The quality and efficiency of care for older patients at the emergency department

The Quality and Efficiency of Care for OLDER PATIENTS at the EMERGENCY DEPARTMENT

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Chapter 1

General introduction

General introduction

"It is Thursday afternoon 4.30 pm, when I arrive at the emergency department (ED) with my 83-year old mother. Her general practitioner had just referred her, because she was feeling extremely tired and confused for several days. While the ED nurse was taking her to the examination room, she explained we will have to wait for a while, as it is quite busy in the ED. Luckily, she added that my mother was not that sick, as her vitals appeared normal. We had been waiting for an hour when a medical student examined my mother. The student went through her extensive medical history, which includes a stroke, type 2 diabetes mellitus, hypertension, mild cognitive impairment and osteoporosis, and the eight different medicines to manage these conditions. During the assessment, my mother was confused and did not answer the questions appropriately. After waiting for another hour, a doctor examined my mother for the first time. She noticed a difference in motor strength between the left and right extremities and therefore a neurologist needed to examine my mother as well. In addition, blood and urine tests and an electrocardiogram were ordered. Four hours after arrival in the ED, my mother was finally diagnosed with, what the doctor called, a severe salt deficit (hyponatraemia) due to the use of diuretics, which in retrospect explained all her symptoms. Ultimately, she was admitted to the acute medical ward for observation and further treatment."

Many healthcare professionals will recognize the complexity of the assessment of an older patient, as described above, in an already busy ED. One of the reasons is their atypical presentation of rather typical problems. In this thesis, we will elaborate on the challenging aspects of the ageing population in the ED.

Ageing

One of the major challenges of current health care, including the emergency department (ED), is ageing of the population. The average life expectancy for men in the Netherlands has risen from 75.5 to 80.2 years between 2000 and 2018, and for women from 80.6 to 83.3 years.[1] By 2030, the average life expectancy will be nearly 82 years for men and 85 years for women.[1] Furthermore, the proportion of people aged 65 years and older has increased from 15% to 19% between 2010 and 2019 and is expected to increase further to 23.5% in 2030.[1]

Although the life expectancy has increased over the past decades, the healthy life expectancy has decreased. Due to both advances in health care over the past decades and ageing of the population, the number of people living with chronic conditions has

increased considerably.[2] Previous research in the Dutch population revealed that 84% of the patients aged 75 years and older had one chronic condition and 59% had more than one chronic condition (multimorbidity).[3] Multimorbidity is associated with disability, poor quality of life and frequent health care use.[4] This ageing of society and increase in multimorbidity will have an important impact on the health care system in the Netherlands, including emergency care use.

The impact of ageing in the emergency department

The number of ED visits by older patients (≥65 years old) has increased considerably over the past decades. Currently, in The Netherlands, older patients account for up to 30% of all ED visits, with approximately 800,000 ED visits by older patients annually, resulting in 280,000 acute hospital admissions. [5] This number is expected to increase with 40% by 2030, leading to 1.1 million ED visits and 400,000 acute hospital admissions of older patients.[5] Older patients represent a complex population with specific health care needs, as they often have an atypical disease presentation, cognitive impairment, and communication problems.[6,7] Furthermore, they present with more severe illnesses, use more resources, and have a longer emergency department length of stay (ED-LOS) than younger patients.[8,9]

The ageing of the population, the increase in ED visits by older patients, and their distinct patterns of emergency care use cause specific challenges in the provision emergency care. EDs are often not able to meet the specific needs that are wanted to address the aforementioned challenges, because emergency care nowadays is mainly focused on rapid assessment and timely management of patients.[10] Consequently, this will increase the pressure on an already overburdened system and will have significant impact on emergency care organisations.[11] In addition, it appears that the current disease-oriented model in emergency care, focusing on a specific disease and its diagnostic work-up and treatment, does not appropriately address the needs of older patients.[12]

Adverse outcomes

In older patients, ED visits are associated with a high risk of adverse outcomes, such as loss of independence, institutionalisation, and mortality.[7,8] Moreover, ED visits are accompanied with great fears and worries in a majority of older patients and their caregivers, concerning their medical condition, the risk of dying and functional decline.[13] It is imperative to increase awareness among health care personnel on the risks for older patients associated with emergency care use. In order to prevent these

poor outcomes, mentioned previously, it is essential to identify older patients who are at highest risk for adverse outcomes.
Besides patient-related factors, such as multimorbidity, polypharmacy and an atypical disease presentation, there are organisational factors as well that influence emergency care processes and outcome of older patients.

In conclusion, the way the older population in the ED is approached should change, in order to adequately meet their needs regarding medical care and improve their experience and outcome.

Part I Organisational factors influencing emergency care

Several organisational factors affect emergency care processes of older patients (Figure 1.1) and may consequently influence emergency care services, resources and outcome for older patients.

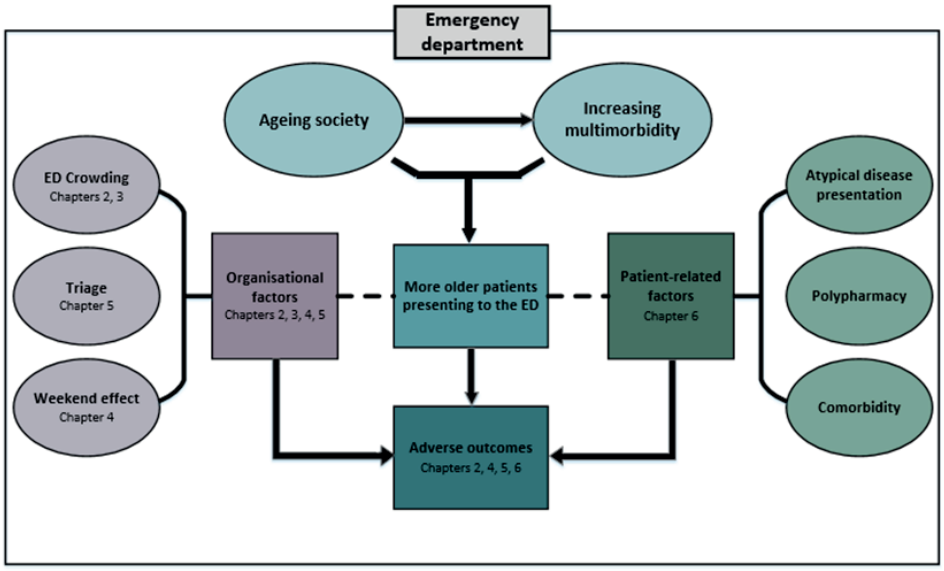

Figure 1.1 Overview of challenging aspects of the increase in older patients in the emergency department. ED = emergency department

ED crowding

Crowding is a major and persistent problem for emergency care around the world. ED crowding occurs when there is a mismatch between the demand for emergency services and the available resources at the ED or in the hospital.[14]

ED crowding is an important patient safety issue as it is associated with adverse outcomes, such as prolonged ED-LOS, patients who leave without being seen by a physician, ambulance diversions (diversion of ambulance-transported patients to other EDs), and delays in treatment.[15-17] Consequently, ED-LOS is considered an important indicator of the quality of emergency care[16,18,19] and prolonged ED-LOS is associated with poor patient outcomes, such as a higher mortality rate and reduced patient satisfaction.[20-22]

Older patients may contribute to ED crowding[23,24], bearing in mind their atypical disease presentation, presence of frailty and comorbid conditions, and the high prevalence of psychosocial problems. As such, they represent a complex population that requires an extensive more time-consuming diagnostic work-up with more specialty consultations, which consequently leads to a longer ED-LOS, which puts an extra strain on the emergency care system.

Model of ED crowding

The conceptual model of ED crowding distinguishes three components, which are input, throughput and output.[14]

Input encompasses any factor that adds to the demand for emergency care.[14] Several causes of crowding that affect the need for emergency services have been identified, such as the increased complexity of patients leading to higher triage levels, and a high volume of low urgency patients and limited access to primary care.[25]

Throughput comprises of factors that influence the ED-LOS of a patient. The throughput component can be divided in two phases. The first phase includes triage, and initial assessment by the physician and the second phase includes diagnostic evaluation and ED treatment.[14] Possible causes of ED crowding corresponding to throughput are an understaffed ED, placement of junior staff in the ED, and delay in diagnostic evaluation, including laboratory, radiology and specialty consultation.[25]

Output corresponds to the disposition of patients following the ED visit[14] , which can be broadly divided into discharge home, discharge to care facilities outside the hospital or hospital admission. Important causes of an inefficient output are a lack of follow-up care and the limited availability of staffed hospital beds leading to ED boarding (the inability to transfer admitted patients to a ward).[14]

ED crowding measures

Although ED crowding is an important logistical problem, a clear definition or gold standard does not exist. Consequently, the extent of ED crowding is difficult to assess. Given the association with adverse patient outcome and the impact on emergency care processes, several crowding measures have been developed, such as the occupancy rate and the Emergency Department Work Index (EDWIN).[26,27]

The occupancy rate is the ratio of the total number of ED patients to the total number of ED treatment beds per hour. However, the occupancy rate does not take patient acuity, an important factor contributing to the workload of ED personnel, into account.[19]

The EDWIN incorporates the number of ED patients per triage level (a measure of patient acuity), the number of admitted patients in the ED, the number of physicians and the number of staffed ED beds.[26]

Both the occupancy rate and the EDWIN have been developed and validated in the USA, with a different emergency care system compared to the Netherlands. For example, in the USA, the number of ED visits are higher, and ambulance diversions and ED boarding occur more often. Therefore, these crowding measures may not be generalizable to the health care system in the Netherlands.[14,25]

Weekend effect

EDs are equipped to offer around the clock care for acutely ill patients. However, during the weekend the (acute) care system is often organised differently, with fewer and less experienced personnel, and lower availability of diagnostic resources, such as radiology exams and procedures. Hospital admission during weekends is, in some studies, associated with poor patient outcomes, such as a higher mortality rate.[28-31] This has been labelled as the "weekend effect".[32]

Although there is limited evidence of a generalized "weekend effect", an intriguing hypothesis to explore would be whether older patients are more prone to develop adverse outcomes associated with the different organisation of acute care during the weekends, as they often require an extensive diagnostic work-up and treatment due to their complex medical and psychosocial problems.

Triage

The ED is a distinct setting under continuous time pressure, managing complex patients. A reliable and valid triage system to adequately prioritise patients presenting to the ED, based on the patients' severity of illness, is essential. The Manchester Triage

System (MTS), a five-level triage system is frequently used in the Netherlands to determine treatment priority.[33] However, research on the reliability of triage tools is difficult, as a golden standard for the assessment of patient urgency does not exist.
Older patients are at higher risk of being undertriaged and misdiagnosed than younger patients, which may be due to their atypical disease presentation and presence of multimorbidity, and possibly results in suboptimal treatment and adverse patient outcomes.[6,7,34] Given the vulnerability of this population, it is important to increase awareness regarding the performance of the a frequently used triage system, the MTS, in older patients.

Part II Patient-related factors influencing emergency care

Besides organisational factors, there are several patient-related factors, such as multimorbidity, polypharmacy and an atypical disease presentation, that affect emergency care for older patients (Figure 1.1). Although it is important to elaborate on patient-related factors, such as specific diseases that affect ED assessment of older patients, it is not feasible to study every medical problem of older patients presenting to the ED individually. Therefore, hyponatraemia was used to assess patient-related factors, as it is an important example of a frequently occurring condition in older patients in the ED with a complex and time-consuming diagnostic work-up.[35]

Hyponatraemia

Older patients are particularly susceptible to developing hyponatraemia due to the presence of multimorbidity with consequent polypharmacy and age-related physiological changes in electrolyte and water homeostasis.[36-38] The diagnostic work-up of hyponatraemia is challenging, particularly in older patients, and therefore, a systematic approach is essential.[39-41] More insight into the frequency, clinical presentation and treatment of hyponatraemia in older ED patients would be helpful in order to prevent adverse outcome in this already frail population.

Objective and outline of this thesis

In order to provide efficient and high-quality care for older patients in the ED, it is important to gain more insight into current emergency care processes. In this thesis, many of the above-mentioned knowledge gaps in the care for older patients in the ED are addressed (Figure 1.2).

The **first part** of this thesis focuses on the organisational aspects of emergency care for older patients.

In **chapter two,** we explore the hypothesis that ED-LOS is mainly influenced by organisational factors, such as number of diagnostic tests, seniority of ED physician, and number of specialty consultations, instead of medical factors, such as urgency level, comorbidity, polypharmacy and age. In addition, we hypothesize that the influence of organisational factors on prolonged ED-LOS is more prominent in older patients (aged ≥65 years old) than in younger, adult patients. Furthermore, we explored the effect of age on predictive factors of prolonged ED-LOS.

In **chapter three**, the applicability of the EDWIN as a measure to assess occupancy and fluctuations in occupancy at an ED in the Netherlands in order to gain more insight into ED crowding will be assessed. Furthermore, we explored the discriminatory value of the EDWIN in detecting ED crowding, compared with that of the occupancy rate and prolonged ED-LOS.

Previous studies demonstrated an association between the quality of care at the ED during weekends and adverse outcomes, which has been labelled as the "weekend effect". In **chapter four**, we investigated the effect of weekend admission following an ED visit on the outcome of older patients by assessing in-hospital and two-day mortality rates.

It is essential for EDs to use a reliable triage system to prioritise the clinical urgency of patients in order to provide timely and adequate care, especially in frail older patients. In the **fifth chapter,** the predictive ability of the Manchester Triage System (MTS) in older patients by evaluating ED resource utilisation (i.e., the number of diagnostic tests, medical procedures, medication administered and specialty consultations), ED-LOS, hospitalisation, and in-hospital mortality will be assessed.

The **second part** of this thesis focuses on patient-related factors influencing emergency care and we used a common medical problem in older patients associated with an atypical disease presentation and difficult diagnostic work-up as lead example. We focused on hyponatraemia, as it is a frequently occurring electrolyte disturbance with severe consequences, particularly in older patients. Previous studies have demonstrated that even mild hyponatraemia is associated with important complications such as falls, which is especially relevant in frail older patients. In **chapter**

six, we explore the prevalence, presentation, treatment, and outcome of older patients with clinically relevant hyponatraemia presenting to the ED.
Finally, **chapter seven** encompasses a summary and discussion of the main findings. In addition, we discuss the implications of the main findings on emergency care for older patients and future perspectives in order to optimise assessment and treatment of this frail population.

