5.5-5.9%) for patients admitted during weekday off-hours, 6.6% (95% CI: 6.4-6.8%) for patients admitted during weekend daytime hours, and 6.0% (95% CI: 5.6-6.3%) for patients admitted during weekend night-time hours. The exclusion primarily affected the mortality rates during weekend, where the mortality associated with an admission during daytime hours decreased while the mortality associated with an admission during nighttime-hours increased.

Table 5.8 Crude and age-and sex standardized 30-day mortality rates for the 20 common medical conditions by time of admission.

	Weekday			Weekend			
	Office hours (8.00 am-4.59 pm)	Off hours (5.00 pm-7.59 am)		Day (9.00 am-9.59 pm)		Night (10.00 pm-8.59 am) plus Friday 10.00-11.59 pm and Monday 0.00-7.59 am	
	Reference	Crude (%)	Adj. % (95%CI)	Crude (%)	Adj. % (95% CI)	Crude (%)	Adj. % (95% CI)
Overall	5.1 (5.0-5.3)	5.1	5.7 (5.5-6.0)	6.2	6.4 (6.1-6.7)	5.5	6.3 (5.9-6.8)
Low CCI score	3.2 (3.0-3.3)	3.2	3.8 (3.6-4.1)	4.1	4.3 (4.0-4.6)	3.4	4.2 (3.7-4.7)
Moderate CCI score	6.6 (6.3-6.9)	6.8	7.2 (6.7-7.6)	8.0	8.0 (7.4-8.5)	7.3	8.0 (7.1-8.8)
High CCI score	10.1 (9.5-10.7)	10.5	10.6 (9.8-11.5)	12.1	12.1 (11.0-13.1)	10.9	11.1 (9.6-12.7)
Infectious diseases							
Pneumonia	9.60 (8.9-10.3)	10.3	10.1 (9.0-11.2)	11.5	10.6 (9.4-11.8)	10.1	9.9 (8.1-11.7)
Erysipelas	1.61 (0.8-2.4)	1.6	1.8 (0.6-2.9)	1.6	2.1 (0.5-3.8)	1.6	2.3 (0.0-5.5)
Bacteremia/septicemia	20.6 (18.4-22.9)	20.2	20.1 (17.4-22.9)	19.7	18.9 (15.8-21.9)	26.5	27.1 (21.6-32.6)
Urinary Tract Infection	5.5 (4.5-6.5)	4.6	4.8 (3.5-6.2)	4.6	4.4 (3.0-5.8)	3.7	4.6 (2.0-7.2)
Hematological Diseases							
Anemia	4.4 (3.6-5.2)	6.2	6.5 (4.1-8.9)	7.9	8.0 (4.8-11.3)	8.6	9.2 (3.2-15.3)
Endocrine and nutritional disease							
Diabetes	1.6 (1.0-2.3)	1.8	1.7 (0.6-2.8)	2.8	2.5 (0.9-4.2)	1.3	1.2 (0.0-2.8)
Dehydration	11.1 (9.8-12.4)	11.0	11.3 (9.3-13.3)	12.5	12.4 (10.0-14.8)	9.9	10.3 (6.1-14.4)
Mental and behavioral disorders							
Alcohol intoxication	1.9 (1.1-2.8)	1.1	1.1 (0.5-1.8)	2.0	2.2 (1.0-3.5)	NA	NA
Diseases of the nervous system							
Transient Ischemic Attack	0.5 (0.1-0.9)	0.4	0.3 (0.0-0.7)	1.0	0.8 (0.2-1.5)	NA	NA
Diseases of the circulatory system							
Angina	1.8 (1.2-2.3)	1.00	1.1 (0.4-1.8)	1.5	1.5 (0.5-2.5)	2.7	2.9 (1.3-4.5)
Acute Myocardial Infarction	6.1 (5.1-7.0)	7.1	7.2 (5.8-8.6)	7.7	8.1 (6.4-9.8)	7.1	7.1 (5.2-8.9)
Atrial fibrillation	2.1 (1.6-2.5)	2.6	2.7 (1.8-3.7)	3.0	3.20 (2.0-4.4)	3.7	3.7 (1.8-5.6)
Heart failure	8.0 (6.7-9.3)	8.4	8.6 (6.2-11.0)	13.0	12.4 (8.7-16.1)	10.1	9.2 (5.5-12.9)
Hypertension	1.2 (0.6-1.8)	1.9	1.6 (0.6-2.7)	1.5	1.2 (0.2-2.3)	NA	NA
Stroke	9.2 (8.2-10.2)	13.3	13.4 (11.7-15.0)	12.7	12.2 (10.6-13.9)	11.5	11.9 (9.2-14.7)
Diseases of the respiratory system							
Chronic Obstructive Pulmonary Disorder	4.9 (4.1-5.7)	4.9	5.1 (3.9-6.3)	6.6	6.6 (5.0-8.2)	6.1	6.8 (4.5-9.1)
Respiratory failure	23.2 (20.8-25.6)	23.4	24.0 (20.5-27.5)	28.5	28.1 (23.8-32.3)	22.8	24.9 (19.1-30.6)
Diseases of the digestive system							
Gastroenteritis	1.4 (0.8-2.1)	0.8	1.0 (0.1-1.9)	3.0	3.23 (1.6-4.9)	2.2	2.7 (0.4-5.1)
Symptoms and abnormal findings							
Syncope	0.6 (0.2-1.0)	1.0	1.1 (0.5-1.7)	0.9	0.8 (0.3-1.4)	0.9	1.2 (0.0-2.6)
Factors influencing health status							
Suspected Acute Myocardial Infarction	0.7 (0.4-0.9)	0.7	1.0 (0.5-1.5)	1.1	1.1 (0.6-1.7)	0.8	1.0 (0.2-1.8)
Other	4,3 (4.1-4.5)	4.1	4.8 (4.5-5.1)	5.0	5.5 (5.1-5.9)	4.23	5.3 (4.7-5.9)

Table 5.9 ICU admissions within three days after admission by time of admission

	Weekday		Weekend	
	Office hours (8:00am-4:59 pm)	Off-hours (5:00 pm-7:59 am)	Day (9:00 am -9:59 pm)	Night (10:00 pm-8:59 am) plus Friday 10:00-11:59 pm and Monday 0:00-7:59 am
	(% of group)	(% of group)	(% of group)	(% of group)
Infectious diseases				
Pneumonia	165 (2.8)	118 (4.2)	75 (3.4)	55 (5.6)
Erysipelas	2 (0.2)	2 (0.4)	1 (0.3)	1 (0.8)
Bacteremia/septicemia	132 (11.0)	84 (11.1)	68 (12.1)	29 (12.2)
Urinary Tract Infection	6 (0.3)	6 (0.6)	2 (0.3)	1 (0.3)
Hematological diseases				
Anemia	15 (0.6)	7 (1.7)	7 (2.6)	4 (4.3)
Endocrine and nutritional diseases				
Diabetes	52 (3.4)	31 (6.1)	28 (8.6)	18 (11.4)
Dehydration	8 (0.4)	7 (0.7)	4 (0.6)	0
Mental and behavioral disorders				
Alcohol intoxication	17 (1.7)	18 (1.8)	11 (2.0)	16 (4.1)
Diseases of the nervous system				
Transient ischemic attack	0	2 (0.3)	1 (0.2)	1 (0.5)
Diseases of the circulatory system				
Angina	25 (1.1)	14 (1.4)	11 (1.8)	7 (1.7)
Acute Myocardial Infarction	85 (3.7)	65 (4.9)	43 (4.3)	35 (5.0)
Atrial Fibrillation	23 (0.6)	8 (0.7)	8 (0.9)	2 (0.6)
Heart failure	27 (1.6)	29 (5.4)	13 (4.3)	12 (5.8)
Hypertension	3 (0.3)	3 (0.6)	1 (0.3)	1 (0.7)
Stroke	84 (2.6)	90 (5.7)	46 (3.3)	30 (5.8)
Diseases of the respiratory system				
Chronic Obstructive Pulmonary Disorder	91 (3.2)	65 (5.1)	44 (4.8)	37 (6.8)
Respiratory failure	152 (13.6)	74 (13.2)	81 (19.6)	38 (17.0)
Diseases of the digestive system				
Gastroenteritis	3 (0.3)	7 (1.1)	6 (1.3)	1 (0.4)
Symptoms and abnormal findings				
Syncope	4 (0.3)	8 (0.7)	3 (0.4)	3 (0.9)
Factors influencing health status				
Suspected Acute Myocardial Infarction	6 (0.2)	4 (0.2)	8 (0.6)	7 (1.0)
Other	860 (1.9)	691 (3.1)	462 (3.3)	323 (4.7)
Total (within three days)	1,760 (2.0)	1,333 (3.1)	923 (3.2)	521 (4.4)
Total (within length of hospital stay)	2,603 (3.0)	1,712 (4.0)	1,190 (4.1)	746 (5.3)
Competing risk model				
ICU admission (3 days)	2.2 (2.1-2.3)	3.4 (3.2-3.6)	3.5 (3.3-3.7)	4.9 (4.5-5.3)
ICU admission (30 days)	8.9 (8.3-9.5)	9.7 (8.9-10.6)	9.1 (8.2-10.0)	11.4 (10.0-12.9)

6. Discussion

6.1 Main conclusions

6.1.1 Study I: Validation of the acute admission type in the DNRP

The "acute" admission type registered in the DNRP had a high PPV, sensitivity, and specificity among medical patients. This finding implied that health care quality monitoring and future research on medical patients that require acute care can be performed confidently with the Danish high-quality medical registries.

6.1.2 Study II: Reasons for acute medical admission

The main reason for an acute admission among medical patients was cardiovascular disease. However, one quarter of the patients were admitted acutely based on a non-specific diagnosis. There was a considerable overlap between the reason for admission and the chronic diseases of the patients. In addition, the diagnostic groups varied considerably in median age, gender distribution, comorbidity level, and length of hospital stay.

6.1.3 Study III: Variation in timing of admissions and mortality

For all common conditions among medical patients admitted acutely, the hourly admission rate was highest during weekday office hours. However, the difference between weekday office-hour admission rates and the rates during weekday off-hours, weekend daytime hours, and weekend night-time hours varied substantially between conditions. Weekend admissions were associated with the highest mortality for the majority of conditions examined.

6.2 Main findings and comparison to existing literature

6.2.1 Study I: Validation of the acute admission type in the DNRP

We ascertained that the validity of the admission types registered for medical patients was acceptable. The registered acute admission type showed a high PPV, sensitivity, and specificity compared to those specified in the medical records. We could not assess any time trend, because we considered data from only one year. However, comparing our results with previous findings indicated that no changes occurred over time (Table 2.2). The high validity of the acute admission type is of crucial importance in establishing the national database of patients that require acute care; the initiation of data extraction from DNRP to this database is planned to begin in 2015.

6.2.2 Study II: Reasons for acute medical admission

This population-based study confirmed previous studies by showing that cardiovascular and infectious diseases were among the main reasons for admission to internal medicine departments.[41,42] In addition, we confirmed previous findings that a high proportion of patients admitted acutely had non-specific diagnoses.[44,65,66] The mechanism underlying this finding may be related to the prevalence of chronic diseases; in addition, organizational factors may play a role. Organizational factors include a high rate of transfer from acute medical admission units to specialized departments; a short hospital stay, which precludes the establishment of a final diagnosis; or inaccuracy in coding the diagnosis.

In accordance with increasing trends, we observed a high prevalence of atrial fibrillation/flutter and of pneumonia.[65,110,111] Both cardiovascular diseases and infectious diseases were highly prevalent among very old patients and patients with high CCI scores. The main limitation of previous studies was that they did not specifically investigate the CCI scores for the individual diagnostic groups.[41-44] Generally, we found that the diagnostic group overlapped with the corresponding CCI condition, which indicated that chronic diseases were associated with an increased risk of acute admission due to complications. Neoplasms were a rare reason for acute admission, but the coding system does not indicate whether the primary diagnoses are complications associated with a neoplasm; therefore, the prevalence of admissions related to neoplasms may be obscured.

In the identification of the study population, we decided to include acute admission units. The primary limitation of that decision was that some patients may have been surgical, rather than medical patients. Some acute admission units were not intended to treat only medical patients. However, in 2010, the majority of surgical patients were directly admitted to surgical departments. This practice was reflected in the rather low number of transfers to surgical departments during the first day.

According to WHO and Danish guidelines, the discharge diagnosis should be the primary reason for admission. [64,101] In the case of non-specific diagnoses, the discharge diagnosis describes the presenting complaint or the condition suspected to be associated with the presenting complaint. The urgency of an admission is often associated with the presenting complaint. In Danish medical registries, no data on the presenting complaint are included. Studies from the US have found limited concordance between the presenting complaint and the discharge diagnosis.[112,113] This limited concordance suggested that our approach of including the discharge diagnosis was preferable to including the presenting complaint. This approach increased the homogeneity of the diagnostic groups, and consequently, the data could better describe the pathway of clinical care, the costs, and the prognosis.

6.2.3 Study III: Variation in timing of admissions and mortality

This study was the first population-based study to analyze hourly admission rates and mortality rates associated with the time of admission for 20 common conditions among medical patients that required acute care. We found that the reasons for admission were different for patients admitted during office hours than for those admitted during off-hours and weekend hours. For example, the rate of acute admissions for anemia decreased tremendously outside of weekday office hours. Moreover, the mortality rate and risk of an ICU admission for patients with anemia more than doubled for acute admissions during the weekend. From this finding, one might infer that most patients that sought admission on the weekend were those with severe conditions.

Although the Danish healthcare system differs from those in other countries, our study lends support to previous evidence that a higher mortality was associated with acute admissions during the weekend.[47,80,84-97] All previous studies, except the previous Danish study, reported in-hospital mortality. [80] The present study examined mortality within 30 days after the index date, which assured no loss to follow-up due to discharge. The previous Danish study primarily aimed to examine the association between number of beds occupied in the departments of internal medicine and mortality. Secondarily, they aimed to examine the association between the time of admission, as a proxy for the staffing level, and mortality. Both staffing level and educational level of the staff are known to associate to mortality.[80,114-117]

The other previous studies identified a 3-42% increase in mortality associated with a weekend admission; in contrast, the previous Danish study identified a doubling in mortality associated with a weekend admission.[47,80,84-97] However, they provided no patient characteristics associated with the time of admission; in particular, they gave no information about age, reasons for admission, comorbidity, or severity of disease. The crude estimates were not provided and confidence intervals were not given for the adjusted estimates. Moreover, they did not consider an interaction between number of beds occupied and the time of admission. In contrast, our results are expressed in absolute measures, not relative. Our overall figures suggested that the mortality associated with acute admissions increased by approximately 20% for weekend admissions.

Our study lacked clinical data on the severity of disease, but included information on the proportion of patients admitted to the ICU. We found a higher proportion of ICU admissions during weekday off-hours and over the weekend compared to the proportion during weekday office hours, even in a competing risk model accounting for death as a competing risk. Our findings contrasted with those from previous US and Australian studies.[91,118] Both studies found that weekend admissions were not associated with a higher risk of ICU transfer. The US study was based on medical record reviews of 824 admissions to general medicine units.[91] However, we must take into account the differences in ICU settings between countries when making comparisons of ICU admission rates.[119] In support of the hypothesis that more patients with severe illnesses are admitted during the weekend, previous studies on stroke, a common disorder that requires acute care, found that the “weekend effect” disappeared after adjusting for deferred admissions and disease severity.[120-122]

By including weekday off-hours as a separate admission time period, we were able to discern important differences in patient characteristics. For example, the proportion of patients admitted through the emergency room increased dramatically during weekday off-hours compared to weekday office hours. The reasons could be associated with the unavailability of personal GPs for consultation, or it could be patient-related; for example, that the proportion of patients with severe diseases is larger among admission outside office hours than among admissions during office hours.

We also restricted the cohort in study III to first-time admissions; that is, no patient had been an inpatient within 30 days prior to the admission or on the day of admission. The majority of the excluded patients had been transferred on the day of admission. The assumption behind this restriction was that transferred patients may be subject to a different level of diagnostic criteria, and that substantial timing may be involved in the transfer. In the sensitivity analysis without exclusions the overall estimates of mortality only changed during weekend and the overall conclusion was the same; the highest mortality was associated with an admission during weekend.

6.3 Methodological considerations

When discussing the findings of an epidemiologic study, it is important to address the precision and validity of the results. Precision is associated with the random errors in a study; validity is associated with the selection bias, information bias, or confounding factors, which are the systematic errors introduced in a study.[123,124] The following discussion reviews the potential random and systematic errors in the presented studies.

6.3.1 Precision

All three studies estimated results with rather narrow confidence intervals, which indicated acceptable sample sizes. However, the stratified analyses in study III comprised reduced sample sizes; thus, random errors may have affected the results. Overall, random errors represented only minor threats to the interpretation of the results.

6.3.2 Selection bias

Selection bias is a systematic error that results from the inclusion and exclusion processes for selecting study participants. In etiological studies, the error occurs when the association between the exposure and the outcome differ between study participants and non-participants.[124] In all three studies employed in this thesis, the study populations were identified in high-quality medical databases that covered all hospital admissions nationwide.[30] Therefore, we considered the selection bias regarding catchment areas or patient demographics to be essentially negligible.

In study I, the study population was identified in one well-defined region of Denmark. The departments of internal medicine in this region are generally believed to be representative of the departments of internal medicine in the entire country. Therefore, the high validity of the acute admission type found among medical patients in this region claims to be generalizable to medical patients in the entire country. Consequently, no influence on our results was attributed to selection bias. In the medical record review process, we were able to retrieve more than 98% of the medical records, and missing records were assumed to be a random occurrence.

The DNRP includes a variable concerning the specialty of the departments. This specialty code is used, for example, when analyzing hospital statistics.[5] It was also used in a recent

Danish study on medical patients.[80] Nevertheless, the validity of this variable is unknown. In study II, we sought to avoid a potential selection bias by selecting the medical departments after a thorough review of all departments that admitted patients for acute care in 2010. Thus, we assumed that the selection bias associated with identification of the study population would have little or no influence. Selection bias may also be introduced via loss to follow-up; however, due to the descriptive cross-sectional design of study II, no selection bias associated with follow-up was introduced.

In study III, the study population was restricted to patients that had no acute admission within 30 days prior or on the day of admission. The main purpose of this restriction was to determine the prognosis of medical patients that required acute care, starting from entry into the hospital and ending with the final discharge, independent of prior clinical examinations and treatments. The majority of the excluded patients were transferred from a non-medical department on the day of admission. A sensitivity analysis found that independent from inclusion of transferred or readmitted patients, weekend was associated with the highest mortality rate. Finally, we used high-quality data from the CRS for mortality information; therefore, the loss to follow-up was considered negligible in this study.

6.3.3 Information bias

Information bias is a systematic error that arises from erroneous information about the variables. Briefly, in etiologic studies, when erroneous information about the exposure is associated with the outcome, or vice versa, the bias is said to be *"differential"*; conversely, when the erroneous information about the exposure is independent of the outcome, or vice versa, the bias is said to be *"non-differential"*.[124]

In study I, we confirmed that the admissions were acute, when "acute" was used in the admission note or when it was stated that the admission was unscheduled; but we did not evaluate the diagnostic criteria for the acuteness of the illness. Therefore, our conclusion depicted nothing about the appropriateness of the admissions, only the concordance between the DNRP and the medical records. Using a medical record review as a reference had some limitations. First, medical records are seldom uniform, and thus, interpretations prevail. Second, we employed only one reviewer, therefore, no inter-observer variability was assessed. Third, the reviewer was not blinded to the admission type registered in the DNRP. These limitations may have introduced some information bias, but there was a high consistency in the phrasing regarding the type of admission in the medical records; therefore, we expect these limitations to have little or no influence on the results.