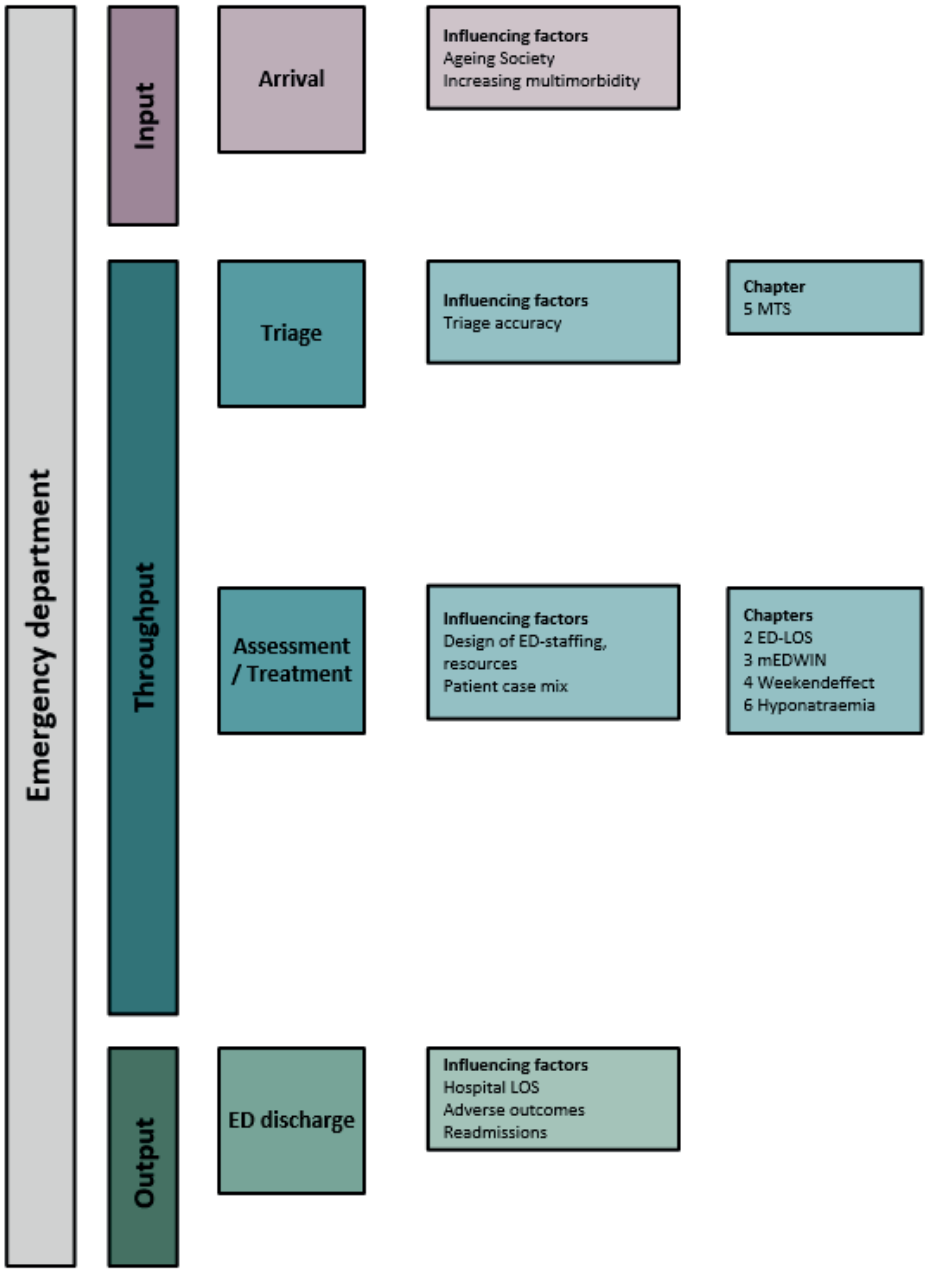

Figure 1.2 Overview of this thesis.
ED-LOS = emergency department length of stay; MTS = Manchester Triage System; ED = emergency department; mEDWIN = modified emergency department work index; LOS = length of stay.

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Part I

Organisational factors influencing emergency care

Chapter 2

Organisational factors induce prolonged emergency department length of stay in elderly patients - A retrospective cohort study

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Abstract

Study objective

To assess the association of patient and organisational factors with emergency department length of stay (ED-LOS) in elderly ED patients (≥65 years old) and in younger patients (<65 years old).

Methods

A retrospective cohort study of internal medicine patients visiting the emergency department between September 1st 2010 and August 31st 2011 was performed. All emergency department visits by internal medicine patients ≥65 years old and a random sample of internal medicine patients <65 years old were included. Organisational factors were defined as non-medical factors. ED-LOS is defined as the time between ED arrival and ED discharge or admission. Prolonged ED-LOS is defined as ≥75th percentile of ED-LOS in the study population, which was 208 minutes.

Results

Data on 1782 emergency department visits by elderly patients and 597 emergency department visits by younger patients were analysed. Prolonged ED-LOS in elderly patients was associated with three organisational factors: >1 consultation during the emergency department visit (odds ratio (OR) 3.2, 95% confidence interval (CI) 2.3-4.3), a higher number of diagnostic tests (OR 1.2, 95% CI 1.16-1.33) and evaluation by a medical student or non-trainee resident compared with a medical specialist (OR 4.2, 95% CI 2.0-8.8 and OR 2.3, 95% CI 1.4-3.9). In younger patients, prolonged ED-LOS was associated with >1 consultation (OR 2.6, 95% CI 1.4-4.6). Factors associated with shorter ED-LOS were arrival during nights or weekends as well as a high urgency level in elderly patients and self-referral in younger patients.

Conclusion

Organisational factors, such as a higher number of consultations and tests in the emergency department and a lower seniority of the physician, were the main aspects associated with prolonged ED-LOS in elderly patients. Optimisation of the organisation and coordination of emergency care is important to accommodate the needs of the continuously growing number of elderly patients in a better way.

Background

The Emergency Department (ED) manages complex patient populations and is under continuous time pressure.[1,2] The increase in the number of ED visits over the past decade has resulted in ED crowding.[3-5] In particular, the substantial growth of ED visits by elderly patients (≥65 years old) has placed a heavy burden on the acute care system.[6-9]

ED crowding leads to prolonged emergency department length of stay (ED-LOS), delay in treatment and a worse medical outcome, such as a longer hospital stay and a higher mortality rate.[3,5,8,10-12] In addition, prolonged ED-LOS reduces patient satisfaction and has a negative impact on the quality of care and the adherence to ED guidelines.[3,13] Therefore, ED-LOS is marked as an important quality indicator of emergency care.[14-18]

The association of prolonged ED-LOS with poor patient outcome has been studied in various settings and patient groups, demonstrating diverse results.[19-22] As to whether the patients' age has an effect on ED-LOS remains unclear from previously published reports. ED-LOS has been reported to exceed 4 hours in 26% of elderly patients and in 11% of patients aged 18-64 years.[23] In contrast, a large prospective study showed no association between prolonged ED-LOS and age.[24]

Elderly patients represent a complex population in the ED, owing to a sometimes atypical presentation and to the presence of multi-morbidity.[25] In addition, they often have high urgency problems and are frequently transported by ambulance.[26,27] In elderly patients, an ED visit may prelude functional decline. The average 30-day mortality rate of elderly patients following an ED visit is 10%.[25,28] Given the anticipated increasing size of this vulnerable population presenting to the ED, it is necessary to avoid prolonged ED-LOS in order to maintain and improve patient outcome and quality of care at the ED. Our hypotheses are that ED-LOS is mainly influenced by organisational factors instead of disease-related factors and that the influence of organisational factors on prolonged ED-LOS is more prominent in elderly patients than in younger patients (<65 years old).

The objectives of this study are to assess the association of medical factors and organisational factors with ED-LOS in elderly patients and to explore the effect of age on predicting factors of prolonged ED-LOS.

Methods

Study design, setting and participants

Exemption of approval by the Institutional Review Board of Máxima Medical Centre (MMC) was acquired. A retrospective cohort study was conducted at MMC, a 550-bed teaching hospital in the Netherlands. Approximately 28,000 patients visit the ED of Máxima Medical Centre annually, of which 13-14% requires assessment by an internist. Most patients for internal medicine are referred to the ED by a general practitioner (GP, who provide service 24/7) (51.8%), while others are referred by ambulance (10.9%), are referred by medical specialists (8.5%), or are self-referrals (28.8%). Either a medical student in the last year of medical education, a non-trainee resident (physicians who have not yet started traineeship in a clinical speciality), a trainee resident or an emergency physician will assess the patients presenting to the ED, supervised by an internist.[29]

Data on all ED visits of patients ≥65 years old, referred to the ED for internal medicine between September 1st 2010 and August 31st 2011, were extracted according to a fixed data collection form by one investigator. A sample of patients <65 years old, presenting to the ED for internal medicine, was randomly obtained from the ED visit list by the random SPSS procedure (IBM SPSS Statistics for Windows, Version 19.0, Armonk, New York). The sample population of younger patients was comparable with the total population of younger patients in terms of age, gender, day of ED presentation, time of ED presentation, mode of presentation, triage category and final disposition, as visually checked with descriptive statistics and tested using Chi-square and unpaired T-tests. Exclusion criteria were an overt incorrect ED recording time or a principle treating specialty in the ED other than internal medicine.

Data sources and variables

Baseline and medical data were retrospectively retrieved from electronic patient and hospital records using standard data-collection forms. Data included age, gender, medical history, medication use, ED visits and hospitalisation in the previous three months, triage level, presenting complaint and ED diagnosis. Organisational factors, defined as non-medical factors, included day of the week and time of ED visit, mode of presentation, seniority of the first physician who assessed/treated the patient in the ED, number and type of diagnostic tests, number of consultations by medical specialties other than internal medicine at the ED, number medical procedures performed in the ED and number medication administered during the ED stay. In addition, we retrieved

ED recording times, final disposition, date of admission and discharge, and date of last follow-up and date of death.

Definitions

In absence of a definition of prolonged ED-LOS in the literature, prolonged ED-LOS was defined as a length of stay that lasted longer than the 75th percentile of ED-LOS in the total study population (elderly and younger patients), which was an ED-LOS ≥208 minutes. Medical history and presenting complaint, as documented in the patient ED records, were classified according to the International Classification of Disease-10 (ICD-10). The ICD-10 category "Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified" was classified as aspecific complaints. The following ICD-10 categories were combined into the group "miscellaneous": diseases of the musculoskeletal system, genitourinary system, eye and adnexa, ear and mastoid process, skin and subcutaneous tissue, injury or poisoning, and external causes of morbidity and mortality (see Supplemental file). The Charlson Co-morbidity index (CCI) was calculated to assess the comorbidity levels of the patients.[30] Polypharmacy was defined as the use of five or more different medications.[31] Time of presentation was classified as morning (7.00-11.59h), afternoon (12.00-16.59h), evening (17.00-23.59h) and night (0.00-6.59h). Mode of presentation was categorised into referral by a GP, ambulance or medical specialist and self-referral. ED recording times (in minutes) were sectioned into 1) time in waiting room: time from ED arrival to ED bed placement, 2) time to triage: time from ED arrival to assignment of a triage category, 3) treatment time: time from ED bed placement to final disposition and 4) ED-LOS: time between ED arrival and ED discharge or hospital admission. Triage at presentation was performed using the Manchester Triage System (MTS).[32] Urgency levels were classified as high (MTS categories red and orange), moderate (MTS category yellow) and standard (MTS category green and blue). The seniority of the first physician was classified as medical student in last year of medical education, non-trainee resident, trainee resident or medical specialist (internist or emergency physician).[33] Diagnostic tests performed at the ED comprised of a blood test, an arterial blood-gas test, a urine test, a culture test, an electrocardiogram (ECG), an X-ray, ultrasonography, computed tomography (CT) scan or magnetic resonance imaging (MRI). Medical procedures consisted of intubation, placement of urinary catheter or gastric tube, cardiac rhythm monitoring and administration of oxygen. Prolonged hospital LOS was defined as a stay that lasted longer than the 75th percentile of hospital LOS from ED discharge until hospital discharge, as calculated for all patients that were hospitalised, which was ≥12 days.

Statistical analysis

Statistical analysis was performed using SPSS version 19.0. Comparisons of the characteristics of patients ≥65 years old and patients <65 years old were tested using the Chi-square test for categorical variables. The numerical variables were tested using one-way analysis of variance (ANOVA), the Kruskal-Wallis test, Mann-Whitney U-test, and unpaired T-test, depending on the number of groups and the distribution pattern of the variable. Missing data were categorised as "unknown" and included in the analyses to assess the influence of missing data on ED-LOS. Univariable and multivariable logistic regression analyses were performed in order to estimate the effect of various factors on prolonged ED-LOS and to calculate the odds ratio (OR) with 95% confidence intervals (CI). Multivariable analysis was done to calculate adjusted OR (ORadj) and included all variables from the univariable analysis associated with prolonged ED-LOS with a p-value of ≤0.05. A two-sided p-value <0.05 was considered statistically significant.

Results

Study population

In the study period, 4137 ED visits by internal medicine patients were recorded, of which 1784 visits (43.1%) were made by 1435 elderly patients (Figure 2.1). Two ED visits by elderly patients were excluded because of inaccurate ED recording times. In the same period, 2353 ED visits were by younger patients, of which 597 (25%) visits made by 564 patients were randomly selected (Figure 2.1).

Baseline characteristics and medical factors

The sex distribution was similar for both the elderly and younger patients visiting the ED (Table 2.1). Elderly patients had more comorbidity (CCI 2.5 vs. 1.0, p<0.001) and more prevalent polypharmacy (57.7 vs. 17.1%, p<0.001) than younger patients (Table 2.1). They also had visited the ED (28.3 vs. 21.1%, p<0.001) more often and were hospitalised (28.1 vs. 14.2%, p<0.001) more often in the three months before the ED visit than younger patients. In total, 1100 (61.7%) elderly patients presented with aspecific complaints, of whom 11.0% had a high urgency level, 57.6% moderate, 30.7% standard, and 0.6% were not classified. In younger patients with aspecific complaints (65.3%), 6.4% had a high urgency level, 54.1% moderate, 36.9% low, and 2.6% were not classified.

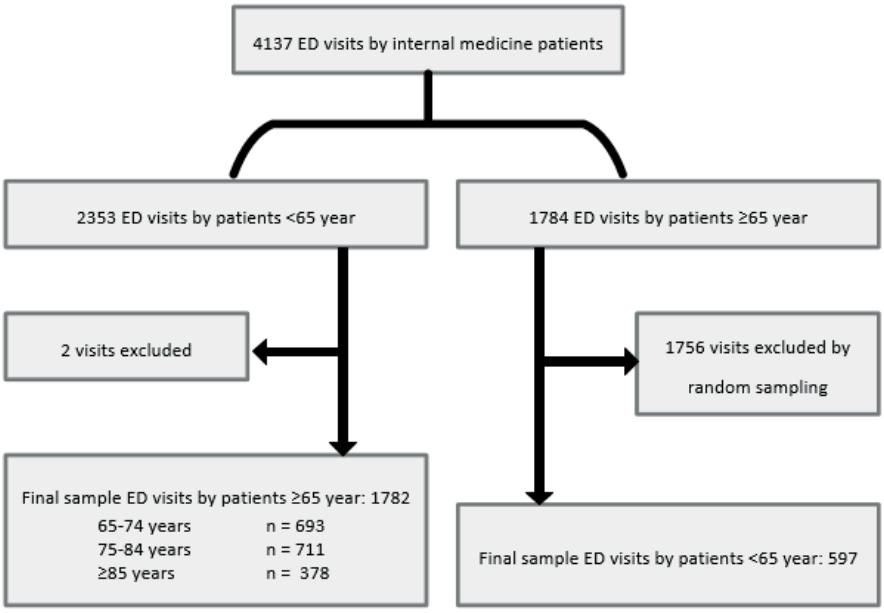

Figure 2.1 Flow chart of the studied population.
ED = emergency department

Organisational factors

Elderly patients were referred by their GP in 71.3% of cases compared with only 38.2% in younger patients (Table 2.1). In both age groups, most patients presented to the ED on Friday (16.4% in elderly and 17.6% in younger patients). The diagnostic work-up in the ED was more extensive for elderly patients (mean 3.2 tests in elderly patients vs. 2.1 in younger patients, p<0.001). Elderly patients more often received medication (42.8 vs. 35.9%, respectively, p=0.011) and underwent medical procedures (41.9 vs. 26.5%, respectively, p<0.001) at the ED than younger patients. In 72.9% of elderly patients, the ED visit resulted in hospital admission, compared with 38.7% of younger patients (p<0.001). If hospitalised, the median hospital LOS was 6 days in elderly patients (range 1-91) and 3 days (range 1-89) in younger patients (p<0.001).

ED recording times

The median ED-LOS was 172 minutes in elderly patients (range 6-542), compared with 147 minutes for younger patients (range 3–413, p<0.001) (Figure 2.2). Among elderly patients, 27.1% experienced a prolonged ED-LOS (i.e. ED-LOS ≥208 min), compared with

20.3% for younger patients (p=0.002). The ED-LOS exceeded 4 hours in 16.3% of elderly patients and 11.2% of patients <65 years (p=0.003). The median treatment time for elderly patients was 158 minutes versus 130 minutes for younger patients (p<0.001). Both the time spent in the waiting room (5 vs. 2 minutes, p<0.001) and time to triage (10 vs. 9 minutes, p=0.011) were longer in elderly patients than in younger patients.

Table 2.1 Characteristics of emergency department visits by internal medicine patients.