In all three studies, only inpatients were included in the study population. An inpatient hospital admission cannot be defined in terms of the length of hospital stay or the extent of diagnostic work-up. The assignment of medical patients as inpatients or outpatients largely depends on the department policy. In addition, medical patients that died or received care only in the emergency room were not registered as inpatients; consequently, they were not included in our study population. This restriction may potentially have introduced an information bias. However, we believe the impact on the results, if any, would be negligible.

In study II, patient characteristics were analyzed at an individual level. The patients were assigned to the primary diagnostic groups based on the codes included in the ICD-10. The coding accuracy is an inherent limitation in administrative databases. We relied on physician accuracy in coding diagnoses at discharge, but the extent of diagnostic work-up or the presence of complications during admission may influence the coding employed. For example, for patients with neoplasms, the primary reason for admission may be coded based on a complication. This gives rise to questions about the consistency in coding practices. For other diagnoses, the accuracy in DNRP registration is known; for example, reasonably high accuracies were found for registering the diagnoses of COPD, syncope, and acute stroke.[125-127]

Comorbidity was assessed with the widely used CCI score. Nonetheless, the CCI score restricted the assessments of comorbidity to 19 conditions, and it did not include information on other frequent conditions, like hypertension, obesity, and atrial fibrillation. The coding was known to be highly accurate for the 19 conditions in the DNRP.[105] We chose to search the patient records over a five-year period prior to admission (‘look-back’) to detect chronic conditions. Moreover, we included secondary diagnoses in the CCI score to capture recently or newly diagnosed chronic conditions.

However, secondary diagnoses may reflect complications of the primary disease; thus, their usefulness was limited for indicating comorbid chronic diseases. Also, the primary diagnosis could be a chronic disease. In cases where chronic diseases were identified in both primary and secondary diagnoses, multimorbidity may be a more accurate term than comorbidity. The length of the 'look-back' period affected the completeness of the comorbidity determination.[73,74,128] The five-year period was a pragmatic choice intended to capture clinically significant morbidities. Therefore, the assessment of comorbidity may have inherently included some degree of misclassification, but this was expected to be independent from the primary diagnosis.

In study III, the exposure was the time of admission. The accuracy of the registered time of day was unknown. However, other administrative data in the DNRP is known to be highly accurate; therefore, we assumed that the registered time of day was reasonably accurate. An inaccurate registration of the time of admission may introduce information bias into our estimates, but we assumed that that bias would be minor because, the admission time periods included intervals of several hours. In addition, the time of admission was registered prospectively, independent of future events, such as death or ICU admission; thus, the potential bias would be non-differential.

The information on mortality within 30-days of admission was obtained from the CRS, which is updated daily and holds information on all Danish residents. The follow-up data were complete for all patients, which indicated that an information bias from a misclassification of mortality was unlikely.

As a proxy for disease severity, we reported the proportions of patients admitted to the ICU within three days of the index date. The ICU admission may be limited as a proxy for the severity of a disease, due to the influences of age and ICU bed availability. The number of patients admitted to the ICU decreases with patient age; however, the overall trend is that older patients are being admitted to the ICU, and age alone is no longer considered a reason for refusing an ICU admission.[129,130] Also, bed availability is positively associated with an ICU admission. Therefore, a possible misclassification of ICU admissions may be associated with the reduced number of ICU beds outside office hours, and this misclassification may have attenuated the results.

6.3.4 Confounding

Finally, confounding is a systematic error, where the effect from the exposure is confused with the effect from other variables, thus obscuring the estimate for the outcome of interest. In the context of confounding it is, however, important to specify that confounding is hypothesis specific. Confounders are defined based on empirical evidence or clinical knowledge. They can be accounted for in the study design or in the statistical analysis. The study design can minimize confounding with randomization, matching, restriction, or stratification. The statistical analysis can apply standardization or adjustments. All methods depend on accurately measured confounders.

In general, a confounding variable must fulfill three criteria: 1) it must be an independent risk factor for the outcome or a proxy for a cause; 2) its presence should be imbalanced among exposure groups; and 3) it should not be involved in the causal pathway; i.e., it should not be an intermediate between exposure and outcome.[124]

In study III, the exposure; time of admission was used as a marker of patient and organizational characteristics. For example, we identified that a higher proportion of the patients arrived through the emergency room and that a higher proportion of the patients received ICU care if they were admitted outside office hours. It is possible that the association between time of admission and mortality is confounded. We considered age and gender the primary confounders, therefore we directly standardized the mortality for all admission times to the age- and gender-distributions of patients admitted during weekday office hours. Another possible confounder was CCI score, but as Table 5.6 shows there were no major differences in CCI scores between the different times of admission. A supplementary analysis on the mortality associated with each level of CCI score according to the time of admission supported the overall conclusion; that is, the highest mortality was found during the weekend. Other known, but unmeasured confounders included disease severity and organizational factors, like staffing levels and availability of advanced treatment outside office hours. The DNRP did not contain any information on these confounders. Admission to the ICU was used as a proxy of disease severity (see the discussion on misclassification in 6.3.2).

Moreover, we stratified the cohort by the 20 most common conditions observed among medical patients that require acute care. Patients were stratified into specific diagnostic groups to create clinically relevant groups and to balance the distribution of possible confounders across all times of admission.

7. Future perspectives

The increasing number of patients that require acute care and the high degree of specialization among physicians that care for these patients present a challenge to the structure of acute hospital care. Therefore, more detailed research is warranted to guide health care planners.

This thesis adds to the current state of knowledge about medical patients that require acute care and the prospects of using the Danish medical registries in research focused on these medical patients. However, several questions remain unanswered.

- What proportion of patients is acceptable for discharge with a non-specific diagnosis?
- How should we define “inappropriate” in describing admissions that may be preventable?
- What is the prognosis of patients discharged with non-specific diagnoses?
- Can non-specific diagnoses predict specific diseases; e.g., cancer or cardiovascular disease?
- How does the organization of acute hospital care impact prognosis, for example “the weekend effect”?

Undoubtedly, we must accept that a proportion of medical patients that require acute care will be discharged with non-specific diagnoses, because these patients were admitted to the hospital to determine whether the acute symptoms were associated with a disease. However, the need for diagnostic tests to clarify a diagnosis greatly impacts the cost of health care service. To identify possible alternative health care services for “inappropriate” acute admissions, we need to define “inappropriate”. The international literature provides several definitions, but often, admissions are deemed “inappropriate” retrospectively.[131,132] Thus, to address this question, we need to evaluate the clinical pathway of the acute patients, from the initial symptoms to the outcome of interest, i.e. death, diseases/complications, discomfort, disability, and dissatisfaction. This includes research building the bridge between primary health care and secondary health care and back. Continuity of care has become more important than ever because of the increase in chronic conditions managed across this bridge.

An ongoing study that was inspired by our data has been designed to elucidate the prognosis of patients that received non-specific diagnoses; e.g., readmission, specific diagnoses. This study aims to identify unmet diagnostic needs for these patients. Future studies need to evaluate the association between prior non-specific diagnoses and diagnoses of neoplasm and cardiovascular diseases. An earlier diagnosis may prevent the disease to progress to the advanced stage and thereby improve the prognosis of the patients.

To meet the high burden of chronic diseases in the population of medical patients that require acute care, a generalist approach is warranted from health care personnel. In the future, we need studies that examine the clinical and prognostic impact of establishing acute medical admission units, which intend to take a generalist approach for treating patients. Similarly, to understand the weekend effect further, we need studies that examine the complex association between mortality and the different organizational models for care during office hours and outside office hours.

To conclude, the Danish medical registries may play a central role in providing data to facilitate prioritization, planning, and improvements in the quality of health care for medical patients that require acute care. The findings from these studies illustrated that many prognostic determinants must be brought into play to improve the prognosis of medical patients that require acute care.

8. Summary

In recent decades, Internal Medicine has become highly specialized. However, the specialty is currently challenged by the increasing numbers of acute admissions, the greater proportion of older patients, and the reorganization of the acute care setting. Thus, more knowledge about the broad population of patients that require acute admission to departments of internal medicine is needed to guide healthcare planning and to guide future research.

This thesis includes three clinical epidemiological studies focused on medical patients acutely admitted to internal medicine departments. We conducted the studies with data from the Danish population-based administrative and medical registries.

The aims of this thesis were: 1) to evaluate the validity of the registration of acute admissions among medical patients in the Danish National Registry of Patients (DNRP), by comparison with a medical record review as reference; 2) to describe the reasons for admission and the associated age, gender and Charlson Comorbidity Index score (CCI score); 3) to examine hospital admission rates and mortality for patients with common medical conditions according to the time of admission.

In study I, we identified 160 medical patients registered in the DNRP. We identified 158 medical records for these patients. We found that, among medical patients, the acute admission type was registered with a high positive predictive value, sensitivity, and specificity. The positive predictive value was 97.6% (95% CI: 93.8-99.3%), sensitivity was 97.6% (95% CI: 93.8-99.3%) and specificity was 90.3% (95% CI: 76.4-97.2%).

Study II included 264,265 medical patients that required acute admissions during 2010. The most common reasons for admission were cardiovascular diseases (19.3%), non-specific Z-diagnoses (16.9%), infectious diseases (15.5%), and non-specific R-diagnoses (11.8%). For the 45% of patients with a CCI score of one or greater, there was substantial overlap between the presence of chronic diseases and the reason for admission. The median age was 64 years (IQR: 47-77 years). The age, gender, comorbidity, and length of hospital stay varied considerably between the diagnostic groups.

In study III, we included 174,192 medical patients that required acute care. The admission rate (expressed in patients per hour) was 38.7 (95% CI: 38.4-38.9) during weekday office hours, 13.3 (95% CI: 13.2-13.5) during weekday off-hours, 19.8 (95% CI: 19.6-20.1) during weekend daytime hours, and 7.9 (95% CI: 7.8-8.0) during weekend night-time hours. Admission rates varied considerably among the different medical conditions, and changes in admission rates also varied across times of admission. The standardized 30-day mortality rates were 5.1% (95% CI: 5.0-5.3%) for patients admitted during weekday office hours, 5.7% (95% CI: 5.5-6.0%) for patients admitted during weekday off-hours, 6.4% (95% CI: 6.1-6.7%) for patients admitted during weekend daytime hours, and 6.3% (95% CI: 5.9-6.8%) for patients admitted during weekend night-time hours. In 17 out of the 20 medical conditions examined, weekend admissions were associated with higher mortality than weekday admissions.

In conclusion, this thesis has described important data for a cohort of medical patients that required acute care. These data can be used in future research, by physicians that provide acute hospital care, and by health care planners.

9. Dansk Resume

Intern Medicin er i det seneste årti blevet mere og mere subspecialiseret. Aktuelt udfordres specialet af flere akutte indlæggelser, flere ældre og af den igangværende omstrukturering af den akutte behandling med indførelsen af centrale akutmodtagelser. Set i det lys, er det nødvendigt med en bred viden om patientpopulationen; de akutte medicinske patienter. En viden der skal hjælpe i planlægningen af sundhedsvæsnet og guide den fremtidige forskning.

Denne afhandling er baseret på tre klinisk epidemiologiske studier der har hentet populationsbaserede data fra de danske nationale medicinske registre på akutte patienter, der har været indlagt på de interne medicinske afdelinger og akutmodtagelser.

Formålet med afhandlingen var 1) at evaluere validiteten af den variabel i landspatientregistret der beskriver akut indlæggelse blandt medicinske patienter, 2) at beskrive de primære årsager til den akutte indlæggelse og de associerede variable såsom alder, køn og kronisk sygdom, 3) at undersøge indlæggelsesrater og dødelighed for patienter med de mest almindelige medicinske sygdomme i forhold til indlæggelsestidspunktet.

I studie I identificerede vi 160 medicinske patienter i Landspatientregistret (LPR) af hvilke vi kunne lokalisere patientjournalerne på 158. Den overordnede validitet af den akutte indlæggelsesmåde blandt medicinske patienter var høj. Den positive prædiktive værdi for indlæggelsesmåden "akut" blandt medicinske patienter var 97.6% (95% CI 93.8%-99.3%), sensitiviteten var 97.6% (95% CI 93.8%-99.3%) og specificiteten var 90.3% (95%CI 76.4%-97.2%).

Studie II inkluderede en studiepopulation på 264,265 medicinske patienter indlagt akut på de medicinske afdelinger i løbet af 2010. De hyppigste årsager til indlæggelse var kardiovaskulære sygdomme (19.3%), uspecifikke Z-diagnoser (16.9%), infektionssygdomme (15.5%) og uspecifikke R-diagnoser (11.8%). For de cirka 45% af patienterne der havde registreret en eller flere kroniske sygdomme fandt vi et betydeligt overlap mellem de kroniske sygdomme og årsagen til indlæggelsen. Median alder var 66 år (IQR 47-77). Såvel alder, som køn, komorbiditet og indlæggelseslængde varierede betydeligt mellem de enkelte sygdomsgrupper.

I studie III blev 174,192 akutte medicinske patienter inkluderet. Indlæggelsesraten (indlagte patienter pr time) i tidsrummet mellem 8 og 17 på hverdage var 38.7(95% CI 38.4-38.9) og 13.3 (95% CI 13.2-13.5) i løbet af aften og nattetimerne på hverdage. I løbet af weekenden var indlæggelsesraterne henholdsvis 19.8 (95% CI 19.6-20.1) i dagtimerne og 7.9 (95% CI 7.8-8.0) i nattetimerne. Indlæggelsesraterne varierede betydeligt mellem sygdomsgrupperne. Den alders -og køns standardiserede 30-dages dødelighed var i samme tidsrum henholdsvis 5.1% (95% CI 5.0-5.3%), 5.7% (95%CI 5.5-6.0%), 6.4% (95%CI 6.1-6.7%) og 6.3% (95%CI 5.9-6.8%). For 17 ud a de 20 almindelige sygdomme blandt medicinske patienter var dødeligheden størst efter en indlæggelse i weekenden.

Denne afhandling har beskrevet vigtige data på de akutte patienter der modtages på de danske interne medicinske afdelinger. Denne viden kan anvendes i fremtidige studier, blandt personalet der arbejder med akutte medicinske patienter samt blandt sundhedsplanlæggere.

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APPENDICES

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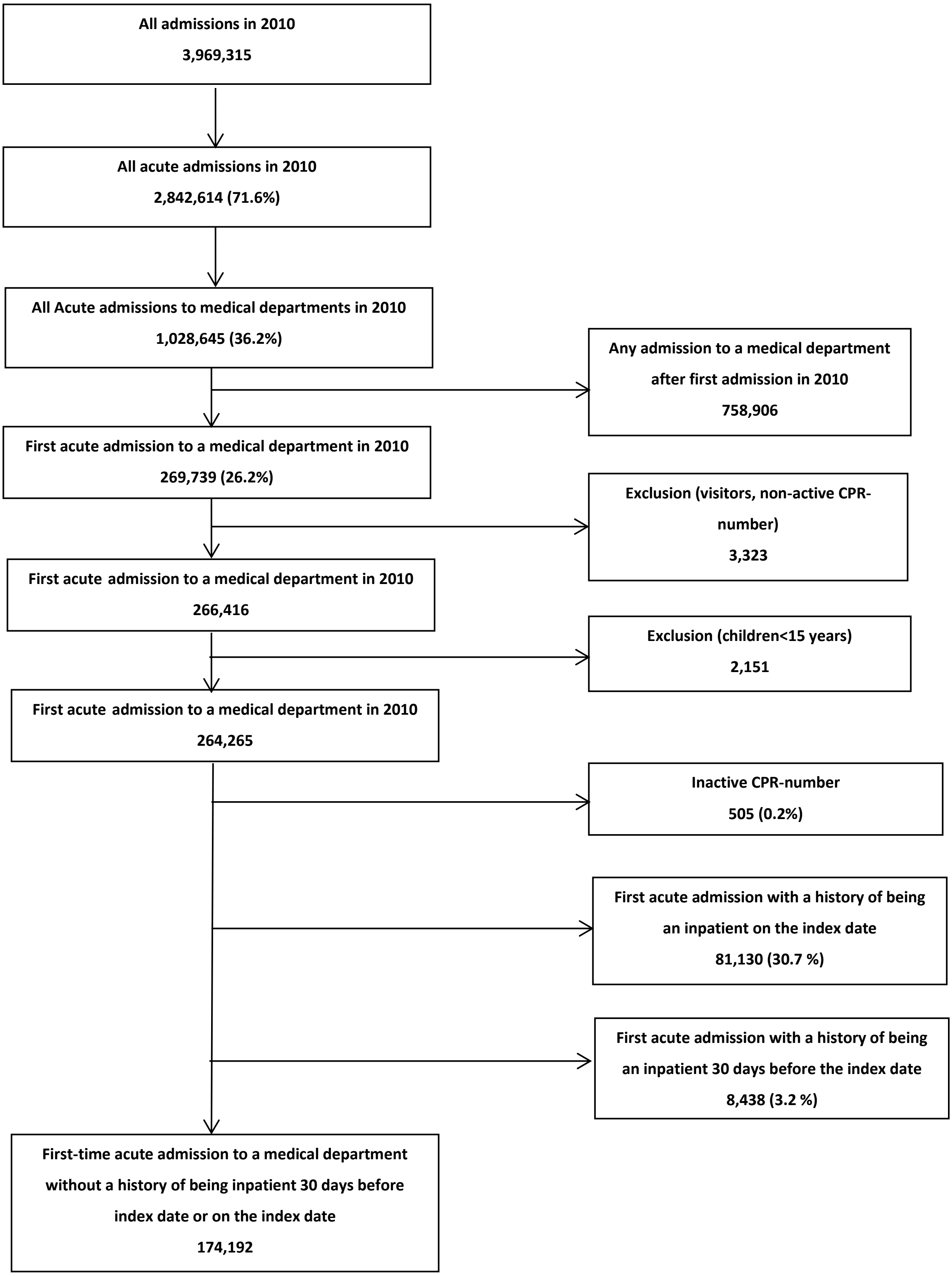
APPENDIX I:

Flowchart for the patients admitted to departments of internal medicine in 2010



Appendix II:
ICD-10 codes of each primary diagnostic group

Disease category	ICD-10
Infectious diseases	A00-B99
• Infections of the blood-forming organs	D73.3
• Infections of the endocrine organs	E06.0, E06.9, E32.1
• CNS infections	G00-G02, G04-07
• Infections of the eye, ear, and adnexa	H00, H01.0, H03.0-1, H04.0, H04.3, H05.0, H06.1, H10, H13.0-1, H15.0, H19.1-2, H22.0, H32.0, H44.0-1, H60.0-1, H60.3, H62.0-3, H65.0-1, H66.0-4, H66.9, H67.1, H67.8, H68.0 H70.2, H73.0, H75.0, H94.0
• Heart infections	I00-02, I30.1, I32.0-1, I33.0, I38, I39.8 I40.0, I41, I43.0, I52.0-1, I68.1, I98.1
• Respiratory tract infections	J00-J06, J09-J18, J20-22, J34.0, J36, J38.3D, J38.7G, J39.0-1, J39.8A, J44.0, J85.1-3, J86
• Infections of the digestive system	K04.0, K04.6-7, K05.2, K11.2-3, K12.2, K13.0A, K14.0A, K20.9A, K23.0-1, K35, K37, K57.0, K57.2, K57.4, K57.8, K61, K63.0, K65.0, K65.8I, K67, K75.0-1, K77.0, K80.0, K80.3-4, K81.0, K83.0, K85.9, K93.0-1
• Skin and subcutaneous infections	L00-03, L05-08, L88
• Infections of the musculo-skeletal system and connective tissue.	M00-01, M46.1-5, M49.0-3, M60.0, M60.8, M63.0-2, M65.0-1, M68.0, M71.0-1, M86.0-2, M86.9, M90.0-2
• Urinary tract infections	N10, N12, N13.6, N15.1, N16.0, N20.0I, N29.1, N30.0, N33.0, N34.0-1, N39.0
• Male genital infections	N41, N43.1, N45.0, N45.9, N48.1-2, N49
• Female genital infections	N61, N70-77
• Obstetrical infections	O23, O26.4, O41.1, O75.3, O85, O86, O88.3, O91, O98
• Infectious complications of procedure, catheters etc.	T80.2, T81.4, T82.6-7, T83.5-6, T84.5-7, T85.7, T88.0, T89.9
Neoplasms (Chapter II)	C00-D48
Diseases of the blood and blood-forming organs and certain disorders involved in the immune system (Chapter III)*	D50-D89
Endocrine, nutritional and metabolic disorders (Chapter IV)*	E00-E90
Mental and behavioral disorders (Chapter V)	F00-F99
Diseases of the nervous system (Chapter VI)*	G00-G99
Diseases of the circulatory system (Chapter IX)*	I00-I99
Diseases of the respiratory system (Chapter X)*	J00-J99
Diseases of the digestive system (Chapter XI)*	K00-K93