Characteristic	**ED visit by elderly patients (n=1782)**	**ED visit by younger patients (n=597)**
Mean (SD) age, years	77.5 (7.7)	43.5 (14)
No. of male participants (%)	824 (46.2)	281 (47.1)
Mean (SD) CCI**	2.5 (2.2)	1.0 (1.7)
Polypharmacy (%)**	1028 (57.7)	102 (17.1)
No. of ED visit in previous 3 months (%)**	505 (28.3)	126 (21.1)
No. of admissions in previous 3 months (%)**	501 (28.1)	85 (14.2)
No. of patients per day of presentation		
Weekday (%) *	1386 (77.8)	427 (71.5)
Weekend (%) *	396 (22.2)	170 (28.5)
No. of patients per time of presentation		
Morning (%)**	368 (20.6)	117 (19.6)
Afternoon (%)**	750 (42.0)	195 (32.7)
Evening (%)**	532 (29.9)	193 (32.3)
Night (%)**	132 (7.4)	92 (15.4)
No. of patients per mode of presentation		
GP referral (%)**	1270 (71.3)	228 (38.2)
Medical specialist (%)**	153 (8.6)	59 (9.9)
Ambulance (%)**	158 (8.9)	70 (11.7)
Self-referral (%)**	201 (11.3)	240 (40.2)
Urgency level		
High (%)**	207 (11.6)	59 (9.9)
Moderate (%)**	960 (53.9)	311 (52.1)
Standard (%)**	603 (33.8)	193 (32.3)
No triage (%)**	12 (0.7)	34 (5.7)
Seniority of first physician on ED		
Medical student (%)**	51 (2.9)	9 (1.5)
Non-trainee resident (%)**	558 (31.3)	175 (29.3)
Trainee resident (%)**	1039 (58.3)	326 (54.6)
Medical specialist (%)**	110 (6.2)	63 (10.6)
Unknown (%)**	24 (1.3)	24 (4.0)
Mean no. (SD) diagnostic tests on ED**	3.2 (1.8)	2.1 (1.6)
Medication on ED (%)*	762 (42.8)	214 (35.9)
Medical procedures on ED (%)**	746 (41.9)	158 (26.5)
No. of admissions (%)**	1299 (72.9)	231 (38.7)

P-values were calculated using unpaired T-test and Chi-square test. SD = standard deviation; ED = emergency department; mo = months; CCI = Charlson co-morbidity index. * =0.001<p<0.05; ** =p<0.001.

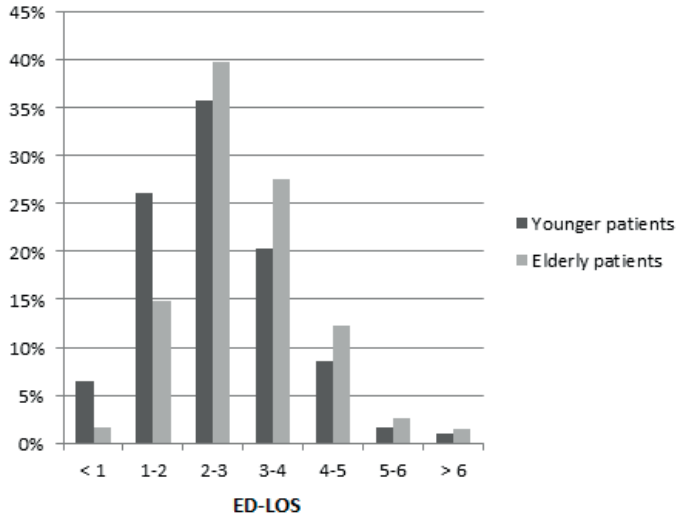

Figure 2.2 Emergency department length of stay per hour for elderly patients and younger patients. ED-LOS = Emergency department length of stay.

Determinants of prolonged ED-LOS

Baseline characteristics and medical factors

In the elderly, a moderate urgency level (compared with a standard urgency), was associated with prolonged ED-LOS (OR 1.3, 95% CI 1.01-1.59). Unknown medical history (versus no medical history) was associated with a lower risk of prolonged ED-LOS (OR 0.2, 95% CI 0.1-0.9) (Table 2.2). Over a quarter (27.6%) of elderly patients with aspecific complaints had a prolonged ED-LOS. The triage level distribution in those patients was similar to those without prolonged ED-LOS. The presence of cognitive impairment (e.g. dementia or delirium) was not associated with prolonged ED-LOS in elderly patients (OR 1.3, 95% CI 0.9-1.8), nor was the presence of polypharmacy or the presenting complaint (Table 2.2).

In younger patients, polypharmacy (OR 1.7, 95% CI 1.1-2.9), previous hospital admission (OR 1.7, 95% CI 1.02-2.87), and a presenting complaint classified as “miscellaneous” (OR 0.5, 95% CI 0.3-0.8) rather than aspecific complaints were associated with prolonged ED-LOS (Table 2.2). In younger patients with aspecific complaints, 23.4% had a prolonged ED-LOS, of which 63.7% had a moderate urgency level and 31.9% a standard.

Organisational factors

Risk of prolonged ED-LOS was lower for elderly patients who arrived over the weekend compared to those arriving on a weekday (OR 0.7, 95% CI 0.5-0.9). Similarly, the risk of prolonged ED-LOS was lower during the night (OR 0.4, 95% CI 0.2-0.6) than the morning. The risk was also lower if the patient was referred by a medical specialist (OR 0.66, 95% CI (0.44-0.99) or self-referral (OR 0.6, 95% CI 0.4-0.9), compared with referral by a GP (Table 2.3).
In both elderly and younger patients, more diagnostic tests performed on the ED (OR 1.2, 95% CI 1.1-1.3 and OR 1.3, 95% CI 1.1-1.5), >1 consultation (OR 2.7, 95% CI 2.0-3.6 and OR 2.6, 95% CI 1.5-4.5) and lower seniority of physician (OR 1.7, 95% CI 1.1-2.9 and OR 2.4, 95% CI 1.04-5.79 when evaluated by a non-trainee resident) at the ED were associated with prolonged ED-LOS. Younger patients arriving by ambulance or after self-referral had a shorter ED-LOS (OR 0.4, 95% CI 0.2-0.9 and OR 0.4, 95% CI 0.3-0.7, respectively).

Multivariable analysis of factors associated with prolonged ED-LOS

The only baseline or medical characteristic associated with prolonged ED-LOS in elderly patients after multivariable adjustment for other variables was a high urgency level (ORadj 0.4, 95% CI 0.2-0.6) versus a standard urgency level (Table 2.4).
However, several organisational factors were associated with prolonged ED-LOS in elderly patients, including, > 1 consultation (ORadj 3.1, 95% CI 2.3-4.2), the number of diagnostic tests (ORadj 1.2, 95% CI 1.1-1.3) and evaluation by a medical student or non-trainee resident (ORadj 4.2, 95% CI 2.0-8.8 and ORadj 2.3, 95% CI 1.4-3.9, respectively) (Table 2.4). Weekend or night-time arrivals were associated with shorter ED-LOS in elderly patients (ORadj 0.7, 95% CI 0.5-0.9 and ORadj 0.4, 95% CI 0.2-0.7, respectively).
In younger patients, the number of consultations and self-referral remained associated with prolonged ED-LOS in the multivariable analysis (ORadj 2.6, 95% CI 1.5-4.7 and ORadj 0.6, 95% CI 0.35-0.99, respectively) (Table 2.4).

Table 2.2 Unadjusted data on the impact of baseline characteristics and medical factors on emergency department length of stay.

	Elderly patients			Younger Patients		
	ED-LOS <208 min (*n*=1299)	**ED-LOS ≥208 min (*n*=483)**	**OR (95% CI)**	**ED-LOS <208 min (*n*=474)**	**ED-LOS ≥208 min (*n*=123)**	**OR (95% CI)**
Female vs. male (%)	692 (53.3)	266 (55.1)	1.1 (0.9–1.3)	250 (52.7)	66 (53.7%)	1.0 (0.7–1.5)
Medical history						
Cognitive impairment (%)	128 (9.9)	59 (12.2)	1.3 (0.9–1.8)	4 (0.8)	-	-
Unknown medical history (%)	25 (1.9)	2 (0.4)	0.2 (0.1–0.9)*	58 (12.2)	10 (8.1)	0.6 (0.3–1.3)
Mean (SD) CCI	2.46 (2.2)	2.45 (2.2)	1.0 (0.95-1.05)	0.97 (1.7)	0.96 (1.7)	1.0 (0.9–1.1)
Polypharmacy						
Yes vs. no (%)	727 (56.0)	301 (62.3)	1.3 (0.99–1.59)	71 (15.0)	31 (25.2)	1.7 (1.1–2.9)*
Unknown vs. no (%)	167 (12.9)	48 (9.9)	0.9 (0.6–1.3)	99 (20.9)	16 (13.0)	0.6 (0.4–1.2)
Previous ED visit						
Yes vs. no visit (%)	378 (29.1)	127 (26.3)	0.9 (0.7–1.1)	99 (20.9)	27 (22.0)	1.0 (0.6–1.7)
Unknown vs. no visit (%)	15 (1.2)	2 (0.4)	0.3 (0.8–1.5)	14 (3.0)	2 (1.6)	0.5 (0.1–2.5)
Previous admission						
Yes vs. no admission (%)	378 (29.1)	123 (25.5)	0.82 (0.65–1.04)	60 (12.7)	25 (20.3)	1.71 (1.02–2.87)*
Unknown vs. no admission (%)	13 (1.0)	-	-	15 (3.2)	1 (0.8)	-
Presenting complaint						
Aspecific complaints (%)	797 (61.4)	303 (62.7)	Reference	299 (63.1)	91 (74.0)	Reference
Endocrine/metabolic (%)	84 (6.5)	25 (5.2)	0.9 (0.5–1.3)	13 (2.7)	2 (1.6)	0.5 (0.1–2.3)
Circulatory (%)	82 (6.3)	31 (6.4)	1.0 (0.6–1.5)	22 (4.6)	7 (5.7)	1.0 (0.4–2.5)
Gastrointestinal (%)	54 (4.2)	22 (4.6)	1.1 (0.6–1.8)	12 (2.5)	4 (3.3)	1.1 (0.3–3.5)
Neoplasm/hematologic (%)	43 (3.3)	16 (3.3)	1.0 (0.5–1.8)	4 (0.8)	1 (0.8)	-
Respiratory (%)	39 (3.0)	13 (2.7)	0.9 (0.5–1.7)	6 (1.3)	1 (0.8)	-
Infectious (%)	38 (2.9)	8 (1.7)	0.6 (0.3–1.2)	7 (1.5)	1 (0.8)	-
Psychiatric/neurologic (%)	34 (2.6)	14 (2.9)	1.1 (0.6–2.0)	3 (0.6)	1 (0.8)	-
“Miscellaneous” complaints (%)	128 (9.9)	51 (10.6)	1.0 (0.7–1.5)	108 (22.8)	15 (12.2)	0.5 (0.3–0.8)*
Urgency level						
High (%)	167 (12.9)	40 (8.3)	0.7 (0.48-1.04)	51 (10.8)	8 (6.5)	0.6 (0.3-1.4)
Moderate (%)	671 (51.7)	289 (59.8)	1.3 (1.01-1.59)*	239 (50.4)	72 (58.5)	1.2 (0.8-1.9)
Standard (%)	450 (34.6)	153 (31.7)	Reference	154 (32.5)	39 (31.7)	Reference
No triage (%)	11 (0.8)	1 (0.2)	-	30 (6.3)	4 (3.3)	0.5 (0.2-1.6)

ED-LOS = Emergency Department Length Of Stay; min = minutes; OR = Odds Ratio; CI = Confidence Interval; CCI = Charlson Comorbidity Index; SD = standard deviation. * =0.001<p<0.05; ** =p<0.001.

Table 2.3 Unadjusted data on the impact of organisational factors on emergency department length of stay.

	Elderly patients			Younger patients		
	ED-LOS <208 min (n=1299)	**ED-LOS ≥208 min (n=483)**	**OR (95% CI)**	**ED-LOS <208 min (n=474)**	**ED-LOS ≥208 min (n=123)**	**OR (95% CI)**
Weekend vs. week (%)	312 (24.0)	84 (17.4)	0.7 (0.5–0.9)*	134 (28.3)	36 (29.3)	1.1 (0.7–1.6)
Time of presentation						
Morning (%)	257 (19.8)	106 (21.9)	Reference	94 (19.8)	26 (21.1)	Reference
Afternoon (%)	513 (39.5)	228 (47.2)	1.1 (0.8–1.4)	148 (31.2)	52 (42.3)	1.3 (0.7–2.2)
Evening (%)	421 (32.4)	133 (27.5)	0.8 (0.57–1.03)	163 (34.4)	35 (28.5)	0.8 (0.4–1.4)
Night (%)	108 (8.3)	16 (3.3)	0.4 (0.2–0.6)**	69 (14.6)	10 (8.1)	0.5 (0.2–1.2)
Mode of presentation						
General practitioner (%)	898 (69.1)	372 (77.0)	Reference	162 (34.2)	66 (53.7)	Reference
Medical specialist (%)	120 (9.2)	33 (6.8)	0.66 (0.44–0.99)*	48 (10.1)	11 (8.9)	0.6 (0.3–1.2)
Ambulance (%)	122 (9.4)	36 (7.5)	0.7 (0.5–1.1)	60 (12.7)	10 (8.1)	0.4 (0.2–0.9)*
Self-referral (%)	159 (12.2)	42 (8.7)	0.6 (0.4–0.9)*	204 (43.0)	36 (29.3)	0.4 (0.3–0.7)**
>1 vs. 1 consultation on ED (%)	127 (9.8)	109 (22.6)	2.7 (2.0–3.6)**	42 (8.9)	25 (20.3)	2.6 (1.5–4.5)**
Seniority of physician on ED						
Medical student (%)	26 (2.0)	25 (5.2)	3.6 (1.8–7.4)**	7 (1.5)	2 (1.6)	2.3 (0.4–13.3)
Non-trainee resident (%)	382 (29.4)	176 (36.4)	1.7 (1.1–2.9)*	134 (28.3)	41 (33.3)	2.4 (1.04–5.79)*
Trainee resident (%)	780 (60.0)	259 (53.6)	1.3 (0.8–2.0)	255 (53.8)	72 (58.5)	2.3 (0.99–5.17)
Medical specialist (%)	87 (6.7)	23 (4.8)	Reference	56 (11.8)	7 (5.7)	Reference
Unknown (%)	24 (1.8)	-	-	22 (4.6)	1 (0.8)	-
No of diagnostic tests on ED (SD)	3.01 (1.8)	3.58 (1.6)	1.2 (1.1–1.3)**	2.01 (1.5)	2.67 (1.6)	1.3 (1.1–1.5)**
Medical procedures at ED (%)	545 (42.0)	201 (41.6)	1.0 (0.8–1.2)	125 (26.4)	33 (26.8)	1.0 (0.7–1.6)
Medication at ED (%)	539 (41.5)	223 (46.2)	1.2 (0.98–1.50)	166 (35.1)	48 (39.0)	1.2 (0.8–1.8)
Admissions (%)	922 (71.0)	377 (78.1)	1.5 (1.1–1.9)*	169 (35.7)	62 (50.4)	1.8 (1.2–2.7)*

ED-LOS = emergency department length of stay; min = minutes; OR = odds ratio; CI = Confidence interval. * =0.001<p<0.05; ** =p<0.001.

Table 2.4 Medical and organisational factors with significant impact on emergency department length of stay after multivariable analysis.

	Elderly patients ORadj (95% CI)	Younger patients ORadj (95% CI)
High urgency level	0.4 (0.2–0.6)**	-
Weekend arrival	0.7 (0.5–0.9)*	-
Arrival during night time	0.4 (0.2–0.7)*	-
Self-referral	-	0.59 (0.35–0.99)*
>1 consultation on ED	3.1 (2.3–4.2)**	2.6 (1.5–4.7)*
Seniority of first physician on ED		
Medical student	4.2 (2.0–8.8)**	-
Non-trainee resident	2.3 (1.4–3.9)*	-
Mean no. of diagnostic tests on ED	1.2 (1.1–1.3)*	-

ED-LOS = emergency department length of stay; ORadj = adjusted odds ratio; CI = confidence Interval. * =0.001<p<0.05; ** =p<0.001.

Correlation between hospital admission, placement and ED-LOS

The median ED-LOS for elderly patients discharged home was shorter than for those who were hospitalised (158 and 175 minutes, respectively, p<0.001). The ED-LOS was comparable for both elderly and younger patients if admitted to an ICU (intensive care unit) or medium-care unit, as compared with admission to the acute medical unit or general ward (OR 1.2, 95% CI 0.6-2.3 and OR 2.8, 95% CI 0.8-9.8, respectively).
If admitted, the median hospital LOS in elderly patients was longer if ED-LOS was prolonged rather than normal (8 days (range 1-91) vs. 6 days (range 1-74), p<0.001). In younger patients, as well, the median hospital LOS was longer in patients with prolonged ED-LOS than in those with a normal ED-LOS of 5 days (range 1-41) versus 2 days (range 1-89, p=0.001). Accordingly, a prolonged hospital LOS (i.e. a hospital LOS ≥12 days) occurred more frequently in elderly patients with prolonged ED-LOS than in those with normal ED-LOS (35.0 vs. 24.7%, OR 1.6, 95% CI 1.3-2.1). Similarly, in younger patients with prolonged ED-LOS, a prolonged hospital LOS occurred more frequently than in those with normal ED-LOS (22.6 vs. 10.7%, OR 2.4, 95% CI 1.1-5.3).

Discussion

In this study, we have demonstrated that the ED-LOS is considerably longer (30 minutes) in elderly internal medicine patients than in younger patients. The effect of organisational factors on the ED-LOS, such as the number of consultations, number of diagnostic tests performed at the ED and the seniority of the physician, is more evident in elderly patients than in the younger group.

The proportion of patients with a prolonged ED-LOS, for research purpose defined as the 75th percentile of ED-LOS (i.e. ED-LOS ≥208 minutes), is higher in the elderly. Moreover, 16.3% of the elderly patients have an ED-LOS exceeding 4 hours, which is predominately caused by organisational factors and its effect on the treatment time of elderly patients.

Our study shows a clear relationship between the ED-LOS and organisational factors. In accordance with other studies, the number of investigations performed at the ED significantly increased the ED-LOS for elderly patients.[25-27,34] Although an extensive diagnostic work-up during ED visits is becoming customary, particularly in elderly patients, it has important implications for emergency care processes.[35] Additionally, the number of consultations involved at the ED is an important contributor to prolonged ED-LOS in the elderly, which is consistent with a study by Vegting et al.[23] In our study, almost 50% of elderly patients with multiple consultations at the ED has an ED-LOS exceeding 4 hours, which may reflect the complexity of the elderly population.

Apart from a beneficial effect on ED-LOS of more staffing at the ED, as reported before,[36] the type of physician appears to be of special importance. Our study shows that the lower seniority of the first treating physician at the ED is a significant determinant for the prolonged ED-LOS in elderly patients. This indicates that experience and education of the ED doctors plays an important role in the occurrence prolonged ED-LOS, especially in the elderly.[26,27]

Although resources and staffing levels are usually reduced on weekends and during the night,[37-41] our data show a positive association between ED-LOS and temporal factors, such as day or time of ED arrival, in elderly patients. This might be explained by the number of patients presenting at our ED, as this is considerably lower on weekends or during the night, suggesting that the number of patients at the ED may contribute more to the prolonged ED-LOS of elderly patients than the availability of resources or ED personnel.[37,39]

A remarkable result is the lack of association between ED-LOS in elderly patients and medical or baseline factors, such as CCI, medication use, and presenting complaint. In addition, the presence of cognitive impairment in elderly patients does not affect ED-LOS. These findings contradict other reviews, in which factors such as comorbidity, atypical presentation and polypharmacy were mentioned to be of major influence in ED evaluation of elderly patients.[26,27] The only medical factor in elderly patients with influence on ED-LOS in our population is a high urgency level, which is associated with a shorter ED-LOS. This is also in contrast with other studies that found prolonged ED-LOS in critically ill patients.[14,34,42] This discrepancy can be explained by the presence of an access block to the ICUs in these studies, caused by the inability to transfer admitted ED patients to ICU beds, which hardly occurs in our hospital.

Another main finding in our study is the difference in impact of organisational factors on ED-LOS between elderly and younger patients. Although several organisational factors contribute to prolonged ED-LOS in the elderly, only multiple consultations in the ED were associated with prolonged ED-LOS in the younger patient group. There is no association between the seniority of the physician, number of tests performed or temporal factors and ED-LOS in younger patients. On the other hand, in younger self-referred patients, the ED-LOS is significantly shorter. These patients typically have no need for diagnostic work-up (25.4%), require only one consultation at the ED (91.2%), and are discharged following the ED visit (80%). Hence, it is predominantly the elderly population that affects the emergency care processes at our ED, as is consistent with other studies.[12,24,34,43]

Limitations

Our findings may have been influenced by several limitations. Firstly, owing to the single-centre setting, our findings may be less applicable to other hospitals and other countries. Although the healthcare system is well organised in the Netherlands, the organisation of emergency care in other countries should be taken into account in interpreting our findings. As a consequence our study may not address some of the problems encountered in other settings. Nevertheless, the findings of our study may very apply to other settings and explain part of the problems. Secondly, there is a risk of bias, because of the retrospective observational design. It is possible that part of the data were incomplete or incorrect, such as for example ED recording times. However, we have no reason to believe that the resulting misclassification is differential except for extreme short visits, which may have more missing data than longer visits. Random misclassification of determinants may have diluted contrasts. The reference category of the presenting complaints, being the largest group, comprised a range of signs and symptoms, which may have introduced noise. The effect of missing values for the ED-LOS was evaluated by including these in the analyses. Overall, more data was missing in younger patients than in elderly patients, yet missing data was not associated with a shorter ED-LOS. Thirdly, the relatively small number of younger patients may contribute to a reduced reliability of our results, due to lack of power. Fourthly, in the absence of a generally accepted definition of prolonged ED-LOS, we based the definition of prolonged ED-LOS for our study on the upper quartile of recorded times in the entire population studied. Although, the relevance of ED-LOS >208 minutes is uncertain, it is useful for the identification of risk factors. Lastly, the effect of staffing levels of medical personnel as well as radiology and laboratory staff, and their workload on ED-LOS were not included in our analysis.

Implications

This study emphasises the need for a distinct emergency care approach for elderly patients presenting in the ED. In addition, it suggests that sufficient training of ED doctors for the emergency care of the elderly population can help to assess and treat these patients in a timely and effectively manner.[44]

The negative impact of the number of consultations on the ED-LOS provides an important opportunity to improve care, since the waiting time between assessments can be reduced if collaboration between different disciplines can be enhanced. Therefore, coordination of emergency evaluation by a leading physician at the ED, specifically in elderly patients, could be helpful in improving the quality of acute care and in reducing the ED-LOS.[23] In addition, a possible solution to reduce prolonged ED-LOS caused by an extensive diagnostic work-up is the implementation of diagnostic-triage standing orders, which are medical orders developed for distinct types of complaints performed by ED nurses (advanced triage). This has previously shown to be beneficial in reducing ED treatment times.[45] Moreover, the development of a clinical decision rule or care pathway for elderly ED patients could potentially improve efficiency in emergency care and diagnostic processes and, subsequently, reduce ED-LOS. However, the cost effectiveness of such an intervention needs to be considered.

Reorganisation of emergency care processes, following the implementation of the four hour target in the UK, contributed towards an improvement in patient flow and reduced ED-LOS, although the relevance of a specific cut-off of ED-LOS remains questionable.[46,47] However, as the number of elderly patients presenting to the ED is expected to increase, the high percentage of prolonged ED-LOS in this population will have a profound impact on EDs. The introduction of a similar target in the Netherlands may facilitate the required modification of the emergency care system in order to improve the quality of acute care.[18,47-49]

The risks associated with a prolonged ED-LOS and a complete evaluation need to be weighed against the benefits of a shorter ED-LOS with possible incomplete evaluation, balancing efficiency with accuracy and optimal care in this vulnerable group. Furthermore, patients that would benefit from a higher degree of expertise and are more susceptible to risks associated with prolonged ED-LOS need to be identified. Future prospective studies could examine the impact of prolonged ED-LOS on the quality of care for the elderly and patient outcome, specifically relevant to this population, such as the occurence of complications, hospital LOS and functional decline.

Conclusions

ED-LOS was considerably longer in elderly patients than in younger patients in our ED. Prolonged ED-LOS in elderly patients was associated with medical and organisational factors, such as a higher number of tests or consultations involved during the ED visit and the low seniority of the physician. Baseline factors, such as medical history, appeared to be of limited influence on prolonged ED-LOS. These findings indicate that improving operational efficiency and coordination in emergency care processes by focusing on organisational factors, without compromising quality of care, is necessary to better suit the needs of the continuously growing population of elderly patients in the ED.

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Chapter 3

Applicability of the modified Emergency Department Work Index (mEDWIN) at a Dutch emergency department

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Abstract

Background

Emergency department (ED) crowding leads to prolonged emergency department length of stay (ED-LOS) and adverse patient outcomes. No uniform definition of ED crowding exists. Several scores have been developed to quantify ED crowding; the best known is the Emergency Department Work Index (EDWIN). Research on the EDWIN is often applied to limited settings and conducted over a short period of time.

Objectives

To explore whether the EDWIN as a measure can track occupancy at a Dutch ED over the course of one year and to identify fluctuations in ED occupancy per hour, day, and month. Secondary objective is to investigate the discriminatory value of the EDWIN in detecting crowding, as compared with the occupancy rate and prolonged ED-LOS.

Methods

A retrospective cohort study of all ED visits during the period from September 2010 to August 2011 was performed in one hospital in the Netherlands. The EDWIN incorporates the number of patients per triage level, physicians, treatment beds and admitted patients to quantify ED crowding. The EDWIN was adjusted to emergency care in the Netherlands: modified EDWIN (mEDWIN). ED crowding was defined as the 75^{th} percentile of mEDWIN per hour, which was ≥0.28.

Results

In total, 28,220 ED visits were included in the analysis. The median mEDWIN per hour was 0.15 (Interquartile range (IQR) 0.05–0.28); median mEDWIN per patient was 0.25 (IQR 0.15–0.39). The EDWIN was higher on Wednesday (0.16) than on other days (0.14-0.16, $p<0.001$), and a peak in both mEDWIN (0.30-0.33) and ED crowding (52.9-63.4%) was found between 13:00–18:00 h. A comparison of the mEDWIN with the occupancy rate revealed an area under the curve (AUC) of 0.86 (95%CI 0.85-0.87). The AUC of mEDWIN compared with a prolonged ED-LOS (≥4 hours) was 0.50 (95%CI 0.40-0.60).

Conclusion

The mEDWIN was applicable at a Dutch ED. The mEDWIN was able to identify fluctuations in ED occupancy. In addition, the mEDWIN had high discriminatory power for identification of a busy ED, when compared with the occupancy rate.

Background

Emergency department (ED) crowding is a well-known logistical problem affecting emergency care worldwide.[1] ED crowding occurs when the need for emergency services exceeds available resources at the ED or in the hospital.[2] It is associated with adverse patient outcomes, reduces the probability of receiving high-quality care[3-6] and leads to prolonged emergency department length of stay (ED-LOS), delays in treatment and preventable medical errors.[7-11] In addition, crowding at the ED results in ambulance diversion and patients leaving the ED without being seen by a physician.[3,9,12]

ED crowding seems to be less evident in the Netherlands.[1,13,14] ED boarding, defined as the inability to transfer admitted ED patients to hospital beds, ambulance diversion and patients leaving the ED without being seen are rare events.[14,15] Nonetheless, 68% of ED managers participating in a Dutch survey study reported that ED crowding, defined as having more patients in the ED than treatment rooms or more patients than staff should ideally care for, occurred at least twice a week.[13] The anticipated changes in the organization of emergency care in the Netherlands, involving potential closure of EDs as a cost reduction measure, will impact the availability of emergency services and possibly contribute to ED crowding in the future.[16] To monitor the impact on EDs occupancy and allow timely control measures, an adequate measure of ED occupancy and ED crowding is needed.

The extent of ED crowding is difficult to estimate, as there is no general definition or a gold standard other than physician perception of ED crowding.[17] To better understand and manage crowding, and to compare crowding levels across hospitals, several quantitative and objective ED crowding measures have been developed, such as the Emergency Department Work Index (EDWIN), the National ED Overcrowding Scale (NEDOCS), and the occupancy rate.[18-20] The EDWIN, the NEDOCS and the occupancy rate have all been developed and validated in the USA with an emergency care system characterized by high numbers of ED visits and ED boarding.[1] Both EDWIN and NEDOCS are highly associated with physicians' perception of ED crowding.[21] However, the NEDOCS quantifies ED crowding based on the number of respirators at the ED, longest admission time, and waiting room time of the last patient,[20] which requires more detail than routinely stored in electronic hospital records. The occupancy rate is based on the ratio of the total number of ED patients to the total number of licensed treatment beds per hour. However, urgency level, an important factor influencing workload of ED personnel, is not taken into consideration. Furthermore, studies concerning crowding measures have mostly been applied to settings in the USA, Canada and Australia, and were conducted over a short period of time.[21]

The primary objective of the present study was to explore the value of the EDWIN as a measure to track occupancy at an ED in the Netherlands and its ability to identify fluctuations in ED occupancy per hour, day, and month. Our secondary objective was to investigate the discriminatory value of the EDWIN in detecting crowding, as compared with that of the occupancy rate and prolonged ED-LOS.

Methods

Study design, setting and participants

The Institutional Review Board of the MMC confirmed that the Medical Research Involving Human Subjects Act (WMO) was not applicable to this study. A retrospective cohort study was performed at Máxima Medical Centre (MMC), a 550-bed teaching hospital in the Netherlands with approximately 28,000 ED visits per year.[22] The ED consists of a triage room and 18 treatment beds divided over 16 treatment rooms, including rooms for trauma, shock and pediatric patients. The primary modes of presentation to the ED are referral by a general practitioner (GP) or self-referral. Other modes of presentation are referral by medical specialists or ambulance.[14] Triage at presentation is routinely performed using the Manchester Triage System (MTS). This five-level system categorizes ED patients into one of the following urgency levels: 1. red (requires immediate assessment), 2. orange (very urgent, requires evaluation within 10 minutes), 3. yellow (urgent, requires evaluation within 30 minutes), 4. green (standard, requires evaluation within 90 minutes), and 5. blue (non-urgent, requires evaluation within 120 minutes).[23] The least urgent MTS category (i.e. blue) is not used at our ED, as this uncomplicated patient group would be assessed by a general practitioner. A medical student, a non-trainee (physicians who have not yet started traineeship in a clinical specialty) or trainee resident, or an emergency physician will assess the patients presenting to the ED, supervised by a medical specialist. Health insurance is available for every citizen in the Netherlands. Health care costs of uninsured individuals are covered by the Dutch state.

Data on all ED visits between September 1st 2010 and September 1st 2011 for every medical specialty were extracted from electronic hospital records (ChipSoft EZIS). Given the retrospective observational design and population size, no informed consent was obtained. To ensure patient privacy, we pseudo-anonymized data after data extraction by replacing all identifying variables for the database with a unique study patient code. A password protected key file was stored on the secure internal server of the MMC and only accessible by the responsible investigator (SB). ED visits were excluded when there

was an overt incorrect ED recording time or when the patient was directly transferred to another department.

Data collection

The following data were retrieved from electronic patient and hospital records: age, gender, MTS triage level, date and time of the ED visit, mode of presentation (referral by GP, medical specialist, ambulance or self-referral), number of diagnostic tests performed at the ED (blood, arterial blood-gas, urine or culture tests, electrocardiogram (ECG), X-ray, ultrasonography, computed tomography (CT) scan or magnetic resonance imaging (MRI)), number of consultations by medical specialties at the ED, and medical procedures performed at the ED (intubation, placement of urinary catheter or gastric tube, cardiac rhythm monitoring, administration of oxygen, and application of bandages or casts). ED recording times (in minutes) were sectioned into: 1. ED arrival time, 2. time spent in the waiting room, calculated as the time from ED arrival to ED bed placement, 3. time when triage started, 4. time when treatment was started, 5. time when treatment ended, 6. ED-LOS calculated as the time between ED arrival and the end of treatment with subsequent ED discharge or hospital admission. Information on final disposition, including patients who left the ED without being seen by a physician and date of admission and discharge were retrieved.

Endpoints

The primary endpoint of the study was the ability of the EDWIN to track occupancy. The secondary endpoint was the ability of the EDWIN to identify ED crowding as compared to the occupancy rate and ED-LOS.