Diseases of the musculoskeletal system and connective tissue (Chapter XIII)*	M00-M99
Diseases of the genitourinary system (Chapter XIV)*	N00-N99
Injury, poisoning and certain other consequences of external causes (Chapter XIX)*	S00-T98
Factors influencing health status and contact with health services (Chapter XXI)	Z00-Z99
Symptoms and abnormal findings, not elsewhere classified (Chapter XVIII)	R00-R99
Other * i.e., Diseases of the eye and adnexa (Chapter VII)*, Diseases of the ear and mastoid process (Chapter VIII)*, Diseases of the skin and subcutaneous tissue (Chapter XII)*, Diseases associated with pregnancy, childbirth and puerperium (Chapter XV)*, Diseases originating in the perinatal period (Chapter XVI), and Congenital malformations (Chapter XVII)	H00-H95, L00-L99, O00-O99, P00-P99, T00-T99

*except infectious diseases within the chapter

APPENDIX III:

ICD-10 codes for the Charlson Comorbidity Index conditions

Charlson score of 1:	
Myocardial infarction	I21, I22, I23
Congestive heart failure	I50, I11.0, I13.0, I13.2
Peripheral vascular disease	I70, I71, I72, I73, I74, I77
Cerebrovascular disease	I60-I69, G45, G46
Dementia	F00-F03, F05.1, G30
Chronic pulmonary disease	J40-J47, J60-J67, J68.4, J70.1, J70.3, J84.1, J92.0, J96.1, J98.2, J98.3
Connective tissue disease	M05, M06, M08, M09, M30, M31, M32, M33, M34, M35, M36, D86
Ulcer disease	K22.1, K25-K28
Mild liver disease	B18, K70.0-K70.3, K70.9, K71, K73, K74, K76.0
Diabetes mellitus	E10.0-E10.2, E10.9, E11.0-E11.1, E11.9
Charlson score of 2:	
Hemiplegia	G81, G82
Diabetes with end organ damage	E10.2-E10.8, E11.2-E11.8
Any tumor	C00-C75
Leukemia	C91-C95
Lymphoma	C81-C85, C88, C90, C96
Charlson score of 3:	
Moderate to severe liver disease	B15.0, B16.0, B16.2, B19.0, K70.4, K72, K76.6, I85
Charlson score of 6:	
Metastatic solid tumor	C76-C80
AIDS	B21-B24

APPENDIX IV:

ICD-10 codes for the 20 common medical conditions among medical patients that required acute care

Pneumonia	J12-J18, A48.1, A70.9
Erysipelas	A46
Bacteremia/septicemia	A40-41, A02.1, A20.7, A21.7, A22.7, A22.9B, A26.7, A28.2B, A32.7, A39.2-4, A42.7, A49.9A, A54.8G, B37.7, B49.9A, J95.0A
UTI	N30, N34, N39.0
Anemia	D50-64
Diabetes	E10-14
Dehydration	E86
Alcohol Intoxication	F10
Transient ischemic attack	G45
Angina	I20, I24, I25
AMI	I21
AFLI	I48
Heart Failure	I50, I11.0, I13.0, I13.2
Hypertension	I10, D15
Stroke	I60-61, I63-64
COPD	J40-44, J47
Respiratory failure	J96
Gastroenteritis	A0
Syncope	R55
Suspected AMI	Z03.4

APPENDIX V: The 19 individual conditions in the Charlson Comorbidity Index according to each primary diagnostic group

	Total	AMI	CHF	PVD	CVD	DEM	CPD	CTD	ULD	MLD	DIA	DWE	HEM	SRD	NMT	LEU	LYM	SLD	MCA	AID
Primary diagnosis	n	% of diagnostic group																		
Infectious diseases incl. pneumonia	40,865	3.2	7.3	5.8	10.0	4.4	18.0	4.4	3.1	1.8	9.8	5.8	0.8	4.9	10.2	0.9	1.5	0.5	1.7	0.6
Neoplasms	3,483	2.0	3.7	4.8	7.1	1.2	9.4	2.7	2.5	1.4	6.6	3.0	0.3	3.1	25.8	9.1	20.2	0.6	9.3	0.2
Hematological Diseases	5.214	4.8	9.5	7.4	11.5	3.7	11.1	5.7	7.3	3.1	10.9	6.5	0.4	6.2	17.9	1.3	1.3	1.0	4.6	0.1
Endocrine, nutritional and metabolic disorder	12.925	3.6	8.0	6.5	12.7	5.9	8.8	3.5	4.0	2.0	25.9	16.9	0.3	6.0	12.1	0.3	0.7	0.7	2.2	0.1
Mental and behavioral disorders	7,755	1.3	2.1	2.1	7.4	3.8	6.9	1.0	3.4	5.5	4.9	2.7	0.2	1.3	3.6	0.1	0.2	1.7	0.5	0.1
Diseases of the nervous system	11,192	1.6	2.0	2.9	16.1	2.4	5.0	2.0	1.6	0.9	5.2	3.1	1.1	1.2	6.3	0.2	0.4	0.3	1.0	0.1
Diseases of the circulatory system	51,056	6.3	11.5	6.4	11.3	1.9	8.5	2.7	2.4	0.9	9.7	5.6	0.2	3.2	7.6	0.3	0.6	0.3	0.9	0.1
Diseases of the respiratory system	12,719	4.4	11.4	6.3	8.8	2.5	54.3	3.2	3.4	1.4	8.7	4.9	0.5	3.3	10.9	0.4	0.7	0.4	1.8	0.1
Diseases of the digestive system	10,186	2.7	4.5	4.9	7.8	1.9	8.7	2.7	5.9	9.0	8.7	4.7	0.3	3.5	9.1	0.3	0.6	5.0	1.6	0.1
Diseases of the musculo-skeletal system	9,560	2.4	3.7	3.7	6.1	1.1	7.8	7.1	2.3	1.0	6.0	3.3	0.3	2.6	6.2	0.3	0.6	0.3	0.6	0.1
Diseases of the genitourinary system	3,886	5.1	11.3	10.5	11.4	3.0	9.4	4.6	4.1	1.8	15.2	14.5	0.6	36.8	11.0	0.4	1.5	0.6	1.5	0.2
Injury, poisoning and external causes	16,508	1.4	2.6	2.4	5.0	1.5	5.8	1.8	1.6	1.9	4.4	2.4	0.2	1.7	4.5	0.5	1.0	0.5	0.6	0.2
Factors influencing health status	44,570	4.4	5.0	4.2	10.9	1.9	8.4	2.7	2.2	1.2	7.4	4.2	0.3	2.6	7.9	0.3	0.5	0.4	1.2	0.1
Symptoms and abnormal findings	31,200	2.8	4.2	3.7	8.7	2.2	7.6	2.7	2.4	1.5	6.8	3.5	0.3	2.3	8.9	0.5	0.7	0.5	1.8	0.1
Other	3,146	1.4	2.4	2.7	5.2	0.8	5.3	2.4	1.1	0.7	5.8	3.6	0.5	2.5	4.3	0.4	0.4	0.3	0.6	0.0
Total	264,265	3.8	6.7	5.0	9.9	2.6	11.7	3.1	2.8	1.8	8.9	5.3	0.4	3.7	8.7	0.6	1.0	0.7	1.4	0.2

Abbreviations: AMI=myocardial infarction, CHF=congestive heart failure, PVD=peripheral vascular disease, CVD=cerebrovascular disease, DEM=dementia, CPD=chronic pulmonary disease, CTD=chronic tissue disease, ULD=ulcer disease, MLD=mild liver disease, DIA=diabetes mellitus, DWE=diabetes with end organ damage, HEM=hemiplegia, SRD=moderate to severe renal disease, NMT=non metastatic tumor, LEU=leukemia, LYM=lymphoma, SLD=moderate to severe liver disease, MCA=metastatic solid tumor, AID=AIDS

APPENDIX VI: The most frequent diagnoses within the non-specific diagnostic group and the diagnoses assigned after transfer.

		Primary diagnoses assigned in the second department														
	Transfer	Infect.	Neopl.	Blood	Endocr.	Mental	Nervous	Circula.	Respir.	Digest.	Musc.	Genito.	Injury	Factors	Sympt.	Other
Abnormalities of breathing (R06)	275 (13.7)	39 (14.2)	20 (7.3)	6 (2.2)	8 (2.9)	2 (0.7)	2 (0.7)	59 (21.5)	52 (18.9)	3 (1.1)	2 (0.7)	4 (1.5)	4 (1.5)	20 (7.3)	52 (18.9)	2 (0.7)
Pain in throat and chest (R07)	303 (10.7)	12 (4.0)	1 (0.3)	1 (0.3)	2 (0.7)	0	2 (0.7)	98 (32.3)	3 (1.0)	6 (2.0)	7 (2.3)	1 (0.3)	3 (1.0)	77 (25.4)	88 (29.0)	2 (0.7)
Abdominal and pelvic pain (R10)	787 (30.4)	213 (27.1)	21 (2.7)	4 (0.5)	6 (0.8)	3 (0.4)	0	11 (1.4)	4 (0.5)	201 (25.5)	4 (0.5)	25 (3.2)	10 (1.3)	48 (6.1)	234 (29.7)	3 (0.4)
Other signs and symptoms involving the nervous and musculoskeletal system (R29)	289 (11.0)	38 (13.2)	11 (3.8)	3 (1.0)	22 (7.6)	14 (4.8)	18 (6.2)	38 (13.2)	8 (2.8)	5 (1.7)	12 (4.2)	4 (1.4)	8 (2.8)	40 (13.8)	61 (21.1)	7 (2.4)
Dizziness and giddiness (R42)	187 (7.9)	10 (5.4)	9 (4.8)	2 (1.1)	7 (3.7)	1 (0.5)	9 (4.8)	28 (15.0)	1 (0.5)	3 (1.6)	2 (1.1)	1 (0.5)	4 (2.1)	21 (11.2)	69 (36.9)	20 (10.7)
Fever of other and unknown origin (R50)	218 (14.1)	93 (42.7)	15 (6.9)	2 (0.9)	6 (2.8)	2 (0.9)	1 (0.5)	6 (2.8)	2 (0.9)	7 (3.2)	9 (4.1)	6 (2.8)	7 (3.2)	16 (7.3)	44 (20.2)	8 (0.9)
Headache (R51)	88 (4.7)	3 (3.4)	0	0	0	5 (5.7)	19 (21.6)	11 (12.5)	0	1 (1.1)	2 (2.3)	0	5 (5.7)	6 (6.8)	32 (36.4)	4 (4.6)
Pain, not elsewhere classified (R52)	208 (15.9)	13 (6.3)	21 (10.1)	2 (1.0)	7 (3.4)	1 (0.5)	2 (1.0)	26 (12.5)	8 (3.9)	8 (3.9)	30 (14.4)	3 (1.4)	10 (4.8)	38 (18.3)	38 (18.3)	1 (0.5)
Syncope and collapse (R55)	424 (7.0)	23 (5.4)	3 (0.7)	2 (0.5)	14 (3.3)	5 (1.2)	10 (2.4)	72 (17.0)	2 (0.5)	8 (1.9)	4 (0.9)	3 (0.7)	12 (2.8)	47 (11.1)	217 (51.2)	2 (0.5)
Total non-specific R diagnoses	3,846 (12.3)	526 (13.7)	204 (5.3)	39 (1.0)	126 (3.3)	69 (1.8)	109 (2.8)	464 (12.1)	97 (2.5)	335 (8.7)	87 (2.3)	77 (2.0)	96 (2.5)	405 (10.5)	1,156 (30.1)	56 (1.5)
Observation for suspected malignant neoplasm (Z031)	191 (13.2)	8 (4.2)	65 (34.0)	6 (3.1)	1 (0.5)	0	4 (2.1)	6 (3.1)	6 (3.1)	6 (3.1)	4 (2.1)	3 (1.6)	7 (3.7)	66 (34.6)	9 (4.7)	0
Observation for suspected nervous system disorder (Z033)	781 (24.5)	43 (5.5)	31 (4.0)	8 (1.0)	14 (1.8)	15 (1.9)	179 (22.9)	257 (32.9)	4 (0.5)	2 (0.3)	24 (3.1)	3 (0.4)	20 (2.6)	93 (11.9)	75 (9.6)	13 (1.7)
Observation for suspected myocardial infarction (Z034)	542 (4.5)	61 (11.3)	14 (2.6)	8 (1.5)	7 (1.3)	2 (0.4)	4 (0.7)	195 (36.0)	17 (3.1)	23 (4.2)	17 (3.1)	3 (0.6)	7 (1.3)	119 (22.0)	62 (11.4)	3 (0.6)
Observation for other suspected cardiovascular diseases (Z035)	379 (5.8)	50 (13.2)	15 (4.0)	5 (1.3)	7 (1.9)	4 (1.1)	9 (2.4)	119 (31.4)	13 (3.4)	16 (4.2)	12 (3.2)	0	19 (5.0)	83 (21.9)	23 (6.1)	4 (1.1)
Observation for other suspected diseases and conditions (Z038)	659 (17.6)	134 (20.3)	27 (4.1)	4 (0.6)	18 (2.7)	6 (0.9)	22 (3.3)	104 (15.8)	19 (2.9)	70 (10.6)	35 (5.3)	18 (2.7)	36 (5.5)	94 (14.3)	62 (9.4)	10 (1.5)
Observation for suspected disease or condition (Z039)	3,342 (31.3)	747 (22.4)	143 (4.3)	65 (1.9)	199 (6.0)	75 (2.2)	82 (2.5)	542 (16.2)	196 (5.9)	238 (7.1)	116 (3.5)	73 (2.2)	208 (6.2)	344 (10.3)	278 (8.3)	36 (1.1)
Total non-specific Z diagnoses	6,396 (14.4)	1,095 (17.1)	302 (4.7)	97 (1.5)	259 (4.1)	109 (1.7)	308 (4.8)	1,330 (20.8)	264 (4.1)	372 (5.8)	220 (3.4)	108 (1.7)	373 (5.8)	957 (15.0)	528 (8.3)	74 (1.2)

APPENDIX VII: The departments of internal medicine and reasons for admission

		Primary diagnostic group														
Departments of internal medicine	Total	Infect.	Neopl.	Blood	Endocr.	Mental	Nervous	Circula.	Respir.	Digest.	Musc.	Genito.	Injury	Factors	Sympt.	Other
Department of neurology	24,748 (9.4)	567 (2.3)	643 (2.6)	27 (0.1)	203 (0.8)	363 (1.5)	7,206 (29.1)	6,151 (24.9)	28 (0.1)	29 (0.1)	408 (1.7)	38 (0.2)	1,107 (4.5)	3,063 (12.4)	4,474 (18.1)	441 (1.8)
Department of cardiology	31,307 (11.9)	1,565 (5.0)	18 (0.1)	212 (0.7)	550 (1.8)	186 (0.6)	108 (0.3)	15,555 (49.7)	463 (1.5)	244 (0.8)	371 (1.2)	84 (0.3)	603 (1.9)	8,492 (27.1)	2,700 (8.6)	156 (0.5)
Department of pulmonology	8,436 (3.2)	2,966 (35.2)	133 (1.6)	82 (1.0)	138 (1.6)	108 (1.3)	53 (0.6)	270 (3.2)	2,207 (26.2)	119 (1.4)	176 (2.1)	55 (0.7)	315 (3.7)	1,078 (12.8)	661 (7.8)	75 (0.9)
Department of gastroenterology	5,653 (2.1)	985 (17.4)	118 (2.1)	224 (4.0)	344 (6.1)	272 (4.8)	50 (0.9)	303 (5.4)	99 (1.8)	1,524 (27.0)	124 (2.2)	66 (1.2)	459 (8.1)	500 (8.8)	528 (9.3)	57 (1.0)
Department of nephrology	3,122 (1.2)	628 (20.1)	13 (0.4)	60 (1.9)	152 (4.9)	55 (1.8)	16 (0.5)	216 (6.9)	62 (2.0)	79 (2.5)	99 (3.2)	998 (32.0)	130 (4.2)	376 (12.0)	193 (6.2)	45 (1.4)
Department of hematology	3,302 (1.3)	665 (20.1)	1,209 (36.6)	246 (7.5)	58 (1.8)	42 (1.3)	15 (0.5)	133 (4.0)	57 (1.7)	51 (1.5)	53 (1.6)	23 (0.7)	230 (7.0)	260 (7.8)	237 (7.2)	23 (0.7)
Department of infectious diseases	3,653 (1.4)	1,740 (47.6)	16 (0.4)	101 (2.8)	159 (4.4)	149 (4.1)	77 (2.1)	188 (5.2)	103 (2.8)	67 (1.8)	101 (2.8)	34 (0.9)	140 (3.8)	279 (7.6)	433 (11.9)	66 (1.8)
Department of endocrinology	10,863 (4.1)	2,385 (22.0)	47 (0.4)	236 (2.2)	1,528 (14.1)	677 (6.2)	198 (1.8)	660 (6.1)	379 (3.5)	263 (2.4)	634 (5.8)	104 (1.0)	861 (7.9)	1,432 (13.2)	1,284 (11.8)	175 (1.6)
Department of rheumatology	2,319 (0.9)	143 (6.2)	31 (1.3)	23 (1.0)	10 (0.4)	0	26 (1.1)	19 (0.8)	5 (0.2)	3 (0.1)	979 (42.2)	75 (3.2)	44 (1.9)	501 (21.6)	147 (6.3)	313 (13.5)
Department of geriatric medicine	900 (0.3)	90 (10.0)	12 (1.3)	46 (5.1)	39 (4.3)	30 (3.3)	18 (2.0)	60 (6.7)	8 (0.9)	15 (1.7)	255 (28.3)	3 (0.3)	18 (2.0)	260 (28.9)	43 (4.8)	3 (0.3)
Department of internal medicine	113,051 (42.8)	20,245 (17.9)	1,168 (1.0)	2,883 (2.6)	7,120 (6.3)	3,887 (3.4)	2,249 (2.0)	20,604 (18.2)	6,786 (6.0)	4,870 (4.3)	3,782 (3.4)	1,619 (1.4)	5,835 (5.2)	18,280 (16.2)	12,541 (11.1)	1,182 (1.1)
Acute medical admission unit	56,911 (21.5)	8,886 (15.6)	75 (0.1)	1,074 (1.9)	2,624 (4.6)	1,986 (3.5)	1,176 (2.1)	6,897 (12.1)	2,522 (4.4)	2,922 (5.1)	2,578 (4.5)	787 (1.4)	6,766 (11.9)	10,049 (17.7)	7,959 (14.0)	610 (1.1)
Total	264,265	40,865	3,483	5,214	12,925	7,755	11,192	51,056	12,719	10,186	9,560	3,886	16,508	44,570	31,200	3,146

APPENDIX VIII: Outcomes for the patients admitted through the emergency room

	Weekday		Weekend	
Emergency room patients	Office hours (8:00am-4:59 pm)	Off-hours (5:00 pm-7:59 am)	Day (9:00 am -9:59 pm)	Night (10:00 pm-8:59 am) plus Friday 10:00-11:59 pm and Monday 0:00-7:59 am
Total (n)	13,225	14,492	8,810	4,618
Hourly admission rate	5.8 (5.7-5.9)	4.5 (4.4-4.5)	6.00 (5.87-6.12)	2.60 (2.53-2.68)
Crude Mortality (%) Age- and sex standardized mortality (%)	5.9 (5.5-6.3)	4.8 5.5 (5.1-5.9)	5.9 6.2 (5.7-6.7)	4.8 6.0 (5.2-6.7)
ICU admission within 3 days n(%)	622 (4.7)	657 (4.5)	448 (5.1)	266 (5.8)

Study I

Clinical Epidemiology

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ORIGINAL RESEARCH

Registration of acute medical hospital admissions in the Danish National Patient Registry: a validation study

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Background: In recent years, the number of acute hospital admissions has increased and this has imposed both organizational and financial strains on the health care system. Consequently, it is of crucial importance that we have valid data on admission types in the administrative databases in order to provide data for health care planning and research.

Objective: To examine the validity of registration of acute admissions among medical patients in the Danish National Patient Registry (DNPR) using medical record reviews as the reference standard.

Methods: We used the nationwide DNPR to identify a sample of 160 medical patients admitted to a hospital in the North Denmark Region during 2009. Data on admission type was obtained from the DNPR and confirmed by a medical record review. We computed positive predictive values, sensitivity, and specificity including 95% confidence intervals (CI) using the medical record review as the reference standard.

Results: Among the 160 medical inpatients identified in the DNPR, 128 were registered with an acute admission, and 32 were registered with a nonacute admission. Two medical records could not be located. Thus, the analyses included 158 medical patients. Among the 127 patients registered with acute admission, 124 were confirmed to be correctly classified. Correspondingly, 28 of the 31 patients with a registered nonacute admission were confirmed to be correctly classified. The overall positive predictive value of the acute admissions among medical patients was 97.6% (95% CI, 93.8%–99.3%). Sensitivity was 97.6% (95% CI, 93.8%–99.3%) and specificity was 90.3% (95% CI, 76.4%–97.2%).

Conclusion: The registration of acute admission among medical patients in the DNPR has high validity.

Keywords: medical patients, registries, epidemiology, positive predictive value, sensitivity, specificity

Introduction

According to Statistics Denmark, acute admissions constitute approximately 70% of all admissions to hospitals in Denmark.[1] The total number of acute admissions has increased by 14% in a 5-year period from 2006 to 2010. A similar pattern is reported in many other parts of the world.[2–4] The rise in the number of acute admissions imposes both a substantial organizational challenge to and a considerable financial strain on the health care system.

Stratification by admission type is used in studies of prognosis, in the surveillance of health care quality, and in the reimbursement of hospital costs between the hospitals and the state. Valid data on the admission type are therefore pertinent from both an administrative and a research perspective.

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To our knowledge, only two national reports evaluating the admission type registered in the Danish National Patient Registry (DNPR) exist.[5,6] One was based on a random sample of 1094 hospital admissions in 1990.[5] The evaluation covered medical, surgical, gynecological, orthopedic, and pediatric departments at a national level. The acute admissions were correctly classified in 98.6% of the cases. More recently, a second report included a validation of the admission type across surgical and gynecology departments.[6] This report estimated a 3% misclassification in admission type. No validation study has specifically examined the registration of admission type in medical patients.

The aim of the present study is to examine the validity of the registration of acute admissions among medical patients in the DNPR using medical record review as the reference standard.

Method

Study design and setting

We conducted this cross-sectional validation study in the North Denmark Region, covering 580,000 inhabitants (10% of the total Danish population). The Danish population has unrestricted and unfettered access to tax-supported health care, guaranteeing equal access to treatment and hospital admission. The six hospitals in the region report all admissions to the DNPR.

Study population

We used the DNPR to identify a sample of 160 medical patients admitted to hospital in the North Denmark Region during 2009. Medical patients were defined as patients with an admission to any of the medical departments in the study area. In the DNPR, admission type is only registered for inpatients. The admission type is assigned by a secretary upon admission and is either acute or nonacute. Each year, the National Board of Health provides a guideline for correct registration. For the purpose of this study, oncology departments were not included because both surgical and nonsurgical cancer patients are referred to this department. The identified medical patients were admitted to15 different medical departments, of which nine were highly specialized departments.

The Danish National Patient Registry

The DNPR contains information on all hospital admissions to nonpsychiatric hospitals since 1977 and all hospital contacts to emergency rooms and outpatient clinics since 1995.[7] Information on the admission type has been included in the DNPR since 1987. Besides the admission type, other information includes dates of referral, admission, and discharge, data on the hospital and each department, diagnostic codes, and surgical procedures. Diagnostic codes include one principal diagnosis reflecting the main reason for hospital admission and up to 19 secondary discharge diagnoses coded according to the International Classification of Diseases (ICD), 8th revision until 1993 (ICD-8), and the 10th revision (ICD-10) thereafter. Diagnoses are assigned by the attending physician at the time of discharge. Each hospital electronically transfers administrative and clinical data from their patient administrative system to the DNPR. The DNPR is managed by the National Board of Health, and reporting to the DNPR is mandatory. Based on the Diagnosis Related Group system, information from the DNPR is extracted and used for the purpose of financial reimbursement between the hospitals and the state.

Medical record review

The unique personal identification number assigned to all Danish residents, as well as the hospital and department codes registered for the sampled medical inpatients, were used to retrieve the patients' medical records for review. Each medical record review was initiated with a verification of the patient's personal identification number and the date of hospital admission. All medical records were reviewed by the same physician (BVH). Through the review process, we confirmed the admissions to be acute if the attending physician used the word "acute" in the sentences concerning the type and reason for admission, or if it was stated that the admission was unscheduled. All scheduled admissions were considered nonacute admissions. Data on lifestyle factors are usually not available from administrative registries, but may be available from medical records. We therefore included data on smoking status, alcohol abuse (more than 14 or 21 standard drinks in 1 week for women and men, respectively), and weight and height in order to calculate body mass index (BMI) from the medical records to demonstrate availability of these variables. The misclassified acute and nonacute patients were described in terms of their specific characteristics.

Statistical analysis

We described the sample in terms of gender, age, smoking status, alcohol abuse, and BMI. Age was described with the median age and the associated interquartile range (IQR). The concordance between admission type in the DNPR and in the medical records was ascertained with estimates of the positive predictive value (PPV), sensitivity, and specificity with corresponding 95% confidence intervals (CI).[8] We estimated 95% CIs using Jeffrey's method for a binomial proportion.[9] Data collected through the medical record review were used as the reference standard.

To estimate the PPV of the registration of acute admissions in the DNPR, we computed the proportion of patients registered in the DNPR with an acute admission which was confirmed by medical record review (ie, the numerator was the number of patients registered with an acute admission in both data sources, and the denominator was the number of patients registered with an acute admission in the DNPR). Sensitivity was estimated with the numerator being the number of patients registered with an acute admission in both data sources, and the denominator being the total number of patients confirmed by medical record review to have an acute admission. The specificity was estimated with the numerator being the number of patients registered with a nonacute admission in both data sources, and the denominator being the total number of patients confirmed by medical record review to have a nonacute admission. Furthermore, we estimated PPV, sensitivity, and specificity for each hospital. In a subsequent analysis, we restricted the analysis to the medical patients arriving through the emergency room to confirm whether the patients were registered with an acute admission when becoming an inpatient. Sensitivity analysis using a different approach was conducted; it included data from the DNPR on the date of referral and date of admission, as the dates are expected to be the same for acute admissions and different for nonacute admissions. Data were analyzed with the statistical software package STATA (version 11; Stata Corp, College Station, TX, USA). The study was approved by The Danish Data Protection Agency (record number 2006-53-1396).

Results

Characteristics

Table 1 displays information on age, smoking, alcohol abuse, and BMI of the patients confirmed by the medical record review to be correctly registered with an acute or nonacute admission in the DNPR. The acute patients were slightly younger (median age of 62 years [IQR 49–80]), on average, than the nonacute patients (median age of 63 years [IQR 52–69]). Among the acute patients, 49.6% were males, in contrast to 67.7% of the nonacute patients. The medical records lacked data on smoking status for only 13.4% of the acute patients and for 16.1% of the nonacute patients. Data on weight and height in order to compute BMI was missing for 47.2% of the acute patients and for 35.4% of the nonacute patients. Data on alcohol abuse were missing for 23.6% of the acute patients and for 51.6% of the nonacute patients (Table 1).

Table 1 Characteristics of 158 medical hospital admissions in the North Denmark Region in 2009

Characteristics*	Medical hospital admission	
	N (% of group)	
	Acute (n = 127)	Nonacute (n = 31)
Sex		
Women	64 (50.4)	10 (32.3)
Men	63 (49.6)	21 (67.7)
Age, years		
Median	62	63
IQR	49–80	52–69
Smoking		
Never	46 (36.2)	11 (35.5)
Current	32 (25.2)	6 (19.4)
Former	32 (25.2)	9 (29.0)
Unknown	17 (13.4)	5 (16.1)
Alcohol abuse		
Never	86 (67.7)	14 (45.2)
Current	9 (7.1)	0 (0.0)
Former	2 (1.6)	1 (3.2)
Unknown	30 (23.6)	16 (51.6)
Body mass index		
<18.5	3 (2.4)	0 (0.0)
≥ 18.5 and <25	25 (19.7)	6 (19.4)
≥ 25 and <30	16 (12.6)	7 (22.6)
≥ 30	23 (18.1)	7 (22.5)
Unknown	60 (47.2)	11 (35.4)

Note: *Information collected through the DNPR and medical record review.
Abbreviations: N, number; IQR, interquartile range; DNPR, Danish National Patient Registry.

Medical record review process

All 160 sampled inpatients had a registration of either acute or nonacute admission in the DNPR. In total, 128 (80.0%) were registered as acute and 32 (20.0%) were registered as nonacute admissions in the DNPR. In the review process, two medical records could not be located and these admissions were therefore not included in the analysis. A flowchart of the medical record review process is outlined in Figure 1.

PPV, sensitivity, and specificity

The final study population, on which the estimates were computed, included 158 medical inpatients, of which 127 were registered in the DNPR with an acute admission and 31 with a nonacute admission. Of the 127 medical patients registered with an acute admission, we confirmed 124 to be an acute admission based on our review of the medical records. Among the three nonconfirmed acute

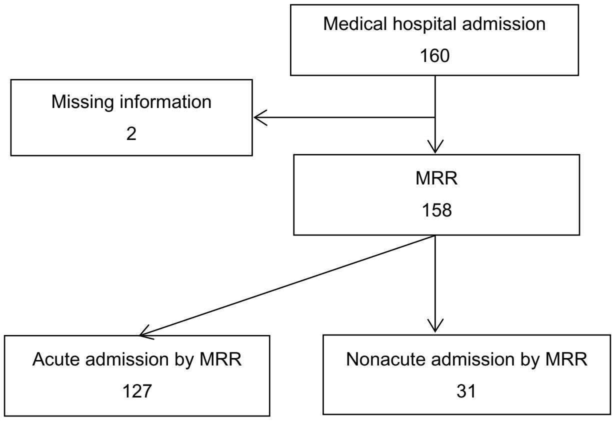

Figure 1 Flowchart of the medical record review (MMR) process.

admissions, one was rescheduled for the following day and two were scheduled admissions. Of the 31 medical patients registered with a nonacute admission in the DNPR, three should have been registered with an acute admission. All three were referred for an acute admission by their general practitioner. The overall PPV of acute admissions was 97.6% (95% CI, 93.8%–99.3%) when using the medical record review as the reference standard. Sensitivity was 97.6% (95% CI, 93.8%–99.3%) and specificity was 90.3% (95% CI, 76.4%–97.2%) (Table 2). The analysis stratified by each hospital did not yield any major differences in results (data not shown). When restricting the analysis to the 21 patients who visited the emergency room before admission, we confirmed that all 21 patients were correctly registered with an acute admission in the DNPR.

Among the six misclassified patients, one patient was transferred from another department during the course of the acute disease, which might explain the misclassification as a nonacute patient. No obvious explanations for the registration error of the remaining five misclassified patients could be found. The median age was 71 years for the misclassified acute patients (ie, patients with a nonacute admission in the DNPR confirmed to be acute admissions through the medical record review) compared with a median age of 62 years of the correctly classified acute patients. All of the misclassified acute patients were women. The characteristics of the misclassified nonacute patients (ie, patients with an acute admission in the DNPR confirmed to be nonacute admissions through the medical record review) were not different from those of the correctly classified patients. A sensitivity analysis comparing referral date and admission date registered in the DNPR confirmed the results from the review of the medical records except in one patient. This one patient was registered with an acute admission in the DNPR, but the medical record review showed that the patient had a scheduled admission. In the sensitivity analysis, the referral date was the same as the admission date, which confirmed the acute admission.

Table 2 Estimation of PPV, sensitivity, and specificity

DNPR[a]	Medical record review		
	Acute	Nonacute	In total
Acute	124	3	127
Nonacute	3	28	31
In total	127	31	158
	Results (95% confidence intervals)		
PPV (TP/(TP+FP))	97.6% (93.8%–99.3%)		
Sensitivity (TP/(TP+FN))	97.6% (93.8%–99.3%)		
Specificity (TN/(TN+FP))	90.3% (76.4%–97.2%)		

Note: [a]The Danish National Patient Registry.

Abbreviations: PPV, positive predictive value; DNPR, Danish National Patient Registry; TP, true positive; FP, false positive; FN, false negative, TN; true negative.

Discussion

In this validation study, we found a high PPV, sensitivity, and specificity of the registration of acute medical admissions in the DNPR. The variable for acute admissions is widely used, but to our knowledge no validation studies have previously been published. Our study has several strengths, including the use of the large and virtually complete registry, the DNPR, which allows individual-level linkage to other databases.[10–12] In addition, we were able to ascertain both sensitivity and specificity, because our sample of medical inpatients included both acute and nonacute admissions, and the sample size was sufficient to provide reasonable precision of the estimates.

Our study does, however, also have limitations. First, the medical record reviewer was not blinded to the admission type registered in the DNPR, which might have led to results that were more concordant than they truly are. Second, a medical record is not perfect or uniform. Nonetheless, consistency in phrasing was high regarding admission type since the admission type and reason for admission were often stated in the first sentence of the admission note. Third, no time trend in the reporting of acute and nonacute admissions is considered, as we only included data from 1 year. However, our results are quite similar to the findings in the previous report from 2004, which might indicate no major changes in the intervening 5-year period. Fourth, we included data from only one region in Denmark. This might limit generalizability to other regions or counties, although the region includes 15 different medical departments, which are likely representative of other medical departments in the country. All 15 medical departments received direct referrals from general practitioners.

Despite these limitations, our findings were confirmed by a sensitivity analysis showing that virtually all acute patients were admitted the same day as they were referred to hospital, and that all nonacute patients had a referral date prior to the admission date.

Our results are comparable to the previous results in terms of the correct classification of acute admissions in 97% and 98.6% of cases.[5,6] The latest validation of administrative data dates back to 2004 and includes only data from surgical and gynecology departments.[6] The first report from 1990 included data on medical patients, but the results are reported in an overall analysis and missing data on admission type are considered correctly classified, which may cause an overestimation of the data quality.[5]

The results of the present study show that the admission type registered in the DNPR is valid. Our study has important perspectives for future studies of acute medical admissions based on the DNPR.

Conclusion

In conclusion, we found that the registration of acute admission among medical patients in the DNPR has a high validity.

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Disclosure

The authors report no conflicts of interest in this work.

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Study II

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Original Article

Acute admissions to medical departments in Denmark: Diagnoses and patient characteristics

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ABSTRACT

Background: Despite extensive research on individual diseases, population-based knowledge about reasons for acute medical admissions remains limited. Our aim was to examine primary diagnoses, Charlson Comorbidity Index (CCI) score, age, and gender among patients admitted acutely to medical departments in Denmark.
Methods: In this population-based observational study, 264,265 acute medical patients admitted during 2010 were identified in the Danish National Registry of Patients (DNRP), covering all hospitals in Denmark. Reasons for acute admissions were assessed by primary diagnoses, grouped according to the *International Classification of Diseases 10th edition*. Additionally, the CCI score, age and gender were presented according to each diagnostic group.
Results: Two-thirds of the patients had one of the four following reasons for admission: cardiovascular diseases (19.3%), non-specific Z-diagnoses ("*Factors influencing health status and contact with health services*") (16.9%), infectious diseases (15.5%), and non-specific R-diagnoses ("*Symptoms and abnormal findings, not elsewhere classified*") (11.8%). In total, 45% of the patients had a CCI score of one or more and there was a considerable overlap between the patients' chronic diseases and the reason for admission. The median age of the study population was 64 years (IQR 47–77 years), ranging from 46 years (IQR 27–66) for injury and poisoning to 74 years (IQR 60–83) for hematological diseases. Gender representation varied considerably within the diagnostic groups, for example with male predominance in mental disorders (59.0%) and female predominance in diseases of the musculoskeletal system (57.8%).
Conclusion: Our study identifies that acute medical patients often present with non-specific symptoms or complications related to their chronic diseases.

1. Introduction

Acute medical patients comprise a high proportion of hospitalized patients, and they often present with complex problems and multiple chronic conditions [1,2]. Despite extensive research on individual diseases, population-based knowledge about reasons for acute medical admissions remains limited [3–5].

Two European studies have reported that cardiovascular diseases are the leading causes for admissions to departments of internal medicine [3,4]. However, both studies lacked detailed information on comorbidity, age, and gender according to diagnostic groups. The non-specific diagnoses from the Z-chapter of *the International Classification of Diseases 10th edition* (ICD-10) have been found to have a surprisingly high prevalence among acute admissions [6–8]. This reflects failure to classify the patients in specific diagnostic groups or failure to meet the patients' diagnostic or consultative needs.

Currently, services provided by inpatient medical departments face the challenge of demographic change. As the population ages, the prevalence of multiple chronic conditions is increasing [1,9]. Knowledge about reasons for acute medical admissions and associated comorbidity levels, age, and gender is important both for physicians in departments of internal medicine and acute medical admission units and for health-care planners.

We therefore conducted a population-based observational study of patients with acute admissions to inpatient medical departments in Denmark during 2010. We examined the primary diagnostic groups, Charlson Comorbidity Index (CCI) scores, age, and gender. In addition, we determined the source of admission, the length of hospital stay, and the distribution of individual conditions in the CCI, according to the primary diagnostic groups.

2. Methods

2.1. Study setting

We conducted this population-based observational study in Denmark using the Danish National Registry of Patients (DNRP), a national

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healthcare registry covering all hospitals [10]. Every Danish citizen is assigned a unique personal identification number at birth or immigration (CPR number), with embedded information on birth date and sex. These identifiers permit unambiguous individual-level linkage among all Danish population-based registries.

The Danish population (5,535,000 million people as of 1 January 2010) has unrestricted access to the tax-supported healthcare system, assuring equal access to specialist treatment and hospital care. Virtually all Danish citizens are under the care of general practitioners (GPs), who are responsible for referrals to outpatient specialist care or hospital admission. Thus GPs act as gatekeepers in the Danish health care system. Exceptions include patient contacts with hospital emergency rooms, which operate on a 24-hour basis, caring for patients who present on their own or by ambulance. These emergency facilities do not provide inpatient care [11].

2.2. Study population

The study included all adult (defined as age ≥ 15 years) medical inpatients with an acute hospital admission between 1 January and 31 December 2010, who were residents of Denmark at the time of admission. We examined only the first acute admission to a medical department in the study period (index admission).

We identified eligible patients through the DNRP, using the unique code for each medical department (general internal medicine and the subspecialties of neurology, cardiology, pulmonology, gastroenterology, nephrology, rheumatology, hematology, endocrinology, geriatric medicine, infectious diseases) and the acute medical admission units (AMAU), the admission date (index date), and acute admission type. It is mandatory for all hospitals to report to the DNRP, which is run by the National Board of Health. The DNRP has recorded all non-psychiatric admissions to hospitals since 1977 and all hospital contacts with emergency rooms and hospital specialist clinics since 1995. Hospital specialist clinics provide specialist outpatient services in virtually all fields of medicine. Hospitals report one primary diagnosis and up to 19 secondary diagnoses to the DNRP, according to the International Classification of Diseases, 10th edition. Before 1993 diagnoses were coded according to the International Classification of Diseases, 8th edition. Because the DNRP data are used for quality monitoring and government financial reimbursement to hospitals, the incentive to report all admissions is high.