The EDWIN was calculated using the following formula[18]: $EDWIN = \sum n_i t_i / N_a (B_T - B_A)$, where n_i = the number of patients present at the ED, including the patients in the waiting room, triage and in ED beds, per triage level i; t_i = the triage category (scale 1-5, 5 being most acute); N_a = number of attending physicians at the ED; B_T = the total number of staffed beds at ED; B_A = the number of admitted patients (i.e. boarding patients: ED patients already admitted but who are not able to be transferred to hospital beds) in the ED.[18]

The EDWIN was adjusted to emergency care in the Netherlands: modified EDWIN (mEDWIN). Four adjustments to the scale of the EDWIN were necessary to make it applicable to our ED.[18] First, as the MTS, a five-level triage system, is used in our ED, we used this system in the mEDWIN instead of the Emergency Severity Index. As only four MTS categories are being used at our ED, corresponding to the following categories in the mEDWIN: red as category 5, orange as category 4, yellow as category 3, and green

as category 2. A missing triage level was coded as 1 and was included in the mEDWIN. Second, since ED boarding does not occur at our ED, B_A was converted into occupied treatment beds by any patient, instead of only boarding patients. Third, the mEDWIN could produce mathematical errors under extreme circumstances: if all treatment beds are occupied ($B_T - B_A = 0$), the denominator of the mEDWIN would become zero ($N_a \times 0 = 0$). Therefore, a constant was used for B_T to prevent a negative mEDWIN. As there were a maximum of 29 patients occupying ED treatment beds in one hour during the study period, the constant was set on 30. Fourth, we also included residents in N_a, as ED patients are primarily assessed by residents, who supervised by a medical specialist. The mEDWIN was calculated for each hour of the day, referred to as hour slots. For each patient, the mEDWIN was calculated based on the hour of arrival at the ED, as we postulated that the mEDWIN at the start of the ED visit would have the highest influence on the subsequent ED processes.

The predefined cut-off values of the EDWIN based on research by Bernstein, mostly in the USA, will not apply to our ED (i.e., manageable but active ED = EDWIN <1.5, busy ED = EDWIN: 1.5-2.0, and crowded ED = EDWIN >2.0),[18] due to a much lower volume of patients presenting to our ED and to the alterations made to the mEDWIN. We expected to detect a lower mEDWIN at our ED compared with the international cut-off values. For the purpose of the present study and in absence of validated absolute cut-off value, we defined periods of relative crowding based on the 75th percentile of the hourly mEDWIN scores representing the scores of the busiest hours at our ED. The mEDWIN ≥75th percentile of all calculated mEDWIN scores per hour in our study population was ≥0.28, which was used as a preliminary cut-off for crowding in the analysis.

The occupancy rate was calculated per hour using the following formula[19]:

Occupancy rate = (total number of patients at the ED / total number of treatment beds), where the numerator includes every patient in the ED regardless of location (including waiting room or hallway) and the denominator includes only the licensed treatment beds. Based on the threshold previously proposed by Beniuk et al., an occupancy rate >1 was considered as ED crowding.[24]

ED-LOS was calculated in minutes per patient. The cut-off value used to define ED crowding was ED-LOS ≥4 hours.[25] A patient having left the ED without being seen by a physician was defined as leaving the ED during the time period starting with the initial registration and ending with the end of treatment.[15]

Data analysis

Data analysis was performed using SPSS, version 21.0 (IBM SPSS Statistics for Windows, Armonk, New York). Arrival times were rounded to the whole hour in order to calculate the mEDWIN. The number of attending physicians (either residents or medical specialists) was derived from the rotation schedule, provided by the ED. As previously mentioned, the number of beds available throughout the entire study period was 30. The number of occupied beds per hour was derived from the number of patients who were treated/assessed in that hour. If no patients were present at the ED, both the occupancy rate and the mEDWIN were set to zero.

Extreme values of ED recording times were checked manually. Missing ED recording times were verified by using ED patient records and completed where possible by manually checking the ED patient records. If the time of the start of treatment was missing, it was calculated by adding the average time in waiting room to the average arrival time.

Descriptive analyses were used to describe the mEDWIN, the occupancy rate (= total number of patients at the ED / total number of treatment beds) and ED-LOS. Normality was checked with histograms and the Kolmogorov-Smirnov test of normality. Continuous variables with a non-normal distribution were tested using the Mann–Whitney U test or the Kruskal–Wallis test, depending on the number of groups. For continuous variables with a normal distribution, T-test and ANOVA (analysis of variance) were used. Variables were described by means with standard deviation (SD) and medians with interquartile ranges (IQR). Comparison of the occurrence of ED crowding (i.e. mEDWIN ≥0.28) between groups was tested using the Chi-square test for categorical variables. The correlation between the mEDWIN, and the occupancy rate, or ED-LOS, was presented as Spearman correlation coefficients for which 95% confidence intervals (CI) were calculated by bootstrapping. Receiver operating (ROC) curves of the mEDWIN versus ED crowding based on an occupancy rate >1, or an ED-LOS ≥4 hours were created and the area under the curve (AUC) was calculated. To describe the ED crowding detection properties of mEDWIN, we calculated the sensitivity and specificity of the mEDWIN compared to the occupancy rate. A two-sided p-value <0.05 was considered statistically significant.

To determine the effect of missing triage levels on the mEDWIN, a sensitivity analysis was performed by excluding the patients with missing triage levels from the analysis to calculate the median EDWIN, and IQR.

Results

Emergency department visits

During the study period, 31,496 ED visits were recorded in the ED registration system (Figure 3.1). We excluded 3,122 ED visits by patients (9.9%) who were directly transferred to another department, mostly the cardiac care unit (n=3,009). Data for 154 ED visits (0.5%) were excluded, due to incorrect ED recording times caused by a computer system malfunction. In total, 28,220 ED visits were included in the analysis, which represented 8,712 hours over 363 days. The median number of physicians or residents at the ED was 9.5 (range 3-10.5) during the hours from 8:00-17:59h, 8.5 (range 3-9.5) during the hours from 18:00-23:59h and 4 (range 4-5) during the hours from 0:00-7:59h.

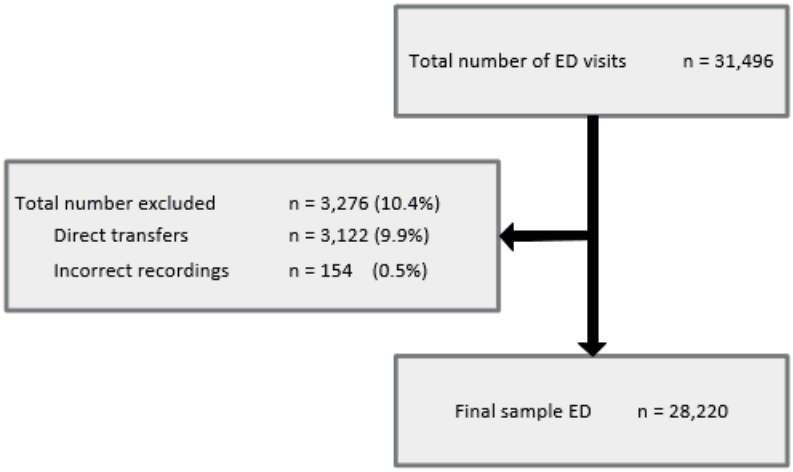


Figure 3.1 Patient flow diagram.
ED = Emergency Department.

Patient characteristics

The mean age of the ED patients was 43.3 years, and 53.7% were male (Table 3.1). The majority of ED visits were self-referrals (45.9%), followed by referrals by a GP (35.1%). Overall, the patients predominantly presented with urgency levels of green (56.1%) and yellow (31.7%), whereas 0.6% of the patients were classified as red, and 9.7% as orange. The triage level was missing in 551 ED visits (2.0%) and coded as 1. A higher

triage level was associated with a higher number of diagnostic tests and medical procedures performed on the ED (both p <0.001) (Table S3.1).
In 511 cases (1.8%), the timing of the start of treatment was unknown. The median treatment time was 77 minutes (IQR 39-132) (Table 3.1). In total, 48 patients (0.2%) left the ED without being seen by a physician. In total 8,485 (30.1%) ED visits resulted in admission to the hospital, either to the acute medical admission unit (AMAU) or to a general ward.

Table 3.1 Characteristics of emergency department patients.

Characteristic	Total no. ED visits N=28,220
Mean (SD) age, years	43.3 (26.3)
Male participants (%)	15,141 (53.7)
Day of presentation	
Weekday (%)	19,858 (70.4)
Weekend (%)	8,362 (29.6)
Time of presentation	
8.00-16.59 (%)	16,344 (57.9)
17.00-23.59 (%)	8,821 (31.3)
0.00-7.59 (%)	3,055 (10.8)
Mode of referral	
General practitioner (%)	9,898 (35.1)
Ambulance (%)	2,158 (7.6)
Medical specialist (%)	2,104 (7.5)
Self-referral (%)	12,954 (45.9)
Other (%)	1,105 (3.9)
Unknown	1 (0.0)
Median time in waiting room in minutes (IQR)	6 (2-22)
Median treatment time minutes (IQR)	77 (39-132)
Disposition	
Leave without being seen (%)	48 (0.2)
Discharge home without follow-up (%)	7,753 (27.5)
Discharge home with follow-up (GP/outpatient clinic) (%)	11,869 (42.1)
Admission to AMAU (%)	6,155 (21.8)
Admission to a hospital ward (%)	2,335 (8.3)
Mortuary (%)	30 (0.1)
Other (nursing home and function department) (%)	30 (0.1)

SD = standard deviation; ED = emergency department; GP = general practitioner; IQR = Interquartile range; AMAU = Acute Medical Admission Unit.

mEDWIN per hour

The median mEDWIN per hour was 0.15 (IQR 0.05–0.28) (Table 3.2). The distribution of the mEDWIN and percentage of ED crowding (i.e. mEDWIN ≥0.28) differed significantly per hour, day, month and season (Figure 3.2). Overall, the median mEDWIN and the percentage of ED crowding were higher on weekdays as compared to weekends

(0.15 vs. 0.14, p=0.021, respectively 26.6% vs. 21.5%, p<0.001). The mEDWIN was highest on Wednesday (median 0.16, IQR 0.05-0.37) (Figure 3.2). Similarly, the occurrence of ED crowding differed among the days of the week, with the highest frequency on Wednesday (p<0.001). During the day, there was a peak in median mEDWIN (0.30-0.33, IQR 0.20-0.49) and ED crowding (52.9-63.4%) between 13:00 and 18:00h (Figure 3.2), whereas the median mEDWIN was lowest between 02:00-09:00h (0.05-0.07, IQR 0-0.11). The median mEDWIN was also lower during the summer than in other seasons (p<0.001). Accordingly, ED crowding was less frequent in the summer than in other seasons (18.3% versus 26.3-27.3%, p<0.001).

Table 3.2 Modified Emergency Department Work Index (mEDWIN), occupancy rate and emergency department length of stay.

	N	Median	IQR	Range
mEDWIN per hour slot*	8,712	0.15	0.05-0.28	0-9.16
mEDWIN per patient	28,220	0.25	0.15-0.39	0-9.15
Occupancy rate per hour slot	8,712	0.50	0.17-0.83	0-1.89
ED-LOS in minutes per patient	28,220	100	61-152	0-613

N = number; IQR = Interquartile Range; *N = the number of hour slots during the 363 days of the study period; ED-LOS = emergency department length of stay.

Based on predefined thresholds of the EDWIN of 1.5-2.0,[18] a busy ED occurred in 0.1% of the hour slots in our study. Furthermore, in only 0.1% of the hour slots, the ED was classified as crowded based on the thresholds by Bernstein (i.e. EDWIN >2.0).

mEDWIN per patient visit

The median mEDWIN for all patient visits was 0.25 (IQR 0.15-0.39) (Table 3.2). Patients <65 years (73.4%) presented at moments with a lower median mEDWIN (0.25, IQR 0.15-0.38) than patients ≥65 years (26.6%) (0.26, IQR 0.16-0.40, p<0.001). In patients who were hospitalized following the ED visit (30.1%), the median mEDWIN at the ED upon first presentation was similar to that of patients who were discharged from the ED (median 0.25, IQR 0.15-0.38 vs. 0.25, IQR 0.15-0.39, respectively, p=0.851). The median mEDWIN was 0.32 (IQR 0.24-0.46; 62.5% during ED crowding) during the visits of the 48 patients who left the ED without being seen versus 0.25 (IQR 0.15-0.39; 42.2% during ED crowding) for the visits in which patients had been seen by a physician(p=0.005).
Excluding visits with missing triage levels did not change the median mEDWIN (0.25, IQR 0.15-0.39).

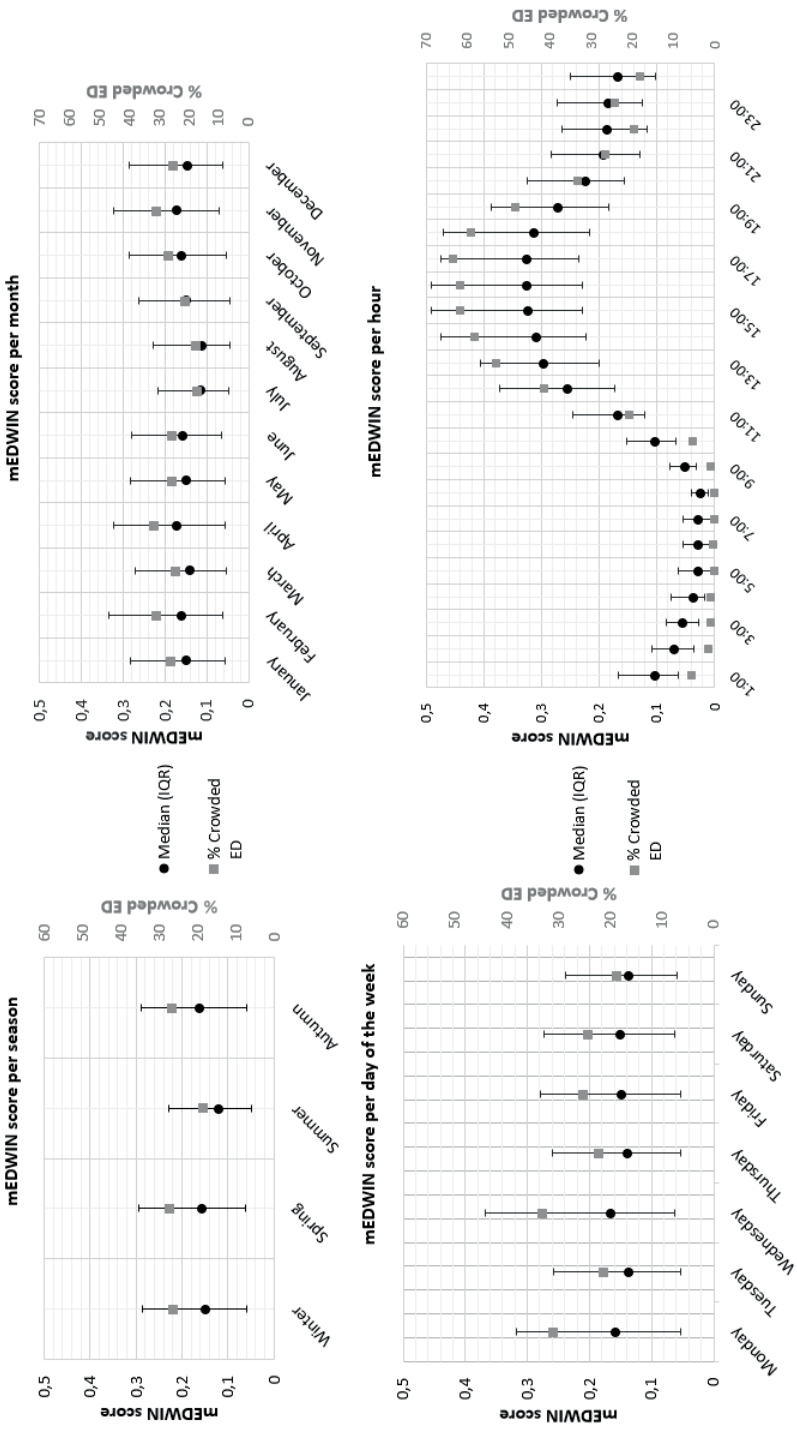
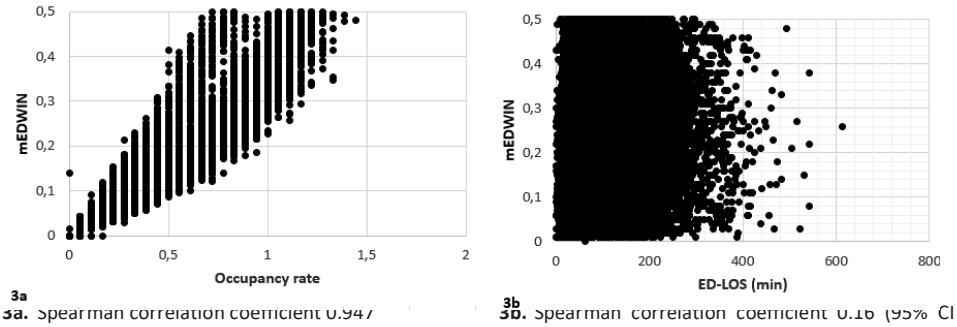


Figure 3.2 Median mEDWIN with corresponding interquartile range and percentage of emergency department crowding based on 75th percentile of the mEDWIN per season, month, day and hour.
ED = Emergency Department; IQR = Interquartile range.

Comparison of mEDWIN with occupancy rate and ED-LOS

The median occupancy rate was 0.50 (IQR 0.17-0.83) (Table 3.2). ED crowding (occupancy rate per hour >1) occurred in 11.5% of ED visits. On Mondays and Fridays, the ED was crowded in 19.2% and 14.9% of visits, respectively (p<0.001 compared with the other days). The occupancy rate mainly exceeded 1 at ED visits between 12:00-19:00h (20.9-35%). Overall, an occupancy rate >1 occurred less frequently during the summer (6.1%) as compared to other seasons (12.2–13.7%, p<0.001).
The median ED-LOS was 100 minutes (range 0-613, IQR 61-152 minutes) (Table 3.2). In 5.3% of the patients, ED-LOS exceeded 4 hours. These patients mostly presented on Monday (6.8%), Tuesday (6.4%), and Friday (7.0%). An ED-LOS ≥4 hours occurred most often at 7:00, 12:00 and 13:00 (9.4, 7.5 and 7.8%, respectively) and least often between 1:00-4:00h (1.2-2.3%) (p<0.001). As predicted by occupancy rate, an ED-LOS ≥4 hours was the least frequent during the summer (3.1%).



3a. Spearman correlation coefficient 0.947 (95% CI 0.15-0.18).

3b. Spearman correlation coefficient 0.16 (95% CI (95% CI 0.945-0.950).

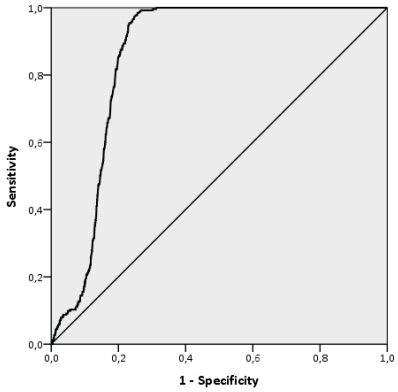
Figure 3.3 Comparison of results for the modified Emergency Department Work Index (mEDWIN) versus occupancy rate (3a) and emergency department length of stay (ED-LOS) (3b).

The Spearman correlation coefficient between the occupancy rate and the mEDWIN was 0.95 (95% CI 0.945-0.950) (Figure 3.3) and 0.16 (95% CI 0.15-0.18) for mEDWIN and ED-LOS (Table 3.3). In 13.5% of hour slots with crowding (based on mEDWIN ≥0.28), the occupancy rate was <1. The AUC was 0.86 (95% CI 0.85-0.87) when mEDWIN was compared with an occupancy rate >1 and 0.50 (95% CI 0.40-0.60) when compared with an ED-LOS ≥4 hours (Figure 3.4).
The sensitivity and specificity of the mEDWIN cut-off of 0.28 was 99.5% and 84.5%, respectively.

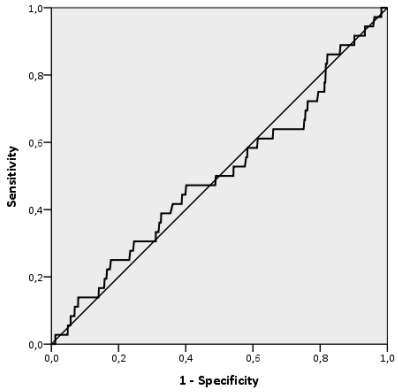
Table 3.3 Characteristics of the modified Emergency Department Work Index (mEDWIN) versus occupancy rate and emergency department length of stay.

	N	Correlation (95% CI)	AUC (95% CI)
mEDWIN versus Occupancy rate	8,712	0.947 (0.945-0.950)	0.86 (0.85-0.87)
mEDWIN versus ED-LOS	28,220	0.16 (0.15-0.18)	0.50 (0.40-0.61)

mEDWIN= modified Emergency Department Work Index; ED-LOS= Emergency Department Length of Stay; AUC= Area Under the Curve.



4a. Crowded ED, i.e. occupancy rate >1; AUC mEDWIN = 0.86.



4b. Crowded ED, i.e. ED-LOS ≥ 4 hours; AUC mEDWIN = 0.50.

Figure 3.4 Receiver operating characteristic curves of the modified Emergency Department Work Index (mEDWIN) for emergency department crowding based on the occupancy rate (4a), and on the emergency department length of stay (4b).

Discussion

Our aim was to explore the applicability of the EDWIN to monitor ED occupancy at a Dutch ED. Given the distinct organization of emergency care in the Netherlands, we adjusted the EDWIN to account for both the absence of a boarding system, which is part of the original EDWIN and the use of a different triage system. The modified EDWIN (mEDWIN) was able to identify fluctuations in ED occupancy over a period of time. By using the 75th percentile of mEDWIN as a threshold of ED crowding, we could identify fluctuations in patient flow and periods of relative ED crowding. In addition, the mEDWIN had additional value for identifying ED crowding when compared with the occupancy rate.

Several adjustments to the mEDWIN were made to match the conditions of the acute care system in the Netherlands. Other studies have applied changes to the formula as well.[21,26] The EDWIN is based on the Emergency Severity Index (ESI), a five-level triage tool associated with resource use and hospitalization rates. In our study, we used the MTS in the mEDWIN. Similar to the ESI, the MTS is highly associated with the number of diagnostic tests and medical procedures performed at the ED, and with the hospital admission rate. The EDWIN was previously evaluated using a non-specified triage system other than the ESI.[21] In addition, another study made adjustments in the calculation of the EDWIN to avoid computational errors by dividing by zero.[26] Furthermore, because the conditions of our ED differ from the hospitals where the EDWIN has been validated, we used altered threshold values to identify a crowded ED. The majority of fluctuations in patient flow and ED crowding would have been unobserved if our results were limited to the predefined cut-off values of the EDWIN determined by Bernstein[18] (i.e., manageable but active ED = EDWIN <1.5, busy ED = EDWIN 1.5-2, and crowded ED = EDWIN >2), as the EDWIN was ≥1.5 in only 0.2% of cases at our ED. This finding is in accordance with another study that found that the accuracy of the EDWIN may be less when ED crowding is less prevalent.[21] Our study reveals that we were able to assess occupancy with the mEDWIN and identify relative busy periods at our ED. However, further research on calibration of the mEDWIN is necessary to find a cut-off which is generalizable to other EDs.

Because the mEDWIN was applied over a period of an entire year, we were able to demonstrate major variations in ED occupancy over seasons and months. A lower mEDWIN and ED crowding during the summer months is understandable, given the decrease in the number of patients visiting the ED during the holiday season. However, this has not previously been quantified. The increase in ED crowding from 13:00-18.00h is consistent with other studies.[13,19] A remarkable finding concerning patient flow was a high mEDWIN and percentage of ED crowding on Wednesdays. This might be explained by a lower number of physicians present in the ED from 8:00-17:00 h on Wednesdays compared with other days, resulting in a smaller numerator, and thus a higher mEDWIN.

A general definition of ED crowding and a gold standard to quantify ED crowding is still lacking, although several ED crowding measures have been developed.[18-20] Our findings show a strong correlation between the mEDWIN and the occupancy rate. When using an occupancy rate >1 as cut-off for ED crowding, the mEDWIN has adequate discriminatory value (AUC 0.86), which is in accordance with other studies.[8,19] Sensitivity and specificity to detect ED crowding as compared with the occupancy rate was 99.5% and 84.5% respectively. The variables of the formula of the occupancy rate are included in the mEDWIN as well, which explains the strong correlation. Other

research has suggested the superiority of the relative simple occupancy rate compared with other crowding measures, such as EDWIN or NEDOCS.[8,19,26-28] However, the mEDWIN may have added value compared with the occupancy rate, as periods of relative crowding were frequently (13.5%) observed based on the mEDWIN (i.e., ≥0.28), while the occupancy rate remained <1.0. The main advantage of the EDWIN compared with the occupancy rate is the incorporation of the triage level in the score for quantifying ED crowding, as one critically ill patient may influence ED crowding more than several patients with minor injuries. Only 0.1% of hour slots with ED crowding based on the occupancy rate (i.e. >1) was missed with the mEDWIN.

In contrast, the correlation between the mEDWIN and the ED-LOS was weak. For instance, the AUC of the mEDWIN compared with an ED-LOS ≥4 hours was only 0.50. ED-LOS has previously been marked as an objective measure to assess ED crowding with great reproducibility.[17] However, additional factors may contribute to longer ED-LOS, such as consultations by different specialties and the experience of the physician, which may only influence ED-LOS in a small number of patients and not ED crowding in general.[29,30] Furthermore, patients with a high urgency level can create high workload, resulting in a high mEDWIN, even when their ED-LOS may be short.

The most commonly used model of ED crowding is the input-throughput-output model.[3,17,31] However, in contrast to emergency care in the USA, Canada and Australia, ED crowding in the Netherlands is primarily based on input and throughput factors rather than output factors, which reflect problems associated with the disposition of ED patients.[3,17,31] This is consistent with other countries with a comparable primary care system, such as Scandinavian countries.[1] The most important input and throughput factors are directly or indirectly included in the mEDWIN: the number of patients in the ED, their acuity level and resource use, the number of physicians at the ED and the number of occupied beds. Our results suggest that the mEDWIN can serve as an adequate measure for monitoring ED occupancy by including organizational factors as well as urgency level, where ED crowding based on previously defined values is infrequent or not taking into account severity and urgency levels.

Limitations

Our results may have been influenced by several limitations. Firstly, there is a risk of bias due to the retrospective observational design. It is possible that data such as ED recording times are incomplete or incorrect. However, the effect of missing values of the triage level (2.0%) on the mEDWIN was minimal as shown in a sensitivity analysis. Some misclassifications of the mEDWIN assigned to patients may have occurred,

because we rounded the arrival times of patients to the whole hour. Secondly, because of the single-center setting, our findings may be less generalizable. Thirdly, the EDWIN was modified to better suit the Dutch emergency care system (mEDWIN), since ED crowding, and ED boarding are infrequent. Although the health care system is well organized in the Netherlands, this distinct organization should be taken into account in interpreting our findings. In addition, we applied a different classification of ED crowding based on the observed mEDWIN. ED crowding was based on the upper quartile of the mEDWIN per hour (i.e., ≥0.28). Although the relevance of a mEDWIN ≥0.28 is uncertain, it is useful for the identification of the busiest periods at the ED, in particular because no standard method for measuring ED crowding exists. Nonetheless, our results may be applicable to sites with a similar organization of primary care, and where ED crowding occurs less frequently as well. Lastly, the influence of medical students or ED nurses on ED crowding was unclear and therefore not considered in this study.

Future perspectives

Emergency care in the Netherlands is on the verge of major changes, involving possible mandatory closure of EDs and a more prominent role for general practitioners. Consequently, the case mix of ED patients is expected to change, as higher numbers of less complex patients are expected to visit general practice centers after hours, and more complex patients will present to the ED. Since the number of ED visits is not expected to decrease proportionately, ED crowding will increase accordingly. More research is necessary to be able to monitor future trends and to anticipate and adapt to the altered patient flow. This study was the first to apply the EDWIN at an ED in the Netherlands.

Future prospective studies may focus on the identification of threshold values of the mEDWIN in an emergency care system where ED crowding occurs less frequently. In addition, comparison of the mEDWIN with physician and patient perception of ED crowding may add valuable information. Moreover, the development of an ED simulation model, incorporating the mEDWIN, could be beneficial in predicting ED crowding and implementing strategies to better manage crowding, for example scheduling more ED personnel from 13:00-18:00 h. In addition, the burden of different medical specialties on ED crowding, such as surgical or medical patients, might be evaluated separately. Further studies on the influence of ED crowding on patient outcome through the use of quantitative measures, such as the mEDWIN, are needed as well.

Conclusion

After minor adjustments, the EDWIN (mEDWIN) was applicable as a monitoring tool for ED occupancy and relative crowding at our ED. The mEDWIN was able to identify fluctuations in ED crowding per hour, day and month. In addition, the mEDWIN demonstrated high discriminatory power for the identification of relative ED crowding, as compared with the occupancy rate. ED-LOS was not an appropriate measure to predict ED crowding. Our findings suggest that the mEDWIN can serve as a valid measure for detecting ED crowding at a Dutch ED. Further prospective research is necessary to validate threshold mEDWIN values.

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Supporting information

Table S3.1 Number of diagnostic tests and medical procedures performed at the emergency department per urgency level.

Urgency level by MTS	No. of patients (%)	No. of diagnostic tests*				No. of medical procedures*			
		Median	IQR	Mean	SD	Median	IQR	Mean	SD
Red	158 (0.6)	3.5	2-5	3.4	2.1	4.0	3-5	3.7	1.6
Orange	2,745 (9.7)	2.0	1-4	2.6	1.9	2.0	1-3	1.8	1.3
Yellow	8,933 (31.7)	1.0	1-3	1.8	1.5	1.0	0-2	1.1	1.0
Green	15,833 (56.1)	1.0	0-1	0.8	1.0	1.0	0-1	0.7	0.8
Missing	551 (2.0)	0	0-0	0.4	1.1	0	0-1	0.5	0.9

MTS = Manchester Triage System; IQR = Interquartile range; SD = standard deviation; * =p<0.001.

Chapter 4

Outcome of elderly emergency department patients hospitalised on weekends – A retrospective cohort study

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Abstract

Background

Studies investigating different medical conditions and settings have demonstrated mixed results regarding the weekend effect. However, data on the outcome of elderly patients hospitalised on weekends is scarce. The objective was to compare in-hospital and two-day mortality rates between elderly emergency department (ED) patients (≥65 years) admitted on weekends versus weekdays.

Methods

A retrospective cohort study of emergency department visits of internal medicine patients ≥65 years presenting to the emergency department between 01-09-2010 and 31-08-2012 was conducted. The weekend was defined as the period from midnight on Friday to midnight on Sunday.

Results

Data on 3697 emergency department visits by elderly internal medicine patients (mean age 78.6 years old) were included. In total, 2743 emergency department visits (74.2%) resulted in hospitalisation, of which 22.9% occurred on weekends. Comorbidity and urgency levels were higher in patients admitted on weekends. In-hospital mortality was 11.4% for patients admitted on weekends compared with 8.9% on weekdays (OR 1.3, 95%CI 0.99-1.8). Two-day mortality was 3.2% in patients hospitalised on weekends versus 1.9% on weekdays (OR 1.7, 95%CI 0.99-2.9). Multivariable adjustment for age, comorbidity and triage level demonstrated comparable in-hospital and two-day mortality for weekend and week admission (ORadj 1.2, 95%CI 0.9-1.7 and ORadj 1.5, 95%CI 0.8-2.6, resp.)

Conclusion

A small weekend effect was observed in elderly internal medicine patients, which was not statistically significant. This effect was partly explained by a higher comorbidity and urgency level in elderly patients hospitalised on weekends than during weekdays. Emergency care for the elderly is not compromised by adjusted logistics during the weekend.