2.3. Discharge diagnoses

According to Danish guidelines and those of the *World Health Organization*, the primary diagnosis assigned at hospital discharge should be the main reason for a patient's hospitalization [12,13]. We therefore described the distribution of primary diagnoses assigned at discharge from the index admission according to the chapters of the ICD-10 (detail is outlined in the online Supplementary Appendix A). We defined the diagnostic groups based on single ICD-10 chapters except for infectious diseases (chapters A and B), which were combined with diagnoses of infectious diseases in the remaining organ-specific chapters. The non-infectious diseases in the chapters of diseases of the eyes and ears, skin diseases, diseases associated with pregnancy, childbirth and puerperium, diseases originating in the perinatal period, and congenital malformations (chapters H, L, O, P, and Q) were merged into a single diagnostic group. The grouping of diagnoses in our analyses was chosen by a consensus among colleagues experienced in diagnostic coding.

2.4. Charlson Comorbidity Index score

We abstracted data from the DNRP on each of the 19 conditions included in the Charlson Comorbidity Index (CCI) and computed CCI scores using the weights assigned to each condition (see online Supplementary Appendix B for the ICD-10 codes of the CCI conditions) [14,15]. We computed the CCI score based on all primary and secondary diagnoses from the five years preceding the index date and on all secondary diagnoses from the index admission. The five year period was chosen to capture clinically significant chronic disease. For purposes of computing the CCI score, the following comorbid conditions were considered mutually exclusive: diabetes with chronic complications and diabetes without chronic complications; mild liver disease and moderate or severe liver disease; and any malignancy and metastatic solid tumor. We divided CCI scores into three levels; low level (Index score 0), moderate level (Index score 1–2), and high level (Index score 3+).

Table 1
Patient characteristics.

Characteristics	Overall n = 264,265 n (%)
Gender	
Female	135,457 (51.3)
Male	128,808 (48.7)
Age group, years	
15–39	43,864 (16.6)
40–59	66,043 (25.0)
60–79	100,016 (37.9)
80+	54,342 (20.5)
Charlson Comorbidity Index (CCI) score	
Low (0)	145,156 (54.9)
Moderate (1–2)	83,987 (31.8)
High (3+)	35,122 (13.3)
Primary diagnosis	
Infectious diseases incl. pneumonia	40,865 (15.5)
Neoplasm	3483 (1.3)
Hematological diseases	5214 (2.0)
Endocrine, nutritional and metabolic disorders	12,925 (4.9)
Mental and behavioral disorders	7755 (2.9)
Diseases of the nervous system	11,192 (4.2)
Diseases of the circulatory system	51,056 (19.3)
Diseases of the respiratory system	12,719 (4.8)
Diseases of the digestive system	10,186 (3.9)
Diseases of the musculoskeletal system	9560 (3.6)
Diseases of the genitourinary system	3886 (1.5)
Injury and poisoning	16,508 (6.3)
Factors influencing health status and contact with health service	44,570 (16.9)
Symptoms and abnormal findings, not elsewhere classified	31,200 (11.8)
Other	3146 (1.2)
Source of admission[a]	
Hospital departments	81,130 (30.7)
Outpatient clinics	14,172 (5.4)
Emergency rooms	64,397 (24.4)
Direct (e.g. from GP)	132,119 (50.0)
Diseases in the Charlson Comorbidity Index	
Myocardial infarction	9981 (3.8)
Congestive heart failure	17,616 (6.7)
Peripheral vascular disease	13,090 (5.0)
Cerebrovascular disease	26,204 (9.9)
Dementia	6841 (2.6)
Chronic pulmonary disease	30,982 (11.7)
Connective tissue disease	8286 (3.1)
Ulcer disease	7326 (2.8)
Mild liver disease	7843 (1.8)
Diabetes without end organ damage	23,526 (8.9)
Diabetes with end organ damage	13,895 (5.3)
Hemiplegia	1060 (0.4)
Moderate to severe renal disease	9723 (3.7)
Non-metastatic solid tumor	22,958 (8.7)
Leukemia	1466 (0.6)
Lymphoma	2698 (1.0)
Moderate to severe liver disease	1713 (0.7)
Metastatic cancer	3814 (1.4)
AIDS	473 (0.2)

[a] Adds up to more than 100% because patients can be seen in more than one hospital location during the index date.

2.5. Length of stay and source of admission

Length of hospital stay was computed as time from the index date to final hospital discharge, including in-hospital and inter-hospital transferals. Admissions occurring more than one day after a discharge were considered readmissions, and therefore not included as a transferal.

Source of admission was defined as a stay or a contact either with a hospital department (other than a medical department), a hospital specialist clinic, or an emergency room on the index date. The remaining patients were considered to be referred directly, primarily from GPs.

2.6. Statistical analysis

We characterized the overall distribution of the patients in the fifteen primary diagnostic groups, as well as patients' CCI score, age, gender, length of hospital stay, and individual conditions in the CCI according to the diagnostic groups. Additionally, we described the most frequent primary diagnostic groups among the very old (80+) and among patients with a high CCI score. We described the proportional distribution of patients by admission sources. Length of hospital stay was described according to patient characteristics. The proportion of patients transferred between departments was examined after stratifying by type of department, i.e., departments of internal medicine and acute admission units (short-stay units). Moreover, the proportion of patients transferred within the first day of admission to a surgical department was examined. Data were analyzed using the statistical software package STATA (version 11, Stata Corp., College Station, Texas, USA). The study was approved by the Danish Data Protection Agency (Central Denmark Region record number 1-16-02-1-08).

3. Results

3.1. Gender and age

We identified 264,265 patients admitted acutely to the 178 medical departments in Denmark in 2010. While the overall study population included 51.3% females (Table 1), gender distribution varied among the diagnostic groups, for example with male predominance in mental disorders (59.0%) and cardiovascular diseases (55.3%), and female predominance in diseases of the musculoskeletal system and connective tissue disorders (57.8%) and hematological diseases (57.4%) (Table 2).

The median age of the study population was 64 years (IQR 47–77 years), but as shown in Fig. 1 the median age differed by diagnostic group. The group with the fewest patients in the young age group (15–39 years) was cardiovascular diseases (5.1%), while the group with the highest proportion of patients in this age group was injury or poisoning (40.2%) (Table 2). The group with the predominant part of the patients aged 40–59 years was mental and behavioral disorders (39.0%). For eleven out of the fifteen diagnostic groups, the majority of patients were in the 60–79-year age group. The two diagnostic groups with the highest proportion of patients in the oldest age group (80+) were hematological diseases and endocrine, nutritional and metabolic disorders. However, when focusing on the diagnostic groups of the 54,342 elderly aged 80+, cardiovascular diseases (n = 12,488) and infectious diseases (n = 10,809) were the most prevalent.

3.2. Diagnostic groups

Table 1 illustrates the overall distribution of the diagnostic groups among the 264,265 patients admitted acutely to a medical department in Denmark in 2010. Two-thirds of the patients were in four diagnostic groups: cardiovascular diseases (19.3%), non-specific Z-diagnoses (*Factors influencing health status and contact with health services*) (16.9%), infectious diseases (15.5%), and non-specific R-diagnoses (*Symptoms and abnormal findings, not elsewhere classified*) (11.8%).

Table 2
Characteristics of the acute medical patients hospitalized in 2010 in Denmark according to primary diagnostic group.

	Total	Gender		Age groups (years)				CCI score		
	n = 264,265	Female n = 135,457 (51.3%)	Male n = 128,808 (48.7%)	15–39 n = 43,864 (16.6%)	40–59 n = 66,043 (25.0%)	60–79 n = 100,016 (37.9%)	80+ n = 54,342 (20.5%)	Low n = 145,156 (54.9%)	Moderate n = 83,987 (31.8%)	High n = 35,122 (13.3%)
Primary diagnosis	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Infectious diseases incl. pneumonia	40,865 (15.5)	21,238 (52.0)	19,627 (48.0)	6792 (16.6)	8189 (20.0)	15,075 (36.9)	10,809 (26.5)	19,289 (47.2)	14,644 (35.8)	6932 (17.0)
Neoplasms	3483 (1.3)	1683 (48.3)	1800 (51.7)	185 (5.3)	688 (19.8)	1982 (56.9)	628 (8.0)	1118 (32.1)	1361 (39.1)	1004 (28.8)
Hematological diseases	5.214 (2.0)	2994 (57.4)	2220 (42.6)	449 (8.6)	843 (16.2)	2047 (39.3)	1875 (36.0)	2044 (39.2)	1994 (38.2)	1176 (22.6)
Endocrine, nutritional and metabolic disorder	12.925 (4.9)	7224 (55.9)	5701 (44.1)	1498 (11.6)	2425 (18.8)	4729 (36.6)	4273 (33.1)	4845 (37.5)	5282 (40.9)	2798 (21.7)
Mental and behavioral disorders	7755 (2.9)	3180 (41.0)	4575 (59.0)	2219 (28.6)	3027 (39.0)	1734 (22.4)	775 (10.0)	5325 (68.7)	1899 (24.5)	531 (6.9)
Diseases of the nervous system	11,192 (4.2)	5691 (50,9)	5501 (49.1)	2565 (22.9)	3403 (30.4)	3971 (35.5)	1253 (11.2)	7325 (65.5)	2980 (26.6)	887 (7.9)
Diseases of the circulatory system	51,056 (19.3)	22,829 (44.7)	28,227 (55.3)	2610 (5.1)	11,438 (22.4)	24,520 (48.0)	12,488 (24.5)	27,347 (53.6)	17,317 (33.9)	6392 (12.5)
Diseases of the respiratory system	12,719 (4.8)	7169 (56.4)	5550 (43.6)	1281 (10.1)	2331 (18.3)	6128 (48.2)	2979 (23.4)	3552 (27.9)	6616 (52.09)	2551 (20.1)
Diseases of the digestive system	10,186 (3.9)	5384 (52.9)	4802 (47.1)	1829 (18.0)	2941 (28.9)	3676 (36.1)	1740 (7.1)	5553 (54.59)	2982 (29.39)	1651 (16.2)
Diseases of the musculoskeletal system	9560 (3.6)	5529 (57.8)	4031 (42.2)	1779 (18.6)	2883 (30.2)	3164 (33.1)	1734 (18.1)	6262 (65.5)	2481 (26.0)	817 (8.6)
Diseases of the genitourinary system	3886 (1.5)	1796 (46.2)	2090 (53.8)	536 (13.8)	810 (20.8)	1588 (40.9)	952 (24.5)	1311 (33.7)	1236 (31.8)	1339 (34.59)
Injury, poisoning and external causes	16,508 (6.3)	9001 (54.5)	7507 (45.5)	6641 (40.2)	4407 (6.7)	3649 (22.19)	1811 (11.0)	12,270 (74.3)	3212 (19.59)	1026 (6.2)
Factors influencing health status	44,570 (16.9)	23,057 (51.7)	21,513 (48.3)	7250 (16.3)	13,55 (30.4)	16,433 (36.9)	7330 (16.5)	26,952 (60.59)	12,980 (29.19)	4638 (10.4)
Symptoms and abnormal findings	31,200 (11.8)	16,702 (53.5)	14,498 (46.5)	7093 (22.7)	8257 (26.5)	10,450 (33.5)	5400 (17.3)	19,624 (62.9)	8390 (26.9)	3186 (10.2)
Other	3146 (1.2)	1980 (62.9)	1166 (37.1)	1137 (6.1)	844 (26.8)	870 (27.7)	295 (9.4)	2339 (74.4)	613 (19.5)	194 (6.2)

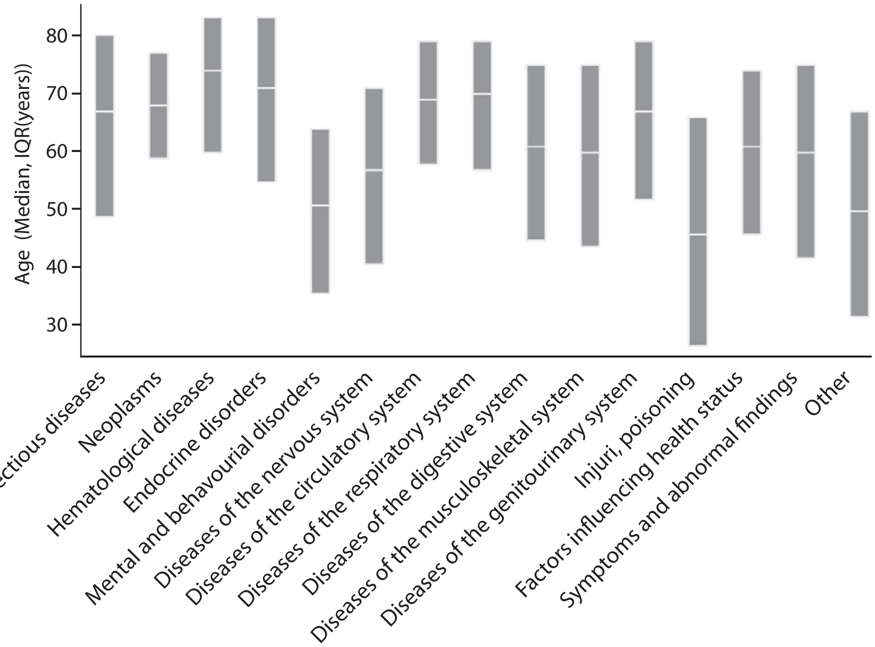

Fig. 1. Age in the primary diagnostic groups (median, IQR (years)).

Within these four groups, we examined the most frequent individual diagnoses using the ICD-10 codes, which are further detailed in online Supplementary Appendix C. Among the 52,056 patients with cardiovascular diseases, the most frequent diagnoses overall were ischemic heart diseases (n = 12,672) and cerebrovascular diseases (n = 9657), with atrial fibrillation representing the single most frequent diagnosis (n = 9344). Among individual non-specific Z-diagnoses most were Z03 diagnoses; "*Medical observation and evaluation for suspected diseases and conditions*" (n = 38,010). Among these 38,010 patients, 12,169 patients were suspected to have cardiovascular disease. Among infectious diseases, pneumonia was the most frequent disease (n = 14,563) and among the non-specific R-diagnoses, "Syncope and collapse" was the most frequent syndrome (n = 6027).

The remaining diagnostic groups represented from 1.2% to 6.3% of all patients. The most frequent individual diagnoses in these diagnostic groups are provided in the online Supplementary Appendix C. Neoplasms were rare as a primary diagnosis for acute admissions (1.3%), although complications or symptoms of neoplasms may be coded in other diagnostic groups.

3.3. Charlson Comorbidity Index score

Forty-five percent of the patients had a moderate or high CCI score, based both on diagnoses within five years before the acute admission and on secondary diagnoses during the index admission (Table 1). When secondary diagnoses from the index admission were excluded

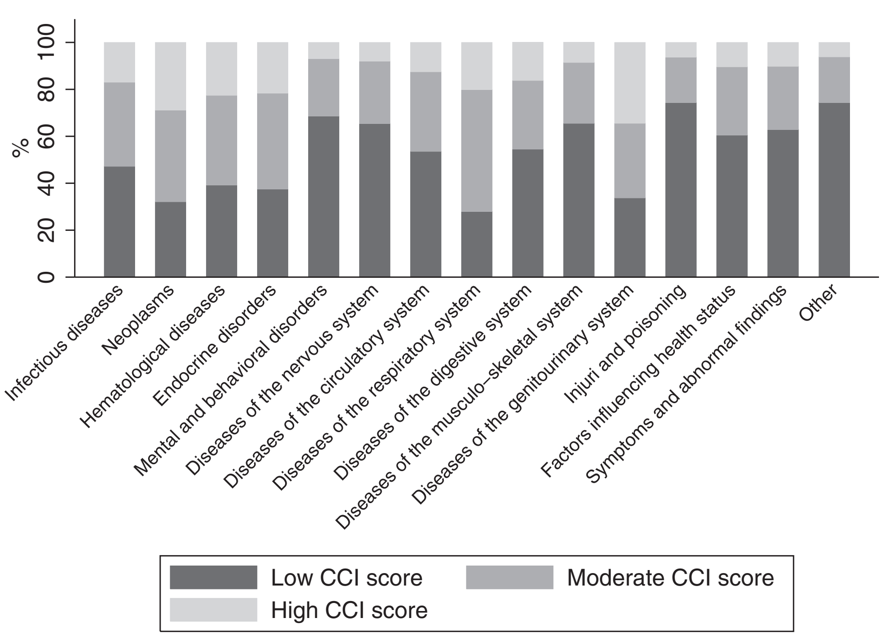

Fig. 2. Proportion of patients with Charlson Comorbidity Index score of 0 (low), 1–2 (moderate), and 3+ (high) in each diagnostic group.

from the CCI score, the proportion of patients with a moderate or high CCI score decreased to 40.8%. Fig. 2 shows levels of CCI scores in each diagnostic group. The most prevalent CCI conditions were chronic pulmonary diseases (11.7%) and cerebrovascular diseases (9.9%) (Table 1).

Diseases of the genitourinary system had the largest proportion of patients with a high CCI score (34.6%). In the diagnostic groups of neoplasms, endocrine, nutritional and metabolic disorders, and respiratory diseases, a moderate CCI score was the most prevalent (from 39.1% among patients with neoplasms to 52.1% among patients with respiratory diseases). A substantial proportion of the patients with neoplasms and respiratory diseases had a high CCI score (28.8% and 20.1%, respectively). In the remaining diagnostic groups proportionally fewer patients had a moderate or high CCI score. However, when focusing on the 35,122 patients with a high CCI score, cardiovascular diseases (n = 6932) and infectious diseases (n = 6392) were the most prevalent, followed by the non-specific Z-diagnoses (n = 4638) and the non-specific R-diagnoses (n = 3186).

We observed a high degree of overlap between the primary diagnostic groups and corresponding individual CCI conditions (see online Supplementary Table in Appendix D). For example, among patients with genitourinary diseases, 36.8% had moderate to severe renal diseases registered either prior to or as a secondary diagnosis during their index admission. Similarly, more than half of patients admitted because of respiratory diseases had a chronic pulmonary disease. Among patients with neoplasms, 25.8% had a non-metastatic solid tumor, 20.2% had lymphoma, 9.3% had a metastatic cancer, and 9.1% had leukemia, registered either prior to or as a secondary diagnosis during their index admission.

3.4. Length of hospital stay

The overall median length of hospital stay was 2 days (IQR 1–6 days), rising to 5 days (IQR 2–12 days) among the 14% patients with an in-hospital or inter-hospital transfer. Length of hospital stay increased with increasing age and increasing CCI score (Table 3). Patients with neoplasms as their primary diagnosis had the highest median length of hospital stay (7 days (IQR 2–15)). The overall length of hospital stay remained unchanged after exclusion of patients admitted to AMAUs (short stay units), although 37% of AMAU patients had an in-hospital or inter-hospital transfer compared to only 8% of patients from the other hospital departments. In total, 37,299 patients were transferred to a second department within their complete length of hospital stay and among these 24,586 (65.9%) were transferred within the first day of admission. Only 3.0% (n = 7937) were transferred to a surgical department within the first day and approximately half of these patients were transferred to departments of abdominal surgery (n = 3759). Surprisingly, many patients with non-specific diagnosis, who were transferred to a second department, were assigned another non-specific diagnosis (data not shown). Among the patients with non-specific Z-diagnoses as their main reason for admission, 23% were assigned another non-specific diagnosis (Z- or R-diagnosis) after transfer. Similar, 41% of the patients assigned a non-specific R-diagnosis as their main reason for admission were assigned a non-specific diagnosis after transfer.

3.5. Source of admission

Approximately 30% of the acute medical patients in our study were referred from another hospital department including surgical departments, and 24.4% arrived through the emergency room. Only 5.4% had been in contact with a hospital outpatient specialist clinic on the index date. Approximately a third of the patients arriving through the emergency room were admitted to an AMAU, which may reflect that AMAUs at some hospitals function as the gateway to specialized departments.

Table 3
Length of hospital stay according to patient characteristics.

Characteristics	Length of hospital stay, days Median (IQR)
Gender	
Female	2 (1–6)
Male	2 (1–6)
Age group, years	
15–39	1 (0.5–2)
40–59	1 (1–4)
60–79	3 (1–7)
80+	5 (1–10)
CCI-score	
Low (0)	1 (1–4)
Moderate (1–2)	3 (1–7)
High (3+)	4 (1–9)
Department type	
Department of neurology	3 (1–7)
Department of cardiology	1 (1–5)
Department of pulmonology	3 (1–7)
Department of gastroenterology	3 (1–7)
Department of nephrology	4 (1–9)
Department of rheumatology	2 (0.5–8)
Department of hematology	4 (1–8)
Department of endocrinology	2 (1–7)
Department of infectious diseases	2 (1–6)
Department of geriatric medicine	9 (7–16)
Department of general medicine	2 (1–6)
Acute medical admission unit	1 (0.5–5)
Source of admission	
Non-medical hospital departments	0.5 (0.5–3)
Outpatient clinics	2 (1–7)
Emergency rooms	1 (1–5)
Direct (e.g. from general practitioner)	3 (1–7)
Primary diagnosis	
Infectious diseases incl. pneumonia	4 (2–8)
Neoplasm	7 (2–15)
Hematological diseases	2 (1–6)
Endocrine and nutritional diseases	3 (1–8)
Mental and behavioral disorders	1 (0.5-2)
Diseases of the nervous system	1 (1–4)
Diseases of the circulatory system	3 (1–7)
Diseases of the respiratory system	3 (1–7)
Diseases of the digestive system	3 (1–7)
Diseases of the musculoskeletal system	2 (0.5–6)
Diseases of the genitourinary system	4 (1–9)
Injury, poisoning and other external causes	1 (0.5–2)
Factors influencing health status	1 (0.5–4)
Symptom, signs and abnormal findings	1 (0.5–3)
Other	1 (0.5–3)

4. Discussion

4.1. Key findings

In this population-based observational study, we found that two-thirds of the patients admitted acutely to the medical departments had one of the following four main reasons for admission: cardiovascular diseases, non-specific Z-diagnoses, infectious diseases, and non-specific R-diagnoses. The finding of high proportion of patients with non-specific diagnoses, particularly in patients with chronic diseases, is striking. In addition, we found considerable disparity in age, gender and chronic disease distribution according to the main reason for admission. Complications to chronic diseases are probably a common reason for admission, as we found a considerable overlap between the patients' chronic diseases and reason for admission.

4.2. Strengths and limitations

The key strength of this study was its use of a population-based hospital registry (DNRP) with timely and valid coverage of all acute admissions to departments of internal medicine [10,16]. We identified the study population from all medical departments, thereby removing any selection bias regarding catchment areas or patient demographics.

Variation in coding practices is a known limitation when using administrative databases. Thus the primary limitations of this study were potential coding inaccuracies of individual diagnoses and the coding variability among the departments. However, we relied on physicians' accuracy in coding diagnoses at discharge, and the accuracy of diagnostic coding in discharge summaries has been shown to be high [14].

The CCI score is a widely used approach for examining comorbidity. Nonetheless, the CCI score is restricted to 19 conditions and does not include information on frequent comorbid conditions such as hypertension, obesity, and atrial fibrillation. We chose the five-year look-back period in order to capture clinically significant morbidity, although a recent study has suggested the use of all available historical data when controlling for confounding from comorbidity [17]. Moreover, the inclusion of secondary diagnoses during the index admission in the CCI score ensured that recently or newly diagnosed chronic conditions were captured. However, the secondary diagnoses assigned during an index admission may reflect complications of primary diagnoses, limiting their use as indicators of chronic disease. This is unlikely to be a major problem, as we found that secondary diagnoses added only limited information to the CCI score.

4.3. Other studies

Our findings confirm not only previous studies showing that cardiovascular and infectious diseases were among the main reasons for admission to internal medicine departments [3,4], but also studies showing a high and increasing prevalence of acute patients with non-specific diagnoses [6–8]. Chronic diseases as well as organizational factors such as a high rate of transfer from the acute medical admission units to the specialized departments, a short length of hospital stay precluding the establishment of a final diagnosis, and coding accuracy may contribute to the high prevalence of non-specific diagnoses in our study. Previous studies from UK concerning non-specific R-diagnoses have questioned the influence of comorbidity on the probability of receiving these diagnoses. Instead, they find that social and organizational factors such as admission through the emergency department or admission out of normal GP hours are important [18,19].

Our finding that neoplasms are a rare reason for acute admission is supported by a study from England, which found a very low incidence of first-ever diagnoses of cancer associated with emergency admissions [20]. Among the individual diagnoses, we observed a high prevalence of atrial fibrillation/flutter and pneumonia, which is in accordance with increasing incidence of these diseases in recent decades [7,21,22]. Our data suggest that these trends may be explained by the aging of the population and the increasing number of patients with multiple chronic conditions, as both cardiovascular diseases and infectious diseases were prevalent among the very old and among patients with a high CCI score. Generally, we found that the diagnostic groups associated with acute admissions overlapped with the corresponding CCI condition, i.e., the admission represented an acute complication of the chronic disease. The limitation of previous studies concerning reasons for acute admissions in internal medicine was their inability to specifically address CCI score of the individual diagnostic groups [3,4].

Our study has addressed the main focal areas of acute internal medicine and future challenges facing the health care planners, as more patients are expected to present with non-specific symptoms or complications of their chronic diseases. Thus, our findings may apply to other Western health care systems.

In conclusion, this population-based description of reasons for admission to medical departments reflects the challenges facing internal medicine, a discipline evolved from general medicine towards subspecialties. Our data suggests that a more generalist approach will be needed as patients present with non-specific symptoms and chronic diseases.

Learning points

- In this large nationwide study describing the main reasons for acute admission to medical departments we found a strikingly high proportion of patients with non-specific diagnoses, particularly in patients with chronic diseases.
- Complications to chronic diseases are probably a common reason for admission, as we found a considerable overlap between the patients' chronic diseases and reason for admission.
- There were a considerable disparity in age, gender and chronic disease distribution according to the main reason for admission.

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Contributors

BV-H, AHR, HTS, and CFC contributed to the study conception, design, and the interpretation of data. BV-H, AHR, HTS, and CFC were responsible for the acquisition of data. BV-H analyzed and drafted the manuscript. All authors critically revised the manuscript and approved the final version.

Conflict of interest statement

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

Appendices (A, B, C, D). Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.ejim.2014.06.017.

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Supplement to

Acute admissions to medical departments in Denmark: Diagnoses and patient characteristics

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Appendix A. ICD-10 codes of each primary diagnostic group

Appendix B. ICD-10 codes for the Charlson Comorbidity Index conditions

Appendix C. ICD-10 codes of most frequent diagnoses within each diagnostic group

Appendix D. The 19 individual conditions in the Charlson Comorbidity Index according to each primary diagnostic group

Appendix A

Disease category	ICD-10
Infectious diseases	A00-B99
• Infections of the blood-forming organs	D73.3
• Infections of the endocrine organs	E06.0, E06.9, E32.1
• CNS infections	G00-G02, G04-07
• Infections of the eye, ear, and adnexa	H00, H01.0, H03.0-1, H04.0, H04.3, H05.0, H06.1, H10, H13.0-1, H15.0, H19.1-2, H22.0, H32.0, H44.0-1, H60.0-1, H60.3, H62.0-3, H65.0-1, H66.0-4, H66.9, H67.1, H67.8, H68.0 H70.2, H73.0, H75.0, H94.0
• Heart infections	I00-02, I30.1, I32.0-1, I33.0, I38, I39.8 I40.0, I41, I43.0, I52.0-1, I68.1, I98.1
• Respiratory tract infections	J00-J06, J09-J18, J20-22, J34.0, J36, J38.3D, J38.7G, J39.0-1, J39.8A, J44.0, J85.1-3, J86
• Infections of the digestive system	K04.0, K04.6-7, K05.2, K11.2-3, K12.2, K13.0A, K14.0A, K20.9A, K23.0-1, K35, K37, K57.0, K57.2, K57.4, K57.8, K61, K63.0, K65.0, K65.8I, K67, K75.0-1, K77.0, K80.0, K80.3-4, K81.0, K83.0, K85.9, K93.0-1
• Skin and subcutaneous infections	L00-03, L05-08, L88
• Infections of the musculo-skeletal system and connective tissue.	M00-01, M46.1-5, M49.0-3, M60.0, M60.8, M63.0-2, M65.0-1, M68.0, M71.0-1, M86.0-2, M86.9, M90.0-2
• Urinary tract infections	N10, N12, N13.6, N15.1, N16.0, N20.0I, N29.1, N30.0, N33.0, N34.0-1, N39.0
• Male genital infections	N41, N43.1, N45.0, N45.9, N48.1-2, N49
• Female genital infections	N61, N70-77
• Obstetrical infections	O23, O26.4, O41.1, O75.3, O85, O86, O88.3, O91, O98
• Infectious complications of procedure, catheters etc.	T80.2, T81.4, T82.6-7, T83.5-6, T84.5-7, T85.7, T88.0, T89.9
Neoplasms (Chapter II)	C00-D48
Diseases of the blood and blood-forming organs and certain disorders involved in the immune system (Chapter III)*	D50-D89
Endocrine, nutritional and metabolic disorders (Chapter IV)*	E00-E90
Mental and behavioral disorders (Chapter V)	F00-F99
Diseases of the nervous system (Chapter VI)*	G00-G99

Diseases of the circulatory system (Chapter IX)*	I00-I99
Diseases of the respiratory system (Chapter X)*	J00-J99
Diseases of the digestive system (Chapter XI)*	K00-K93
Diseases of the musculoskeletal system and connective tissue (Chapter XIII)*	M00-M99
Diseases of the genitourinary system (Chapter XIV)*	N00-N99
Injury, poisoning and certain other consequences of external causes (Chapter XIX)*	S00-T98
Factors influencing health status and contact with health services (Chapter XXI)	Z00-Z99
Symptoms and abnormal findings, not elsewhere classified (Chapter XVIII)	R00-R99
Other * i.e., Diseases of the eye and adnexa (Chapter VII)*, Diseases of the ear and mastoid process (Chapter VIII)*, Diseases of the skin and subcutaneous tissue (Chapter XII)*, Diseases associated with pregnancy, childbirth and puerperium (Chapter XV)*, Diseases originating in the perinatal period (Chapter XVI), and Congenital malformations (Chapter XVII)	H00-H95, L00-L99, O00-O99, P00-P99, T00-T99

*except infectious diseases within the chapter

Appendix B

ICD-10 codes for the Charlson Comorbidity Index conditions

Charlson score of 1:

Myocardial infarction: I21, I22, I23;

Congestive heart failure: I50, I11.0, I13.0, I13.2;

Peripheral vascular disease: I70, I71, I72, I73, I74, I77;

Cerebrovascular disease: I60-I69, G45, G46;

Dementia: F00-F03, F05.1, G30;

Chronic pulmonary disease: J40-J47, J60-J67, J68.4, J70.1, J70.3, J84.1, J92.0, J96.1, J98.2, J98.3;

Connective tissue disease: M05, M06, M08, M09, M30, M31, M32, M33, M34, M35, M36, D86;

Ulcer disease: K22.1, K25-K28;

Mild liver disease: B18, K70.0-K70.3, K70.9, K71, K73, K74, K76.0;

Diabetes mellitus: E10.0-E10.2, E10.9, E11.0-E11.1, E11.9

Charlson score of 2:

Hemiplegia: G81, G82;

Diabetes with end organ damage: E10.2-E10.8, E11.2-E11.8;

Any tumor: C00-C75;

Leukemia: C91-C95;

Lymphoma: C81-C85, C88, C90, C96

Charlson score of 3:

Moderate to severe liver disease: B15.0, B16.0, B16.2, B19.0, K70.4, K72, K76.6, I85

Charlson score of 6:

Metastatic solid tumor: C76-C80;

AIDS: B21-B24

Appendix C

ICD-10 codes of most frequent diagnoses within each diagnostic group

Headings and ICD-10 codes	*n*	*% of diagnostic group*
Unspecified anemia (D64.9)	2,487	47.7
Volume depletion (E86)	5,145	39.8
Diabetes (E10-E14)	3,510	27.2
Mental and behavioral disorders due to use of alcohol (F10)	5,128	66.1
Transient cerebral ischemic attacks and related syndromes (G45)	3,540	31.6
Epilepsy (G40-G41)	2,435	21.8
Ischemic heart diseases (I20-I25)	12,672	24.8
Cerebrovascular diseases (I60-I69)	9,657	18.9
Atrial fibrillation (I48)	9,344	18.3
Pneumonia (J12-J18)	14,563	35.6
Chronic lower respiratory diseases (J40-J44)	3,397	26.7
Functional intestinal disorders (K59)	1,064	10.5
Dorsalgia (M54)	2,312	24.2
Chronic Kidney Disease (N18)	1,221	31.4
Adverse effects (T78)	1,463	8.9
Intracranial injury (S06)	1,351	8.2
Poisoning by psychotropic drugs (T43)	1,075	6.5
Non-specific R-diagnosis		
Abnormalities of breathing (R06)	2,003	6.4
Pain in throat and chest (R07)	2,829	9.1
Abdominal and pelvic pain (R10)	2,593	8.3
Other signs and symptoms involving the nervous and musculoskeletal system (R29)	2,626	8.4
Dizziness and giddiness (R42)	2,365	7.6

Fever of other and unknown origin (R50)	1,547	5.0
Headache (R51)	1,855	6.0
Pain, not elsewhere classified (R52)	1,312	4.2
Syncope and collapse (R55)	6,027	19.3
Other	8,043	25.8
Non-specific Z-diagnosis		
Observation for suspected malignant neoplasm (Z031)	1,446	3.2
Observation for suspected nervous system disorder (Z033)	3,185	7.2
Observation for suspected myocardial infarction (Z034)	12,048	27.0
Observation for other suspected cardiovascular diseases (Z035)	6,582	14.8
Observation for other suspected diseases and conditionsZ038	3,740	8.4
Observation for suspected disease or condition, unspecified (Z039)	10,692	24.0
Care involving use of other rehabilitation procedures (Z508)	1,910	4.3
Other	4,967	11.1

Appendix D

The 19 individual conditions in the Charlson Comorbidity Index according to each primary diagnostic group.

	Total	AMI	CHF	PVD	CVD	DEM	CPD	CTD	ULD	MLD	DIA	DWE	HEM	SRD	NMT	LEU	LYM	SLD	MCA	AID
Primary diagnosis	n	% of diagnostic group																		
Infectious diseases incl. pneumonia	40,865	3.2	7.3	5.8	10.0	4.4	18.0	4.4	3.1	1.8	9.8	5.8	0.8	4.9	10.2	0.9	1.5	0.5	1.7	0.6
Neoplasms	3,483	2.0	3.7	4.8	7.1	1.2	9.4	2.7	2.5	1.4	6.6	3.0	0.3	3.1	25.8	9.1	20.2	0.6	9.3	0.2
Hematological Diseases	5.214	4.8	9.5	7.4	11.5	3.7	11.1	5.7	7.3	3.1	10.9	6.5	0.4	6.2	17.9	1.3	1.3	1.0	4.6	0.1
Endocrine, nutritional and metabolic disorder	12.925	3.6	8.0	6.5	12.7	5.9	8.8	3.5	4.0	2.0	25.9	16.9	0.3	6.0	12.1	0.3	0.7	0.7	2.2	0.1
Mental and behavioral disorders	7,755	1.3	2.1	2.1	7.4	3.8	6.9	1.0	3.4	5.5	4.9	2.7	0.2	1.3	3.6	0.1	0.2	1.7	0.5	0.1
Diseases of the nervous system	11,192	1.6	2.0	2.9	16.1	2.4	5.0	2.0	1.6	0.9	5.2	3.1	1.1	1.2	6.3	0.2	0.4	0.3	1.0	0.1
Diseases of the circulatory system	51,056	6.3	11.5	6.4	11.3	1.9	8.5	2.7	2.4	0.9	9.7	5.6	0.2	3.2	7.6	0.3	0.6	0.3	0.9	0.1
Diseases of the respiratory system	12,719	4.4	11.4	6.3	8.8	2.5	54.3	3.2	3.4	1.4	8.7	4.9	0.5	3.3	10.9	0.4	0.7	0.4	1.8	0.1
Diseases of the digestive system	10,186	2.7	4.5	4.9	7.8	1.9	8.7	2.7	5.9	9.0	8.7	4.7	0.3	3.5	9.1	0.3	0.6	5.0	1.6	0.1
Diseases of the musculo-skeletal system	9,560	2.4	3.7	3.7	6.1	1.1	7.8	7.1	2.3	1.0	6.0	3.3	0.3	2.6	6.2	0.3	0.6	0.3	0.6	0.1
Diseases of the genitourinary system	3,886	5.1	11.3	10.5	11.4	3.0	9.4	4.6	4.1	1.8	15.2	14.5	0.6	36.8	11.0	0.4	1.5	0.6	1.5	0.2
Injury, poisoning and external causes	16,508	1.4	2.6	2.4	5.0	1.5	5.8	1.8	1.6	1.9	4.4	2.4	0.2	1.7	4.5	0.5	1.0	0.5	0.6	0.2
Factors influencing health status	44,570	4.4	5.0	4.2	10.9	1.9	8.4	2.7	2.2	1.2	7.4	4.2	0.3	2.6	7.9	0.3	0.5	0.4	1.2	0.1
Symptoms and abnormal findings	31,200	2.8	4.2	3.7	8.7	2.2	7.6	2.7	2.4	1.5	6.8	3.5	0.3	2.3	8.9	0.5	0.7	0.5	1.8	0.1
Other	3,146	1.4	2.4	2.7	5.2	0.8	5.3	2.4	1.1	0.7	5.8	3.6	0.5	2.5	4.3	0.4	0.4	0.3	0.6	0.0
Total	264,265	3.8	6.7	5.0	9.9	2.6	11.7	3.1	2.8	1.8	8.9	5.3	0.4	3.7	8.7	0.6	1.0	0.7	1.4	0.2

Abbreviations: AMI=myocardial infarction, CHF=congestive heart failure, PVD=peripheral vascular disease, CVD=cerebrovascular disease, DEM=dementia, CPD=chronic pulmonary disease, CTD=chronic tissue disease, ULD=ulcer disease, MLD=mild liver disease, DIA=diabetes mellitus, DWE=diabetes with end organ damage, HEM=hemiplegia, SRD=moderate to severe renal disease, NMT=non metastatic tumor, LEU=leukemia, LYM=lymphoma, SLD=moderate to severe liver disease, MCA=metastatic solid tumor, AID=AIDS

Study III

ORIGINAL RESEARCH

Off Hours and Weekend Admissions to Danish Medical Departments: Admission Rates and 30-Day Mortality for 20 Common Medical Conditions

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Abstract

Objectives: Knowledge on the combined weekly and diurnal variation in timing of admissions and mortality rates for acute medical patients is limited. The aim of the study was to examine hospital admission rates and mortality rates for patients with common medical conditions according to time of admission.

Design: Nationwide population-based cohort study.

Setting: Population of Denmark.

Participants: Using the Danish National Registry of Patients (DNRP) covering all Danish hospitals, we identified all adults (>=15 years) with the first acute admission to a medical department in Denmark during 2010. Readmissions and transfers were excluded.

Primary and secondary outcome measures: Hourly admission rates and age- and sex-standardized 30-day mortality rates comparing weekday office hours, weekday off hours, weekend daytime hours, and weekend nighttime hours.