Introduction

Emergency departments (EDs) offer acute care for critically ill patients 24 hours a day. However, numerous studies have identified a shortfall in the quality of care at EDs during the weekend and demonstrated an association between weekend admission and adverse outcomes, such as increased in-hospital mortality, which has been labelled as "the weekend effect".[1-5]

Several explanations for the weekend effect have been proposed, such as the different organisation of the health care system at the weekend, including a decreased staffing level, less experienced personnel and reduced availability of diagnostic resources.[3,6,7] In addition, the higher weekend mortality may reflect differences in the patient characteristics, such as disease severity.[8] However, previous studies in various settings and different medical conditions have demonstrated mixed results regarding the existence of the weekend effect.[1-3,9,10]

It is well-established that ED visits and hospitalisation of elderly patients are associated with poor outcome, such as morbidity, institutionalisation and mortality.[11,12] To date, it is unknown as to whether the weekend effect adds to the risk of adverse events in the elderly population and if additional control measures tailored to the elderly population are needed. We designed a study to examine the effect of weekend admission following an ED visit on patient outcome in the frail elderly population. The primary objective of the study was to estimate the differences in mortality (in-hospital mortality, 2-day mortality and 30-day mortality) for elderly internal medicine patients (≥65 years old) admitted from the ED during the weekend as compared with weekdays.

Methods

Study design, setting and population

A retrospective cohort study was performed in a 550-bed teaching hospital, the Máxima Medical Centre, in the Netherlands.[13] Around 28,000 patients visit the ED annually, of which approximately 15% require assessment by an internist. The internist assesses patients within the field of endocrinology, immunology, vascular disease, infectious disease, geriatrics, nephrology, haematology, and oncology. The primary mode of referral in the Dutch emergency care system is by the general practitioner (GP).[14] Self-initiated visits, ambulance arrivals and referral by a medical specialist are other modes of referral. The staffing level during the week at the ED for the internal medicine consists of 2 residents during daytime (8:00-21:00) and 1 resident during the

evening and night (21:00-8:00). In the weekend, there is only 1 resident available during daytime, 1 in the evening and 1 at night. This resident also covers the occupied beds on the wards for the internal medicine during the evening and night as well as the pulmonology and cardiology wards during the night.
All elderly patients, aged ≥65 years old, visiting the ED for internal medicine, and being admitted between 1st September 2010 and 31st August 2012 were included. The unit of analysis was hospital admission following an ED visit, allowing multiple admissions per patient. One abstractor extracted the administrative data of all patients. This person was blinded to the study hypothesis, and information bias was minimised by using standard data collection forms. No informed consent of the patients deemed to be necessary because of the retrospective design, and therefor exemption of ethical approval was acquired by the Ethics Committee of MMC.

Data collection

For each ED visit, the following data were obtained from electronic patient and hospital records: age, gender, medical history (past diagnoses), and current medication use. Organisational factors pertaining to the ED visits were day and time of ED visit, mode of referral, seniority of the first treating physician on the ED, and number of diagnostic procedures (laboratory tests, a culture test, magnetic resonance imaging, computed tomography, ultrasound, and ultrasonography or electrocardiogram). Information on the triage level, vital parameters (i.e. blood pressure, and heart rate), laboratory assessments (C-reactive protein (CRP) and leukocyte count), and ED diagnosis was retrieved to estimate the severity of the illness at the ED. The date of admission and discharge were gathered. Follow-up lasted from the date of the ED visit until one year of follow-up was reached, the date of death or the date of last available information whichever was earliest.

Definitions

Visits were categorised into weekend and weekday visit based on the date and time of admission from the ED visit. In accordance with previous studies investigating the weekend effect, the weekend was defined as the period from midnight on Friday until midnight on Sunday.[1] Daytime was defined as 8 am – 5 pm, evening was defined as 5 pm – 23 pm and night was defined as 23 pm – 8 am, corresponding to the different shifts at our hospital. Dutch national holidays were considered as weekend, because the organisation is the same as in weekends (N=53). Mode of referral was categorised into referral by a GP, ambulance or medical specialist, and self-referral. The triage level was based on the five-level Manchester Triage System (MTS),[15] and was categorised

into the following groups: urgent (red and orange), moderate (yellow) and low (green). Triage category blue is not used at our ED. The seniority of the first physician on ED was categorised into a medical student in last year of medical education, a non-trainee resident, a trainee resident or a medical specialist (internist or emergency physician). Medical history, and ED diagnosis, as documented in the ED records, were categorised according to the International Classification of Disease-10 (ICD-10).[16] The diagnosis group "miscellaneous" consisted of the following categories: diseases of the musculoskeletal system, eye and adnexa, ear and mastoid process, skin and subcutaneous tissue and external injury or trauma and poisoning. The ICD-10 category "Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified" was renamed into "aspecific complaints". The Charlson comorbidity index (CCI) was calculated to assess the comorbidity levels of the patients. ED length of stay (ED-LOS) was defined as the time (in minutes) between ED arrival and ED discharge or admission.

Outcome measures

The primary outcome of this study was the mortality rate of elderly ED patients admitted during the weekend as compared with admissions on weekdays. The in-hospital mortality rate, the two-day mortality rate, and the 30-day mortality rate were calculated from the day of admission.

Statistical analysis

All statistical analyses were performed using SPSS (IBM SPSS Statistics for Windows, version 22.0, Armonk, New York). Differences in characteristics between patients admitted on weekends or on weekdays were compared using the Chi-square test for categorical variables. Numerical variables were tested using the Mann-Whitney U test, and unpaired T-test, depending on the number of groups and the distribution pattern of the variable. Missing data were categorised as "unknown" and included in the analysis of categorical parameters in order to explore the influence of missing values. Logistic regression analysis was performed to test differences in mortality rates and to estimate the effect of covariates on patient outcomes. The odds ratios (OR) and the corresponding 95% confidence interval (CI) were calculated as indicated. Admission on weekdays served as the reference category for weekends. Multivariable analysis was performed in order to estimate the effect of age, CCI and severity of illness (triage level) on mortality and to calculate adjusted OR (ORadj). To evaluate the effect of readmissions on the results, we performed a sensitivity analysis including only the first admission following an ED visit in the analysis. In addition, a second sensitivity analysis

was performed in order to evaluate the effect of daytime admission on weekdays versus on weekends on mortality rate. A two-sided *p*-value < 0.05 was considered significant.

Results

Population

A total of 3697 ED visits for internal medicine by 2798 elderly patients were registered, of which 2743 (74.2%) ED visits resulted in a hospital admission. The mean age at admission was 78.2 years old (SD 7.7). A total of 2114 (77.1%) admissions were during weekdays, and 629 (22.9%) were during the weekend (Figure 4.1). A recurrent ED visit was recorded for 675 (24.6%) of the hospitalised elderly patients during the study period.

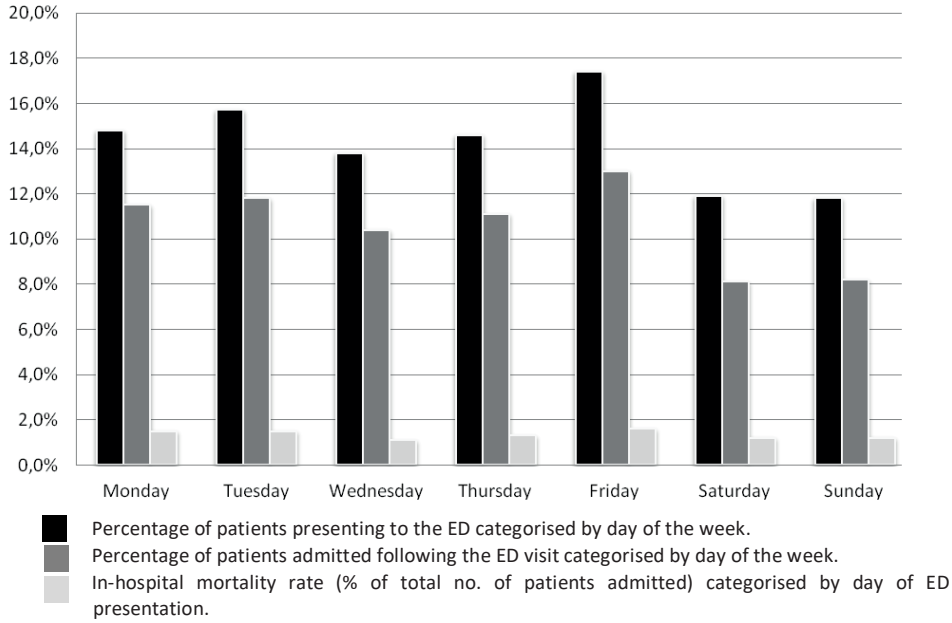

Figure 4.1 Percentages of elderly patients presenting to the emergency department, hospitalized, and the in-hospital mortality.

Patient characteristics

Patient characteristics, such as mean age, gender, and medication use of elderly patients admitted from the ED on weekdays and weekends were comparable (Table 4.1). Week admissions were associated with a lower CCI than weekend admissions (2.4 versus 2.6 respectively, p=0.041). The seniority of the first physician on the ED differed significantly between weekends and weekdays, mainly due to the absence of medical students and more trainee residents during the weekend (Table 4.1). Elderly patients admitted on weekends had undergone more diagnostic testing in the ED than those admitted on weekdays (mean 3.6 versus 3.4, p=0.009). The ED-LOS was comparable between weekend and weekday presentation to the ED (162 minutes and 165 minutes, respectively, p=0.176). Hospital length of stay (LOS) among patients admitted during weekends (median 5 days, range 0-86) was shorter than on weekdays (median 6 days, range 0-100, p=0.031).

Table 4.1 Characteristics of emergency department visits by elderly patients.

	Week admission (N=2114)	**Weekend admission (N=629)**
Mean age (SD)	78.2 (7.8)	78.0 (7.5)
No. of male participants (%)	943 (44.6)	291 (46.3)
CCI, mean (SD)*	2.4 (2.1)	2.6 (2.3)
Unknown CCI (%)	6 (0.3)	5 (0.8)
Number of drugs, mean (SD)	7.0 (4.1)	6.8 (4.0)
Unknown medication use (%)	348 (16.4)	82 (13.0)
Time of presentation **		
Daytime (8am – 5pm) (%)	1356 (64.1)	341 (54.2)
Evening (5pm – 23pm) (%)	602 (28.5)	211 (33.5)
Night (23pm – 8am) (%)	156 (7.4)	77 (12.2)
Mode of presentation **		
General practitioner (%)	1628 (77.0)	437 (69.5)
Ambulance (%)	181 (8.6)	87 (13.8)
Specialist (%)	170 (8.0)	40 (6.3)
Self-referral (%)	135 (6.4)	65 (10.3)
Seniority of first physician on ED**		
Medical student (%)	177 (6.3)	12 (1.4)
Non-trainee resident (%)	883 (31.2)	271 (30.8)
Trainee resident (%)	1561 (55.2)	538 (61.1)
Medical specialist (%)	160 (5.7)	43 (4.9)
Unknown (%)	45 (1.6)	17 (1.9)
Number of diagnostic tests, mean (SD)*	3.4 (1.9)	3.6 (2.0)
ED-LOS in minutes (IQR)	165 (130-204)	162 (129-201)
Hospital LOS in days (IQR) *	6 (2-12)	5 (2-11)

SD = Standard deviation. CCI = Charlson comorbidity index. ED = Emergency department. ED-LOS = Emergency department length of stay. LOS = Length of stay. IQR = interquartile range. P-values for week versus weekend admission: using the Chi-square test, unpaired t-test (normally distributed) or Mann-Whitney U test (not normally distributed). * =0.001<p<0.05; ** =p<0.001.

Severity of illness

Elderly patients admitted during weekends more often had a high urgency level (20.0%) in the ED compared with patients admitted on weekdays (15.8%, p<0.001) (Table 4.2). The laboratory parameters and vital parameters were comparable among patients admitted on weekends and weekdays (Table 4.2). The majority of elderly patients presented with aspecific complaints (29.8% weekend and 30.0% weekday).

Table 4.2 Clinical characteristics of elderly patients admitted following an emergency department visit.

	Week admissions N=2114	**Weekend admissions N=629**
No. of admissions per triage level **		
Urgent (%)	333 (15.8)	126 (20.0)
Moderate (%)	1165 (55.1)	372 (59.1)
Low (%)	603 (28.5)	126 (20.0)
No triage (%)	13 (0.6)	5 (0.8)
ED diagnosis		
Aspecific complaints (%)	631 (29.8)	189 (30.0)
Circulatory/respiratory (%)	247 (11.7)	66 (10.5)
Infectious (%)	189 (8.9)	65 (10.3)
Digestive (%)	187 (8.8)	67 (10.7)
Miscellaneous (%)	187 (8.8)	68 (10.8)
Neoplasm/haematological (%)	186 (8.8)	42 (6.7)
Endocrine/metabolic (%)	174 (8.2)	36 (5.7)
Genitourinary (%)	146 (6.9)	47 (7.5)
Unknown (%)	167 (7.9)	49 (7.8)
Initial vital signs, median (range)		
Systolic pressure (mmHg)	138 (64-270)	137 (50-270)
Not measured (%)	82 (3.9)	16 (2.5)
Heart rate (min^{-1})	84.0 (35-180)	84.0 (46-200)
Not measured (%)	404 (19.1)	145 (23.1)
Laboratory, median (range)		
No laboratory test (%)	96 (4.5)	25 (4.0)
CRP (mg/L)	36.0 (0.1-674)	39.0 (0.1-674)
CRP not measured (%)	20 (0.9)	3 (0.5)
Leucocytes ($x10^3/mm^3$)	9.4 (0.2-239)	9.2 (0.2-198)
Leucocytes not measured (%)	11 (0.5)	1 (0.2)

SD = Standard deviation. CCI = Charlson comorbidity index. ED = Emergency department. ED-LOS = Emergency department length of stay. LOS = Length of stay. P-values for week versus weekend admission, using the Chi-square test, unpaired t-test (normally distributed) or Mann-Whitney U test (not normally distributed). * = 0.001<p<0.05. ** = p<0.001

Weekend mortality rates

Analysis of the mortality rates demonstrated a trend towards a higher in-hospital and two-day mortality rate of patients hospitalised on weekends compared with weekday admission (11.4% versus 8.9%; OR 1.3, 95% CI 0.99-1.8 and 3.2% versus 1.9%;

unadjusted OR 1.7, 95%CI 0.99-2.9, respectively). Weekend admission following the ED visit was not associated with a higher 30-day mortality rate than weekday admission (Table 4.3).

After multivariable adjustment for age, CCI, urgency level and number of diagnostic tests in-hospital mortality rates for weekend and week admission was comparable (ORadj 1.2, 95%CI 0.9-1.7). Additionally, the adjusted two-day mortality was similar for weekend and weekday admission (ORadj 1.5, 95%CI 0.8-2.6).

The sensitivity analysis, performed to evaluate the effect of readmissions on in-hospital mortality outcome, revealed similar results (OR 1.2, 95%CI 0.8-1.7) for the in-hospital mortality rate. Moreover, the outcome was not different for 2-day and 30-day mortality after sensitivity analysis. The second sensitivity analysis demonstrated a higher in-hospital mortality rate among elderly patients hospitalised during daytime on weekdays compared with on weekends (13.2% versus 9.3%; OR 1.5, 95%CI 1.03-2.1). After multivariable adjustment for age, CCI, urgency level and the number of diagnostic tests, the in-hospital mortality for daytime admission on weekdays and on weekends was similar (ORadj 1.3, 95%CI 0.95-1.99). The 2-day and 30-day mortality was comparable among elderly patients hospitalised during daytime on weekdays and weekends.

Table 4.3 Mortality rates of elderly patients hospitalised following an emergency department visit on weekends compared with weekdays.

	Weekend admission N=629	Weekday admission N=2114	OR (95%CI)	ORadj (95%CI)
In-hospital mortality rate (%)	72 (11.4)	189 (8.9)	1.3 (0.99-1.8)	1.2 (0.9-1.7)
2-day mortality rate (%)	20 (3.2)	40 (1.9)	1.7 (0.99-2.9)	1.5 (0.8-2.6)
30-day mortality rate (%)	96 (15.3)	286 (13.5)	1.2 (0.9-1.5)	1.1 (0.8-1.4)

OR = Odds Ratio. CI = Confidence Interval. ORadj = Adjusted Odds Ratio. Multivariable analyses included weekend/weekday admission, age, Charlson comorbidity index, triage level, and number of diagnostic tests on ED.