Results: A total of 174,192 acute medical patients were included in the study. The admission rate during weekday office hours was 38.7 (95% Confidence Interval (CI) 38.4-38.9) patients per hour, and corresponding figures were 13.3 (95% CI 13.2-13.5) during weekday off hours, 19.8 (95% CI 19.6-20.1) during weekend daytime hours, and 7.9 (95% CI 7.8-8.0) during weekend nighttime hours. Admission rates varied considerably between medical conditions. The proportion admitted through the emergency room more than doubled outside office hours. The age- and sex- standardized 30-day mortality rate was 5.1% (95% CI 5.0-5.3%) for patients admitted during weekday office hours, 5.7% (95%CI 5.5-6.0%) for patients admitted during weekday off hours, 6.4%

(95%CI 6.1-6.7%) for patients admitted during weekend daytime hours, and 6.3% (95%CI 5.9-6.8%) for patients admitted during weekend nighttime hours. For 17 out of the 20 medical conditions examined, weekend admission was associated with higher mortality than weekday admission.

Conclusions: While timing of first-time admissions varied, weekend admissions were associated with the highest mortality for the majority of the conditions examined.

ARTICLE SUMMARY

Strengths and limitations of this study

- This study is the first to analyze hourly admission rates and mortality rates associated with time of admission in 20 common conditions among acute medical patients in a population-based design
- We provide a subtle categorization of time of admission including both weekday office hours, weekday off hours, weekend daytime hours and weekend nighttime hours
- Our study lacked clinical data on severity of disease and staffing level, but included information on the proportion admitted to intensive care units according to time of admission.

INTRODUCTION

Acute hospital admission rate decreases during weekend, but an admission during weekend has been associated with higher in-hospital mortality, an association termed "the weekend effect".[1-16] The weekend effect has been observed among acutely hospitalized patients in differing healthcare systems, including Canada, the US, and Australia, as well as in European countries. Understanding the higher short-term mortality associated with weekend admissions is important both for clinicians and healthcare planners. Two possible explanations for the weekend effect are the changes in the availability of specialized care or changes in patient characteristics, *e.g.* disease severity.[17]

A more subtle categorization of time of admission in patients admitted during weekday office hours and off hours, as well as daytime hours and nighttime hours during the weekend may clarify important differences in patient characteristics. Furthermore, admission rates for common medical conditions in these time periods may serve as a proxy of the changes in referral threshold and together with mortality rates add to the understanding of the weekend effect. Variation in timing of admission and mortality rates for common medical conditions has to our best knowledge not previously been examined. Previous studies examining "off hours" and mortality have primarily investigated "off hours" as the time outside regular hours/office hours, not distinguishing between "Office" and "Off" hours during weekdays, as well as between daytime and nighttime hours of the weekend.[8,9]

We therefore examined the hourly admission rates and 30-day mortality rates for patients with 20 common medical conditions comparing weekday office hours, weekday off hours, weekend daytime hours, and weekend nighttime hours in a cohort of acute medical patients with their first admission to departments of medicine during 2010 in Denmark.

METHODS

Study design and setting

In this register-based cohort study, we identified all acute hospital admissions to medical departments in Denmark between 1 January and 31 December 2010, as recorded in the Danish National Registry of Patients (DNRP). The DNRP is a central medical registry covering both public and private hospitals and contains information on all hospital admissions to non-psychiatric hospitals since 1977 and on all hospital contacts with emergency rooms and hospital specialist clinics since 1995. In Denmark, the private hospitals account for less than 1% of the total number of beds and they do not provide acute care.[18] General practitioners (GPs) has a key role in referring patients to the hospital departments since virtually all Danish residents are affiliated with a personal GP. Outside regular office hours, GPs serve the patients from central regional clinics providing both phone service and consultation. In an emergency situation, the patients can present on their own or by ambulance to the emergency room. Denmark has a free, tax-funded health care system, which assures that all residents (5,534,738 million persons as of 1 January 2010) in both rural and urban areas have unrestricted and equal access to GPs and to specialist care in hospitals.[19,20]

Study population

The cohort, which included all patients with their first acute admission to medical departments in Denmark between 1 January and 31 December 2010, has previously been described. [21] For this present study, we excluded patients with an inpatient stay in a hospital department within the preceding 30 days or earlier on the day of admission.

Time of admission

Time of admission was defined as weekday office hours, weekday off hours, weekend daytime hours, and weekend nighttime hours. Public holidays, *e.g.* Easter and Christmas were considered weekend days. In 2010, 26.8% of the total number of hours was defined as weekday office hours (Monday to Friday from 8.00 am to 4.59 pm), 38.7% as weekday off hours (Monday to Friday from 5.00 pm to 7.59 am, except Friday evening from 10.00 pm-11.59 pm and Monday night from 0.00 pm to 7.59 am), 15.4% as weekend daytime hours (Saturday and Sunday from 9.00 am to 9.59 pm), and 19.0% as weekend nighttime hours (Saturday and Sunday from 10.00 pm to 11.59 pm and 0.00 am-8.59 am plus Friday evening from 10.00-11.59 pm and Monday night from 0.00 am to 7.59 am). Admission rates were computed hourly according to time of admission.

Mortality

Each Danish resident is assigned a unique personal identification number (CPR number) at birth or upon immigration by the Danish Civil Registration System (CRS).[22] Information on all-cause mortality within 30 days following the index date was captured by linking patients' CPR number to the CRS. The CRS was established in 1968 to collect and maintain information on vital status, marital status, residency, and migration for all residents of Denmark. The CRS thus contains complete up-to-date data on the vital status of all patients in our study. Patients were followed from their index date until death from any cause, emigration, or 30 days after the index date, whichever came first.

Patient characteristics

The DNRP provided the unique code for each hospital and department, admission type (*i.e*. acute), date of admission (*index date*), hour and minute of admission (00.00-23.59 hours), source of admission (hospital specialist clinic, emergency room, or direct referral), codes for Intensive Care Unit (ICU) admission, date of discharge, and discharge diagnoses, with one primary diagnosis reflecting the reason for admission and up to 19 secondary diagnoses, indicating additional chronic or acute diseases. Diagnoses were coded according to *the International Classification of Diseases*, version 10 (ICD-10).

By tabulation of the primary ICD-10 diagnoses assigned after the index admission, considered to be the main reason for admission, we identified 20 common conditions among acute medical patients, *i.e*. pneumonia, erysipelas, bacteremia/sepsis, urinary tract infection, anemia, diabetes, dehydration, alcohol intoxication, transient ischemic attack, angina, acute myocardial infarction, atrial fibrillation, heart failure, hypertension, stroke, chronic obstructive pulmonary disorder, respiratory failure, gastroenteritis, syncope, and suspected acute myocardial infarction (ICD-10 codes provided in Appendix, Table S1).

To capture clinically important morbidity, data on the 19 conditions included in the Charlson Comorbidity Index (CCI) were obtained from the DNRP for the five years preceding the index date (ICD-10 codes provided in Appendix, Table S2). The CCI score was divided in low (score of 0), moderate (score of 1-2), and high (score of 3 or higher).

From CRS, data on marital status (married, never married, divorced, widowed, and unknown) were provided. We computed length of hospital stay as time from the index date to final hospital discharge, including in-hospital and inter-hospital transfers, except those occurring more than one day after a preceding discharge as they were considered readmissions rather than transfers.

Statistical analysis

We classified patients as admitted during weekday office hours, weekday off hours, weekend daytime hours, and weekend nighttime hours, and characterized them according to patient characteristics. The hourly admission rates and the 30-day mortality rates were computed for the common medical conditions according to time of admission. We standardized 30-day mortality to the age- and gender-distribution of patients admitted during weekday office hours using direct standardization.[23] We also reported the proportions of patients admitted to an ICU within three days following the index date and during the whole hospital stay. An ICU admission serves as a proxy of both the availability of an ICU bed but also for the severity of the disease.

In a subgroup analysis, the admission rate, 30-day mortality rate, and ICU admissions during the four time periods were analyzed only among patients admitted through the emergency room. Data were analyzed with the statistical software package STATA (version 11, Stata Corp., College Station, Texas, USA). The study was approved by the Danish Data Protection Agency (record number 1-16-02-1-08). Because the study was based solely on data from administrative and medical databases, no further approval from the Ethics Committee was required.

RESULTS

Patient characteristics

A total of 264,265 patients with an acute first-time admission to medical departments in Denmark during 2010 were registered. After excluding patients without residency in Denmark (n=505) and patients with a hospital admission within the preceding 30 days or on the day of the index admission (n=89,568), 174,192 patients were included in the study. Of these patients, 50.4% (n=87,764) were admitted during weekday office hours, 24.9% (n=43,312) during weekday off hours, 16.7% (n=29,140) during weekend daytime hours, and 8.0% (n=13,976) during weekend nighttime hours. As shown in Table 1, patients admitted during weekday office hours tended to be older and had slightly higher CCI scores than patients admitted during other time periods. Weekend nighttime hours were the only time of admission when males constituted the highest proportion of patients (50.8%). No major differences among patients were observed with regard to the individual CCI conditions. During weekday office hours, 15.1% were admitted through the emergency room, while 33.5% were admitted through the emergency room during weekday off hours. Similarly, weekend daytime and weekend nighttime hours were associated with a high rate of admissions through the emergency room (30.2% and 33.0%, respectively).

Table 1. Demographic and clinical characteristics of 174,192 patients with an acute admission to a department of medicine, by time of admission, Denmark, 2010

	Weekday		Weekend	
	Office hours (8.00 am-4.59 pm)	Off hours (5.00 pm-7.59 am)	Day (9.00 am -9.59 pm)	Night (10.00 pm-8.59 am) plus Friday 10.00-11.59 pm and Monday 0.00-7.59 am
Overall	87,764 (50.4%)	43,312 (24.9%)	29,140 (16.7%)	13,976 (8.0%)
Age groups				
15-39	9,291 (10.6)	7,246 (16.7)	3,960 (13.6)	2,528 (18.1)
40-59	19,888 (22.7)	10,902 (25.2)	6,764 (23.2)	3,456 (24.7)
60-79	36,722 (41.8)	15,794 (36.5)	11,079 (38.0)	5,146 (36.8)
80+	21,863 (24.9)	9,370 (21.6)	7,337 (25.2)	2,846 (20.4)
Age, Median (years (IQR))	68 (54-79)	64 (47-78)	67 (51-80)	64 (46-77)
Gender				
Female	45,877 (52.3)	22,175 (51.2)	15,073 (51.7)	6,880 (49.2)
Male	41,887 (47.7)	21,1375 (48.8)	14,067 (48.3)	7,096 (50.8)
Charlson Comorbidity Index score				
0	49,384 (56.3)	25,710 (59.4)	16,647 (57.1)	8,055 (57.6)
1-2	27,302 (31.1)	12,687 (29.3)	8,996 (30.9)	4,267 (30.5)
3+	11,078 (12.6)	4,915 (11.4)	3,497 (12.0)	1,654 (11.8)
Presence of diseases included in the Charlson Comorbidity Index				
Myocardial infarction	3,246 (3.7)	1,658 (3.8)	1,117 (3.8)	590 (4.2)
Congestive heart failure	5,735 (6.5)	2,477 (5.7)	1,748 (6.0)	913 (6.5)
Peripheral vascular disease	4,683 (5.3)	1,926 (4.4)	1,388 (4.8)	686 (4.9)
Cerebrovascular disease	8,110 (9.2)	4,052 (9.3)	2,917 (10.0)	1,353 (9.8)
Dementia	1,920 (2.2)	1,013 (2.3)	769 (2.6)	296 (2.1)
Chronic pulmonary disease	9,934 (11.3)	4,758 (11.0)	3,296 (11.3)	1,691 (12.1)
Connective tissue disease	2,977 (3.4)	1,181 (2.7)	889 (3.1)	386 (2.8)
Ulcer disease	2,479 (2.8)	1,138 (2.6)	778 (2.7)	367 (2.6)
Mild liver disease	1,435 (1.6)	691 (1.6)	451 (1.6)	209 (1.5)
Diabetes without end-organ damage	7,154 (8.2)	3,362 (7.8)	2,268 (7.8)	1,099 (7.9)
Diabetes with end-organ damage	4,337 (4.9)	2,101 (4.9)	1,386 (4.8)	675 (4.8)
Hemiplegia	313 (0.4)	163 (0.4)	106 (0.4)	53 (0.4)
Moderate to severe renal disease	3,036 (3.5)	1,289 (3.0)	918 (3.2)	432 (3.1)
Non-metastatic solid tumor	7,555 (8.6)	3,157 (7.3)	2,393 (8.2)	1,032 (7.4)
Leukaemia	500 (0.6)	193 (0.5)	131 (0.5)	56 (0.4)
Lymphoma	874 (1.0)	354 (0.8)	270 (0.9)	107 (0.8)
Moderate to severe liver disease	511 (0.6)	202 (0.5)	159 (0.6)	85 (0.6)
Metastatic cancer	1,035 (1.2)	373 (0.9)	360 (1.2)	140 (1.0)
AIDS	152 (0.2)	85 (0.2)	50 (0.2)	23 (0.2)
Marital status				
Married	40,881 (46.6)	18,719 (43.2)	12,794 (43.9)	6,358 (45.5)
Never married	14,140 (16.1)	9,206 (21.3)	5,364 (18.4)	2,981 (21.3)
Divorced	12,414 (14.1)	6,486 (15.0)	4,230 (14.5)	2,064 (14.8)
Widowed	20,325 (23.2)	8,904 (20.6)	6,751 (23.2)	2,573 (18.4)
Unknown	4	0	1	0
Admission source				
Hospital outpatient specialist clinic	5,781 (6.6)	2,251 (5.2)	1,139 (3.9)	541 (3.9)
Emergency room	13,225 (15.1)	14,492 (33.5)	8,810 (30.2)	4,618 (33.0)
Other	69,438 (79.0)	27,343 (63.1)	19,610 (67.3)	8,997 (64.4)
Length of hospital stay [Median (days)]	3 (1-7)	2 (1-7)	3 (1-7)	3 (1-6)
Common medical conditions				
Pneumonia	5,886 (6.7)	2,797 (6.5)	2,197 (7.5)	978 (7.0)
Erysipelas	991 (1.1)	513 (1.2)	367 (1.3)	125 (0.9)

Bacteremia/Sepsis	1,201 (1.4)	759 (1.8)	563 (1.9)	238 (1.7)
Urinary tract infection	1,944 (2.2)	996 (2.3)	740 (2.5)	300 (2.2)
Anemia	2,384 (2.7)	417 (1.0)	266 (0.9)	93 (0.7)
Diabetes	1,540 (1.8)	507 (1.2)	326 (1.1)	158 (1.1)
Dehydration	2,073 (2.4)	953 (2.2)	697 (2.4)	213 (1.5)
Alcohol intoxication	989 (1.1)	994 (2.3)	556 (1.9)	388 (2.8)
Transient ischemic attack	1,380 (1.6)	811 (1.9)	609 (2.1)	200 (1.4)
Angina	2,191 (2.5)	1,000 (2.3)	616 (2.1)	408 (2.9)
Acute myocardial infarction	2,274 (2.6)	1,317 (3.0)	997 (3.4)	694 (5.0)
Atrial fibrillation	3,707 (4.2)	1,170 (2.7)	889 (3.1)	354 (2.5)
Heart failure	1,645 (1.9)	535 (1.2)	300 (1.0)	207 (1.5)
Hypertension	1,173 (1.3)	487 (1.1)	329 (1.1)	136 (1.0)
Stroke	3,187 (3.6)	1,587 (3.7)	1,407 (4.8)	515 (3.7)
Chronic obstructive pulmonary disorder	2,869 (3.3)	1,273 (2.9)	926 (3.2)	545 (3.9)
Respiratory failure	1,120 (1.3)	559 (1.3)	414 (1.4)	224 (1.6)
Gastroenteritis	1,179 (1.3)	612 (1.4)	466 (1.6)	231 (1.7)
Syncope	1,554 (1.8)	1,195 (2.8)	865 (3.0)	336 (2.4)
Suspected acute myocardial infarction	3,719 (4.2)	2,304 (5.3)	1,455 (5.0)	712 (5.1)
Other	44,758 (51.0)	22,526 (52.0)	14,155 (44.6)	6,921 (49.5)

Abbreviation: IQR= interquartile range

Weekend nighttime hours were associated with the highest proportion of patients admitted to an ICU within the first three days (4.4%) compared to weekend daytime hours (3.2%), weekday off hours (3.1%), and weekday office hours (2.0%) (Appendix, Table S3). For more than half of the individual medical conditions we examined, the highest risk of an ICU admission was associated with an admission during weekend nighttime hours. For all 20 medical conditions except respiratory failure, admission weekday office hours were associated with the lowest risk of an ICU admission.

Admission rates

The admission rate during weekday office hours was 38.7 (95% Confidence Intervals (CI) 38.4-38.9) patients per hour, and corresponding figures were 13.3 (95% CI 13.2-13.5) during weekday off hours, 19.8 (95% CI 19.6-20.1) during weekend daytime hours, and 7.9 (95% CI 7.8-8.0) during weekend nighttime hours (Table 2). Among the common medical conditions, pneumonia had the overall highest admission rate in all time periods. Anemia, diabetes, atrial fibrillation, and heart failure had the relatively largest decreases in admission rates from weekday office hours to the other time periods while a condition like alcohol intoxication was associated with a more stable admission rate across time periods. The medical conditions with the lowest admission rates during weekend nighttime hours were anemia, erysipelas, diabetes, and hypertension.

Table 2. Hourly admission rates for 20 common medical conditions by time of admission.

	Weekday		Weekend	
	Office hours (8.00 am-4.59 pm)	Off hours (5.00 pm-7.59 am)	Day (9.00 am-9.59 pm)	Night (10.00 pm-8.59 am) plus Friday 10.00-11.59 pm and Monday 0.00-7.59 am
Overall	38.7 (38.4-38.9)	13.3 (13.2-13.5)	19.8 (19.6-20.1)	7.9 (7.8-8.0)
Common medical conditions				
Infectious diseases				
Pneumonia	2.60 (2.53-2.66)	0.86 (0.83-0.89)	1.50 (1.43-1.56)	0.55 (0.52-0.59)
Erysipelas	0.44 (0.41-0.47)	0.16 (0.14-0.17)	0.25 (0.22-0.28)	0.07 (0.06-0.08)
Bacteremia/septicemia	0.53 (0.50-0.56)	0.23 (0.22-0.25)	0.38 (0.35-0.42)	0.13 (0.12-0.15)
Urinary Tract Infection	0.86 (0.82-0.90)	0.31 (0.29-0.33)	0.50 (0.47-0.54)	0.17 (0.15-0.19)
Hematological Diseases				
Anemia	1.05 (1.01-1.09)	0.13 (0.12-0.14)	0.18 (0.16-0.20)	0.05 (0.04-0.06)
Endocrine and nutritional disease				
Diabetes	0.68 (0.65-0.71)	0.16 (0.14-0.17)	0.22 (0.20-0.25)	0.09 (0.08-0.10)
Dehydration	0.91 (0.88-0.95)	0.29 (0.27-0.31)	0.47 (0.44-0.51)	0.12 (0.10-0.14)
Mental and behavioral disorders				
Alcohol intoxication	0.44 (0.41-0.46)	0.31 (0.29-0.33)	0.38 (0.35-0.41)	0.22 (0.20-0.24)
Diseases of the nervous system				
Transient Ischemic Attack	0.61 (0.58-0.64)	0.25 (0.23-0.27)	0.41 (0.38-0.45)	0.11 (0.10-0.13)
Diseases of the circulatory system				
Angina	0.97 (0.93-1.01)	0.31 (0.29-0.33)	0.42 (0.39-0.45)	0.23 (0.21-0.25)
Acute Myocardial Infarction	1.00 (0.96-1.04)	0.41 (0.38-0.43)	0.68 (0.64-0.72)	0.39 (0.36-0.42)
Atrial fibrillation	1.63 (1.58-1.69)	0.36 (0.34-0.38)	0.61 (0.57-0.65)	0.20 (0.18-0.22)
Heart failure	0.73 (0.69-0.76)	0.16 (0.15-0.18)	0.20 (0.18-0.23)	0.12 (0.10-0.13)
Hypertension	0.52 (0.49-0.55)	0.15 (0.14-0.16)	0.22 (0.20-0.25)	0.08 (0.06-0.09)
Stroke	1.41 (1.36-1.45)	0.49 (0.46-0.51)	0.96 (0.91-1.01)	0.29 (0.27-0.32)
Diseases of the respiratory system				
Chronic Obstructive Pulmonary Disorder	1.26 (1.22-1.31)	0.39 (0.37-0.41)	0.63 (0.59-0.67)	0.31 (0.28-0.33)
Respiratory failure	0.49 (0.46-0.52)	0.17 (0.16-0.19)	0.28 (0.26-0.31)	0.13 (0.11-0.14)
Diseases of the digestive system				
Gastroenteritis	0.52 (0.49-0.55)	0.19 (0.17-0.20)	0.32 (0.29-0.35)	0.13 (0.11-0.15)
Symptoms and abnormal findings				
Syncope	0.69 (0.65-0.72)	0.37 (0.35-0.39)	0.59 (0.55-63)	0.19 (0.17-0.21)
Factors influencing health status				
Suspected Acute Myocardial Infarction	1.64 (1.59-1.69)	0.71 (0.68-0.74)	0.99 (0.94-1.04)	0.40 (0.37-0.43)
Other	19.7 (19.6-19.9)	6.93 (6.84-7.02)	9.64 (9.48-9.80)	3.90 (3.81-4.00)

Mortality

Table 3 portrays the crude and age- and sex-standardized 30-day mortality rate for the common medical conditions. The age- and sex- standardized 30-day mortality rate was 5.1% (95% CI 5.0-5.3%) for patients admitted during weekday office hours, 5.7% (95%CI 5.5-6.0%) for patients admitted during weekday off hours, 6.4% (95%CI 6.1-6.7%) for patients admitted during weekend daytime hours, and 6.3% (95%CI 5.9-6.8%) for patients admitted during weekend nighttime hours. The medical conditions with the highest mortality in all four time periods were respiratory failure and bacteremia/sepsis. In 17 of the 20 common medical conditions examined in this study, the highest mortality was associated with an admission during weekend, of which seven medical conditions had the highest mortality associated with weekend nighttime hours admission, *i.e.* erysipelas, bacteremia/sepsis, anemia, angina, atrial fibrillation, chronic obstructive pulmonary disorder, and syncope. Urinary tract infection was the only condition associated with the highest mortality for admissions during weekday office hours (5.5% (95% CI 4.5-6.5%)). For patients admitted with hypertension or stroke, the highest mortality was associated with an admission during weekday off hours. Notably, for patients with stroke there was a substantial increase in mortality associated with admissions during weekday off hours compared with weekday office hours (13.4% versus 9.19%). For patients with anemia, there was more than a doubling in mortality for patients admitted during weekend nighttime hours compared to weekday office hours.

Table 3. Crude and age-and sex standardized 30-day mortality rates for 20 common medical conditions among acute medical patients by time of admission.

	Weekday			Weekend			
	Office hours (8.00 am-4.59 pm)	Off hours (5.00 pm-7.59 am)		Day (9.00 am-9.59 pm)		Night (10.00 pm-8.59 am) plus Friday 10.00-11.59 pm and Monday 0.00-7.59 am	
	Reference	Crude (%)	Adj. % (95%CI)	Crude (%)	Adj. % (95% CI)	Crude (%)	Adj. % (95% CI)
Overall	5.1 (5.0-5.3)	5.1	5.7 (5.5-6.0)	6.2	6.4 (6.1-6.7)	5.5	6.3 (5.9-6.8)
Common medical conditions							
Infectious diseases							
Pneumonia	9.60 (8.87-10.3)	10.3	10.1 (9.04-11.2)	11.5	10.6 (9.39-11.8)	10.1	9.92 (8.10-11.7)
Erysipelas	1.61 (0.84-2.39)	1.56	1.76 (0.58-2.94)	1.63	2.11 (0.46-3.76)	1.60	2.33 (0.00-5.46)
Bacteremia/septicemia	20.6 (18.4-22.9)	20.2	20.1 (17.4-22.9)	19.7	18.9 (15.8-21.9)	26.5	27.1 (21.6-32.6)
Urinary Tract Infection	5.45 (4.46-6.45)	4.62	4.81 (3.47-6.15)	4.59	4.41 (2.98-5.84)	3.67	4.59 (1.98-7.21)
Hematological Diseases							
Anemia	4.36 (3.55-5.18)	6.24	6.51 (4.09-8.93)	7.89	8.04 (4.76-11.3)	8.60	9.24 (3.19-15.3)
Endocrine and nutritional disease							
Diabetes	1.62 (1.00-2.25)	1.78	1.68 (0.57-2.78)	2.76	2.51 (0.87-4.15)	1.27	1.16 (0.00-2.82)
Dehydration	11.1 (9.75-12.4)	11.0	11.3 (9.31-13.3)	12.5	12.4 (9.96-14.8)	9.86	10.3 (6.12-14.4)
Mental and behavioral disorders							
Alcohol intoxication	1.92 (1.07-2.77)	1.11	1.11 (0.45-1.77)	1.98	2.24 (0.95-3.52)	NA	NA
Diseases of the nervous system							
Transient Ischemic Attack	0.51 (0.13-0.88)	0.37	0.32 (0.00-0.68)	0.99	0.83 (0.16-1.50)	NA	NA
Diseases of the circulatory system							
Angina	1.78 (1.23-2.33)	1.00	1.13 (0.44-1.82)	1.46	1.52 (0.54-2.50)	2.70	2.90 (1.26-4.54)
Acute Myocardial Infarction	6.06 (5.11-7.02)	7.06	7.20 (5.83-8.58)	7.72	8.09 (6.43-9.76)	7.06	7.05 (5.18-8.92)
Atrial fibrillation	2.05 (1.60-2.50)	2.56	2.72 (1.77-3.66)	3.04	3.20 (2.02-4.38)	3.67	3.68 (1.75-5.61)
Heart failure	8.02 (6.74-9.31)	8.41	8.59 (6.22-11.0)	13.0	12.4 (8.73-16.1)	10.1	9.20 (5.50-12.9)
Hypertension	1.19 (0.57-1.81)	1.85	1.64 (0.63-2.66)	1.52	1.22 (0.17-2.26)	NA	NA
Stroke	9.19 (8.22-10.2)	13.3	13.4 (11.7-15.0)	12.7	12.2 (10.6-13.9)	11.5	11.9 (9.17-14.7)
Diseases of the respiratory system							
Chronic Obstructive Pulmonary Disorder	4.88 (4.10-5.66)	4.87	5.08 (3.85-6.32)	6.59	6.60 (5.02-8.19)	6.06	6.80 (4.53-9.07)
Respiratory failure	23.2 (20.8-25.6)	23.4	24.0 (20.5-27.5)	28.5	28.1 (23.8-32.3)	22.8	24.9 (19.1-30.6)
Diseases of the digestive system							
Gastroenteritis	1.44 (0.77-2.12)	0.82	1.02 (0.14-1.89)	3.00	3.23 (1.57-4.90)	2.16	2.74 (0.42-5.07)
Symptoms and abnormal findings							
Syncope	0.58 (0.20-0.96)	1.00	1.09 (0.48-1.70)	0.92	0.84 (0.26-1.41)	0.89	1.22 (0.00-2.55)
Factors influencing health status							
Suspected Acute Myocardial Infarction	0.67 (0.41-0.93)	0.74	1.00 (0.54-1.47)	1.10	1.11 (0.57-1.65)	0.84	0.97 (0.17-1.77)
Other	4,33 (4.14-4.52)	4.06	4.78 (4.49-5.07)	5.04	5.45 (5.05-5.85)	4.23	5.31 (4.70-5.92)

In our analysis of the subgroup of patients admitted through the emergency room, we identified no major differences in mortality or ICU admissions by time of admission (Appendix, Table S4). The admission rates varied with the lowest admission rate during weekend nighttime hours.

DISCUSSION

Key findings

In this register-based cohort study, timing of first-time admissions varied and weekend admissions were associated with the highest mortality for the majority of the conditions examined. By including weekday off hours as a separate time of admission, we were able to discern important differences in patient characteristics, for example that the proportion of patients arriving through the emergency room changed dramatically from weekday office hours to weekday off hours.

Strengths and limitations

The key strength of this cohort study was the use of a nationwide population-based medical registry that included all first-time acute admissions to departments of medicine in Denmark. The population-based design essentially removes concerns about patient selection bias, and the CPR number assigned to all Danish residents permits unambiguous individual-level linkage among all Danish administrative and medical registries.

A concern is the accuracy of data on time of admission. While the administrative data has high accuracy in the DNRP, the accuracy of the registration of time of the day is unknown. Inaccurate registration of time of admission may introduce bias in our estimates, but we assume such bias to be minor as the intervals range over many hours thereby limiting the misclassification between two periods. In addition, registration of time of admission is registered prospectively, independent of future events such as death or ICU admission.

Administrative databases provide extensive and valuable data, but variation in coding practices is an inherent limitation of administrative databases.[24] Often an acute condition associate with a chronic condition and the extent of diagnostic work-up or complications during admission may influence coding practices.[21] The accuracy of some diagnoses in the DNRP is known, for example the diagnosis of chronic obstructive pulmonary disorder, the non-specific diagnosis of syncope, and the diagnosis of acute stroke, and all have been found to have reasonable high accuracy. [25-27] The accuracy of diagnostic coding for the conditions in the CCI has also been shown to be high.[28] An ICU admission was identified with a special procedure code for intensive care and this variable has been shown to have high accuracy.[29] Since we used a population-based registry to identify large groups of patients diagnosed with the same ICD-10 codes, we assume that misclassification bias had only a minor impact on our results, if any.

Interpretation

The findings from our study indicate that the overall reasons for admissions changed from office hours to off hours and weekend hours. For the majority of the medical conditions examined, weekend admission associated with a higher mortality compared to admission during weekday office hours. In the case of anemia, which demonstrated a tremendous decrease in admission rates after weekday office hours, the mortality rate and risk of an ICU admission more than doubled when patients were admitted during the weekend, which may infer that it was the most severely ill patients who were admitted during weekends. Previous studies of stroke, a common disorder in acute medical patients, found that the weekend effect disappeared after adjustment for deferred admission and disease severity.[30-32] No previous studies presenting admission rates or changes in reasons for admission associated with time of admission were identified.

Although the Danish health care system differs from those in other countries, our study lends support to previous evidence of a higher mortality associated with an acute admission during the weekend but extends this by examining office hours versus off hours, weekend daytime hours and weekend nighttime hours. [1-16] The limited availability of the patients' personal GP and specialized care at the hospitals are assumed to apply to both weekday off hours and to weekend hours. Moreover, it is known that the referral rates of acute hospital admission from the GPs increase outside office hours.[33] Classifying time of admission into four periods, including day and night hours of the weekend, was an attempt to provide a more subtle description of the weekend effect. All earlier studies examined this effect by defining the weekend as starting on Friday at midnight and ending on Sunday at midnight. A few studies have examined mortality associated with admissions during off hours,[8,9] but no studies of an overall cohort of acute patients have distinguished between weekday off hours and weekend daytime and nighttime hours.

A high proportion of patients arrived through the emergency room outside office hours. The reasons could be associated with availability of GPs for consultation, or it could be patient-related, associated with proportionally more patients with severe diseases presenting to departments of medicine outside office hours. The latter explanation is supported by the higher proportion of ICU admissions during weekday off hours and the weekend, and ICU admission may be an indicator of severity. In contrast to our findings, a previous US study based on medical record review of 824 admissions to general medicine units found that weekend admissions were associated with a lower risk of an ICU transfer.[9] However, differences in ICU settings between the US and Europe must be taken into account when making international comparisons of ICU admission rates.[34]

The present study may add important knowledge to healthcare planners about patient characteristics associated with admission outside office hours and the associated risk of ICU admission and death.

In conclusion, timing of first-time admissions varied and weekend admissions were associated with the highest mortality for the majority of the conditions examined. By including weekday off hours as a separate time of admission, we were able to discern important differences in patient characteristics.

Contributor statement:

BV-H, AHR, HTS, and CFC contributed to the study conception, design, and the interpretation of data. BV-H, AHR, HTS, and CFC were responsible for the acquisition of data. BV-H analyzed and drafted the manuscript. All authors critically revised the manuscript and approved the final version.

Competing interests:

The authors report no competing interest in conducting this study.

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Data sharing:

No additional unpublished data are available from the present study.

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Supplement to

Off Hours and Weekend Admissions to Danish Medical Departments: Admission Rates and 30-Day Mortality for 20 Common Medical Conditions

Betina Vest-Hansen, Anders Hammerich Riis, Henrik Toft Sørensen, Christian Fynbo Christiansen

Table S1. ICD-10 diagnoses of common conditions among acute medical patients

Pneumonia	J12-J18, A48.1, A70.9
Erysipelas	A46
Bacteremia/septicemia	A40-41, A02.1, A20.7, A21.7, A22.7, A22.9B, A26.7, A28.2B, A32.7, A39.2-4, A42.7, A49.9A, A54.8G, B37.7, B49.9A, J95.0A
UTI	N30, N34, N39.0
Anemia	D50-64
Diabetes	E10-14
Dehydration	E86
Alcohol Intoxication	F10
Transient ischemic attack	G45
Angina	I20, I24, I25
AMI	I21
AFLI	I48
Heart Failure	I50, I11.0, I13.0, I13.2
Hypertension	I10, D15
Stroke	I60-61, I63-64
COPD	J40-44, J47
Respiratory failure	J96
Gastroenteritis	A0
Syncope	R55
Suspected AMI	Z03.4

Table S2. ICD-10 codes for the Charlson Comorbidity Index conditions

Charlson score of 1:	
Myocardial infarction	I21, I22, I23
Congestive heart failure	I50, I11.0, I13.0, I13.2
Peripheral vascular disease	I70, I71, I72, I73, I74, I77
Cerebrovascular disease	I60-I69, G45, G46
Dementia	F00-F03, F05.1, G30
Chronic pulmonary disease	J40-J47, J60-J67, J68.4, J70.1, J70.3, J84.1, J92.0, J96.1, J98.2, J98.3
Connective tissue disease	M05, M06, M08, M09, M30, M31, M32, M33, M34, M35, M36, D86
Ulcer disease	K22.1, K25-K28
Mild liver disease	B18, K70.0-K70.3, K70.9, K71, K73, K74, K76.0
Diabetes mellitus	E10.0-E10.2, E10.9, E11.0-E11.1, E11.9
Charlson score of 2:	
Hemiplegia	G81, G82
Diabetes with end organ damage	E10.2-E10.8, E11.2-E11.8
Any tumor	C00-C75
Leukemia	C91-C95
Lymphoma	C81-C85, C88, C90, C96
Charlson score of 3:	
Moderate to severe liver disease	B15.0, B16.0, B16.2, B19.0, K70.4, K72, K76.6, I85
Charlson score of 6:	
Metastatic solid tumor	C76-C80
AIDS	B21-B24

Table S3. ICU admissions within three days after admission in medical conditions among acute medical patients according to time of admission

	Weekday				Weekend			
	Office hours (8.00 am-4.59 pm)		Off hours (5.00 pm-7.59 am)		Weekend daytime hours (9.00 am-9.59 pm)		Weekend nighttime hours (10.00 pm-8.59 am) plus Friday 10.00-11.59 pm and Monday 0.00-7.59 am	
	n	ICU admissions (% of group)	n	ICU admissions (% of group)	n	ICU admissions (% of group)	n	ICU admissions (% of group)
Infectious diseases								
Pneumonia	5,886	165 (2.8)	2,797	118 (4.2)	2,197	75 (3.4)	978	55 (5.6)
Erysipelas	991	2 (0.2)	513	2 (0.4)	367	1 (0.3)	125	1 (0.8)
Bacteremia/septicemia	1,201	132 (11.0)	759	84 (11.1)	563	68 (12.1)	238	29 (12.2)
Urinary Tract Infection	1,944	6 (0.3)	996	6 (0.6)	740	2 (0.3)	300	1 (0.3)
Hematological diseases								
Anemia	2,384	15 (0.6)	417	7 (1.7)	266	7 (2.6)	93	4 (4.3)
Endocrine and nutritional diseases								
Diabetes	1,540	52 (3.4)	507	31 (6.1)	326	28 (8.6)	158	18 (11.4)
Dehydration	2,073	8 (0.4)	953	7 (0.7)	697	4 (0.6)	213	0
Mental and behavioral disorders								
Alcohol intoxication	989	17 (1.7)	994	18 (1.8)	556	11 (2.0)	388	16 (4.1)
Diseases of the nervous system								
Transient ischemic attack	1,380	0	811	2 (0.3)	609	1 (0.2)	200	1 (0.5)
Diseases of the circulatory system								
Angina	2,191	25 (1.1)	1,000	14 (1.4)	616	11 (1.8)	408	7 (1.7)
Acute Myocardial Infarction	2,274	85 (3.7)	1,317	65 (4.9)	997	43 (4.3)	694	35 (5.0)
Atrial Fibrillation	3,707	23 (0.6)	1,170	8 (0.7)	889	8 (0.9)	354	2 (0.6)
Heart failure	1,645	27 (1.6)	535	29 (5.4)	300	13 (4.3)	207	12 (5.8)
Hypertension	1,173	3 (0.3)	487	3 (0.6)	329	1 (0.3)	136	1 (0.7)
Stroke	3,187	84 (2.6)	1,587	90 (5.7)	1,407	46 (3.3)	515	30 (5.8)
Diseases of the respiratory system								
Chronic Obstructive Pulmonary Disorder	2,869	91 (3.2)	1,273	65 (5.1)	926	44 (4.8)	545	37 (6.8)
Respiratory failure	1,120	152 (13.6)	559	74 (13.2)	414	81 (19.6)	224	38 (17.0)
Diseases of the digestive system								
Gastroenteritis	1,179	3 (0.3)	612	7 (1.1)	466	6 (1.3)	231	1 (0.4)
Symptoms and abnormal findings								
Syncope	1,554	4 (0.3)	1,195	8 (0.7)	865	3 (0.4)	336	3 (0.9)
Factors influencing health status								
Suspected Acute Myocardial Infarction	3,719	6 (0.2)	2,304	4 (0.2)	1,455	8 (0.6)	712	7 (1.0)
Other	44,758	860 (1.9)	22,5626	691 (3.1)	14,155	462 (3.3)	6,921	323 (4.7)
Total (within three days)	87,764	1,760 (2.0)	43,312	1,333 (3.1)	29,140	923 (3.2)	13,976	521 (4.4)
Total (complete length of hospital stay)		2,603 (3.0)		1,712 (4.0)		1,190 (4.1)		746 (5.3)

Table S4. Admission rates, age-and-sex standardized 30-day mortality and ICU admission within three days after the index date for the patients admitted through the emergency room

	Weekday		Weekend	
	Office hours (8.00 am-4.59 pm)	Off hours (5.00 pm-7.59 am)	Weekend daytime hours (9.00 am-9.59 pm)	Weekend nighttime hours (10.00 pm-8.59 am) plus Friday 10.00-11.59 pm and Monday 0.00-7.59 am
Total (n)	13,225	14,492	8,810	4,618
Hourly admission rate	5.83 (5.73-5.93)	4.46 (4.39-4.53)	6.00 (5.87-6.12)	2.60 (2.53-2.68)
Crude Mortality Age- and sex-standardized mortality	5.87 (5.47-6.26)	4.80 5.51 (5.11-5.90)	5.86 6.19 (5.68-6.69)	4.79 5.95 (5.20-6.70)
ICU n (%)	622 (4.70)	657 (4.53)	448 (5.09)	266 (5.76)

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