Discussion

In this study, we observed a small weekend effect in elderly internal medicine patients (≥65 years old), which was not statistically significant. This effect was partly explained by a generally higher comorbidity level and a higher urgency level in elderly patients hospitalised on weekends than during weekdays. Additionally, the 2-day and 30-day mortality demonstrated no difference between weekend admissions and week admissions.

Our results offer insight into the outcome of elderly internal medicine patients admitted from the ED on the weekends, for which existing literature is scarce. The in-hospital mortality rate of elderly patients hospitalised during weekends was 11.4%, which is higher than the 4.2-5.2% found in other studies examining a general population.[2,4] As our study population consisted solely of elderly patients, a higher mortality rate is to be expected. The weekend effect might be overestimated in this complex population with multi-morbidity,[11,12] because of the reduced access of home care and difficulty of discharge to a hospice during weekends, which might contribute to a higher in-hospital mortality rate.[17]

Our study is one of the first studies to examine the weekend effect among elderly patients. Only one earlier study demonstrated the existence of a weekend effect in an elderly population, focusing on patients with substantial head trauma, and found a mortality rate of 9.3%.[18] In contrast to the presumed increased risk of poor health outcomes of elderly internal medicine patients admitted from the ED during the weekend, we found no evidence supporting the existence of a weekend effect in this population after adjustment for important confounders.

Other studies reported conflicting results on the existence of a weekend effect.[4-6,10] We focused on elderly internal medicine patients admitted following an ED visit, whereas the presence of the weekend effect is potentially related to specific acute diagnoses, such as ruptured abdominal aortic aneurysm, acute epiglottitis, stroke and myocardial infarction.[1,2] These are all diseases requiring immediate and accurate assessment, intervention and adequate coordination, which could be compromised during the weekend. In our analyses, these acute complex diagnoses were not included, because these are not managed by the internist at the ED in the Netherlands. However, we provide useful insight into the potential added risk of other domains or diseases within the ED.

The discrepancy with other studies might be due to the difference in health care organisation of various countries. It is plausible that certain health care systems, or even individual health centres, create a weekend effect.[5,19,20] The majority of studies on the weekend effect have been conducted in the United States, Canada and the United Kingdom.[1-6] The health care system in the Netherlands differs from these countries, as emergency departments cooperate intensely with the ambulance services and GPs. Moreover, the acute care system depends on the gatekeeping role of GPs, who are obligated to offer emergency care 24 hours a day and provide an important safety net.[14] Consequently, our findings suggest that, despite the possible reduction in staffing and services provided on the ED, the Dutch acute care system seems effective in the management of acutely ill elderly patients during the weekend.

Since the main supposed causes of the weekend effect are of an organisational nature, such as decreased availability of diagnostic resources, and less experienced ED personnel,[3,5,7] we analysed these factors to gain more insight into the potential determinants of the weekend effect. Remarkably, comparison of in-hospital mortality following daytime admission on weekdays versus weekends, which represents the main contrast in availability of resources, reveals no differences after adjustment for severity of illness. Elderly patients admitted on weekends used even more diagnostic resources and had shorter hospital length of stay compared with patients admitted on weekdays, contradicting previous studies of reduced access to the necessary resources and treatment.[1]

A strength of our study was the assessment of confounders, such as the severity of illness of elderly ED patients hospitalised on weekends or weekdays, which contributes important information to existing evidence.[2,3,8] We found a higher comorbidity and urgency level among elderly patients hospitalised during weekends than on weekdays, which could be explained by a delay in presentation to the ED.[8] However, the difference in the severity of illness of elderly patients presenting to our ED on weekdays versus weekends did not appear to influence their health outcomes, as mortality (in-hospital mortality, 2-day and 30-day mortality) was comparable between both groups. This might be caused by a more thorough assessment and timely treatment on the ED in these patients with a higher triage level. Another possible explanation is appropriate referral by primary care during weekends, with subsequent early intervention. This could clarify the absence of a weekend effect in our study and may verify the adequate acute health care organisation and referral by primary care.

Our results may have several limitations being retrospective and observational by nature. Firstly, there is a potential for bias, because of the use of administrative data with the possibility of coding errors. Due to missing values, we were unable to apply a standardised tool, such as the Acute Physiology and Chronic Health Evaluation Score, to assess the severity of illness. Instead, we analysed surrogate markers for the severity of illness, such as triage level, vital parameters, and laboratory measurements. The effect of incomplete data was assessed by including this information in the analyses. A second limitation is the single centre setting, which may compromise the generalisability of the results. However, to the best of our knowledge so far, no similar study has been done yet regarding the weekend effect in the Netherlands. Furthermore, the organisation of acute care system in other centres and countries should be considered in interpreting our results, although we can also learn from the differences in this respect. Third, the relatively small number of patients may have led to reduced reliability of our results. It is possible that the sample size of the study was too small to exclude the presence of a

weekend effect with sufficient statistical power. Fourth, although we corrected for confounders, such as severity of illness, residual confounding may still be present.

Conclusion

Our results demonstrate a slightly higher in-hospital mortality rate in elderly internal medicine patients hospitalised on weekends compared with weekdays. However, adjustment for a higher comorbidity and higher urgency level showed there is no independent causal association between weekend effect and in-hospital mortality. This suggests that emergency care in the Netherlands is not compromised by different logistics during the weekend and appears to provide adequate emergency care to elderly patients.

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Chapter 5

Performance of the Manchester Triage System in older emergency department patients: A Retrospective Cohort Study

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Abstract

Background

Studies on the reliability of the Manchester Triage System (MTS) and its predictive power for hospitalisation and mortality in the older population have demonstrated mixed results. The objective is to evaluate the performance of the MTS in older patients (≥65 years) by assessing the predictive ability of the MTS for emergency department resource utilisation, emergency department length of stay (ED-LOS), hospitalisation, and in-hospital mortality rate. The secondary goal was to evaluate the performance of the MTS in older surgical versus medical patients.

Methods

A retrospective cohort study was conducted of all emergency department visits by patients ≥65 years between 01-09-2011 and 31-08-2012. Performance of the MTS was assessed by comparing the association of the MTS with emergency department resource utilisation, ED-LOS, hospital admission, and in-hospital mortality in older patients and the reference group (18-64 years), and by estimating the area under the receiver operating characteristics curves.

Results

Data on 7,108 emergency department visits by older patients and 13,767 emergency department visits by patients aged 18-64 years were included. In both patient groups, a higher emergency department resource utilisation was associated with a higher MTS urgency. The AUC for the MTS and hospitalisation was 0.74 (95%CI 0.73-0.75) in older patients and 0.76 (95%CI 0.76-0.77) in patients aged 18-64 years. Comparison of the predictive ability of the MTS for in-hospital mortality in older patients with patients aged 18-64 years revealed an AUC of 0.71 (95%CI 0.68-0.74) versus 0.79 (95%CI 0.72-0.85). The majority of older patients (54.8%) were evaluated by a medical specialty and 45.2% by a surgical specialty. The predictive ability of the MTS for hospitalisation and in-hospital mortality was higher in older surgical patients than in medical patients (AUC 0.74, 95%CI 0.72-0.76 and 0.74, 95%CI 0.68-0.81 versus 0.69, 95%CI 0.67-0.71 and 0.66, 95%CI 0.62-0.69).

Conclusion

The performance of the MTS appeared inferior in older patients than younger patients, illustrated by a worse predictive ability of the MTS for in-hospital mortality in older patients. The MTS demonstrated a better performance in older surgical patients than older medical patients regarding hospitalisation and in-hospital mortality.

Background

Over the past few decades, the number of Emergency Department (ED) visits has increased substantially, resulting in ED crowding.[1,2] This leads to prolonged ED length of stay (ED-LOS), treatment delay and reduced patient satisfaction, these are associated with adverse patient outcomes and a longer hospital stay.[3-6] In particular, the ageing of the population has a major impact on emergency care. Older patients (≥65 years old) presently account for up to 30% of all ED visits, which is expected to increase further.[2,7-9]

Older patients more often than younger patients present with atypical signs, symptoms and multi-morbidity, they therefore represent a complex population at the ED.[10,11] EDs may not be appropriately suited to these circumstances, as emergency care is focused on rapid assessment and treatment of acutely ill patients rather than addressing complex medical and social problems.[12] Consequently, older patients at the ED have a higher risk of being misdiagnosed than younger patients, potentially resulting in inadequate treatment and a poor outcome.[11]

EDs require a valid and reliable triage system to rapidly prioritise patients presenting in the ED based on their clinical urgency, as to efficiently plan available resources and time. Since 2003 the Dutch EDs use the five-level Manchester Triage System (MTS) to determine treatment priority.[13] Studies on the reliability of the MTS and its predictive power for hospitalisation and mortality in the general and paediatric population, however, have demonstrated mixed results.[14-20] Furthermore, the performance of the MTS differs between medical versus surgical specialties.[14] There is also some evidence suggesting that the MTS performs worse in the older population.[21,22]

The objective of this study was to evaluate the performance of the MTS in older patients (≥65 years) by assessing the predictive ability of the MTS for ED resource utilisation, ED-LOS, hospitalisation, and in-hospital mortality. The secondary objective was to compare the performance properties of the MTS between older surgical patients and older medical patients.

Methods

Study design, setting and participants

A retrospective cohort study was conducted at a teaching hospital in the Netherlands.[23] Approximately 28,000 patients visit the ED annually, of which about 25% are patients aged 65 years and older. Primary healthcare is accessible for every citizen 24 hours a

day and provides an important safety net in the Netherlands. Emergency departments cooperate closely with general practitioners (GPs) and the ambulance services. Patients are predominantly referred by a GP in the Dutch acute care system. Other modes of referral are by self-referral, referral by a medical specialist or ambulance.[24] In addition, in case of referral by GPs, they will provide the primary assessment for which medical specialty the patient will be referred. Assessment of patients presenting to the ED is predominantly performed by a non-trainee resident, a trainee resident or an emergency physician, supervised by a medical specialist.[25,26]

Data on all consecutive ED visits between September 1st 2011 and August 31st 2012 were extracted from electronic patient records by one investigator using a standard data collection form. Multiple visits per patient were possible and numbered accordingly in the database. Patients referred for cardiology are predominantly cared for in the emergency cardiac care unit, and therefore are not part of this study. Additionally, the majority of patients with gynaecologic and obstetric emergencies are cared for elsewhere in the hospital and do not present to the ED. Exclusion criteria were patients aged <18 years old, visits with a missing triage level and patients directly transferred to another department. Patients aged 18-64 years were included as a reference group to the older patients. Exemption of ethical approval by the Institutional Review Board of Máxima Medical Centre was acquired.

Manchester Triage System

Triage at the ED presentation is performed using the MTS.[13] This five-level system, developed by a consensus group in the United Kingdom, is based on 52 flowcharts representing pre-defined symptoms, such as “shortness of breath” and “abdominal pain”. In addition, each flowchart comprises of six key discriminators, such as danger to life, or severe pain, in order to distinguish between urgency categories.[13] The MTS consists of the following urgency categories corresponding to the maximum waiting time for first contact with a physician: 1. immediate (red), 2. very urgent (orange), evaluation within 10 minutes, 3. urgent (yellow), evaluation within 60 minutes, 4. standard (green), evaluation within 120 minutes and 5. non-urgent (blue), evaluation within 240 minutes.[13] The non-urgent level (blue) is not being used at our ED. All triage nurses are specialised ED nurses and have received specific training in applying the MTS using a computerised triage programme. Triage is performed either in the dedicated triage room or in a treatment room when patients arrive by ambulance.

Data collection and definitions

The primary outcome of interest was the performance of the MTS as assessed by the predictive ability for ED resource utilisation, ED-LOS, hospitalisation and in-hospital mortality of older ED patients (aged ≥ 65 years old). ED resource utilisation comprised of the number of diagnostic tests, medical procedures, medication administration and the number of specialty consultations. Diagnostic tests performed on the ED consisted of laboratory tests, urine tests, cultures, electrocardiograms, X-rays, ultrasonography, computed tomography scans, and magnetic resonance imaging. Placement of intravenous access, intubation, placement of urinary catheter or gastric tube, cardiac rhythm monitoring, wound, eye or compressive bandage, plaster cast, sling, and tetanus vaccination were considered as medical procedures. Final disposition was categorised into discharge home without follow-up, discharge home with follow-up by a GP or in an outpatient clinic, admission to the acute medical unit, admission to a high care unit, or admission to another hospital ward, died on ED and left without been seen by a physician (LWBS). Intensive care unit (ICU), medium care unit (MCU), stroke care unit (SCU) and cardiac care unit (CCU) were considered high care units. Data on admission to a high care unit was extracted manually from electronic patient records and only collected for the older patients. The primary medical specialty involved on the ED was divided into surgical (including general surgery, plastic surgery, urology, orthopaedics, otorhinolaryngology, ophthalmology, dermatology, oral surgery and gynaecology) and medical (including internal medicine, pulmonology, cardiology, neurology, psychiatry, gastroenterology and rheumatology). The time of presentation was divided into day (8 am - 5 pm), evening (5 pm - 12 pm) and night (12 pm - 8 am). The mode of referral was categorised as referral by GP, ambulance or medical specialist and self-referral. ED recording times (in minutes) were sectioned into 1) time in waiting room: time from ED arrival to ED bed placement, 2) treatment time: time from ED bed placement to end treatment time and 3) ED-LOS: time between ED arrival and ED discharge or hospital admission.[24]

Statistical analysis

Statistical analyses were performed using SPSS (IBM SPSS Statistics for Windows, version 22.0, Armonk, New York). The unit of analysis for this study was the ED visit thereby assuming independence of multiple visits by the same patient. Comparisons of the patient characteristics per triage category were tested using the Chi-square test for categorical variables. The Mann-Whitney U test, the Kruskal-Wallis test, the T-test, or ANOVA (analysis of variance) were used for the comparison of continuous variables depending on the number of groups and distribution. Continuous variables were

described by means of standard deviation (SD) or medians with interquartile range (IQR) as appropriate.
The association between the MTS category and dichotomous outcome variables was described by odds ratios (OR) and corresponding 95% confidence intervals (CI) as calculated by an univariable logistic regression analysis. The association between MTS category and ED-LOS was expressed as a regression coefficient and the corresponding 95% CI as calculated using linear regression analysis. A poisson regression analysis was performed to assess the association between the MTS category and the number of diagnostic tests and medical procedures performed. Results were expressed as incidence density ratios (IDR) with a 95% CI. The MTS category green was considered as the reference category in the regression analyses. Multivariable regression analysis was not performed as we were interested in the predictive ability of the MTS only. Patients that died on the ED were considered as not admitted to the hospital and excluded from the analyses on admission, and in-hospital mortality.
To compare the predictive ability of the MTS between older patients and the reference group (i.e. aged 18-64 years), we performed regression analyses with the MTS category as the independent variable stratified by age category. In addition, to compare the performance of the MTS in older patients assessed by a surgical versus medical specialty, a regression analysis was used stratified by the primary specialty on the ED.
The ability of the MTS categories to predict hospitalisation, admission to a high care unit, and in-hospital mortality was evaluated by estimating the area under the receiver operating characteristics (ROC) curves. A higher area under the curve (AUC) indicates a better accuracy; an AUC of 1.0 indicates an excellent performance and an AUC of 0.5 indicates a 50% chance of an accurate score. A two-sided p-value <0.05 was considered significant. The Bonferroni test was performed to correct for multiple comparisons. A p-value <0.0036 was considered significant after Bonferroni correction.

Results

During the study period, 30,748 ED visits were recorded. In total, 9,873 (32.1%) ED visits were excluded because they consisted of a paediatric population (19.4%), a missing triage level (2.5%) or direct transfers to other departments (10.2%). Older patients (aged ≥65 years) accounted for 34.1% (n=7,108) out of 20,875 eligible ED visits and were considered for the study population. In addition, 13,767 ED visits by patients aged 18-64 years old were included as the reference population (Figure 5.1).
The majority of older patients were assigned to the MTS category yellow (44.5%), followed by green (39.7%), orange (15.0%), and red (0.9%). In the group aged 18-64

years old, patients were predominantly assigned to the MTS category green (59.7%), followed by yellow (32.0%), orange (7.9%) and red (0.4%) (p<0.001 compared with older patients).

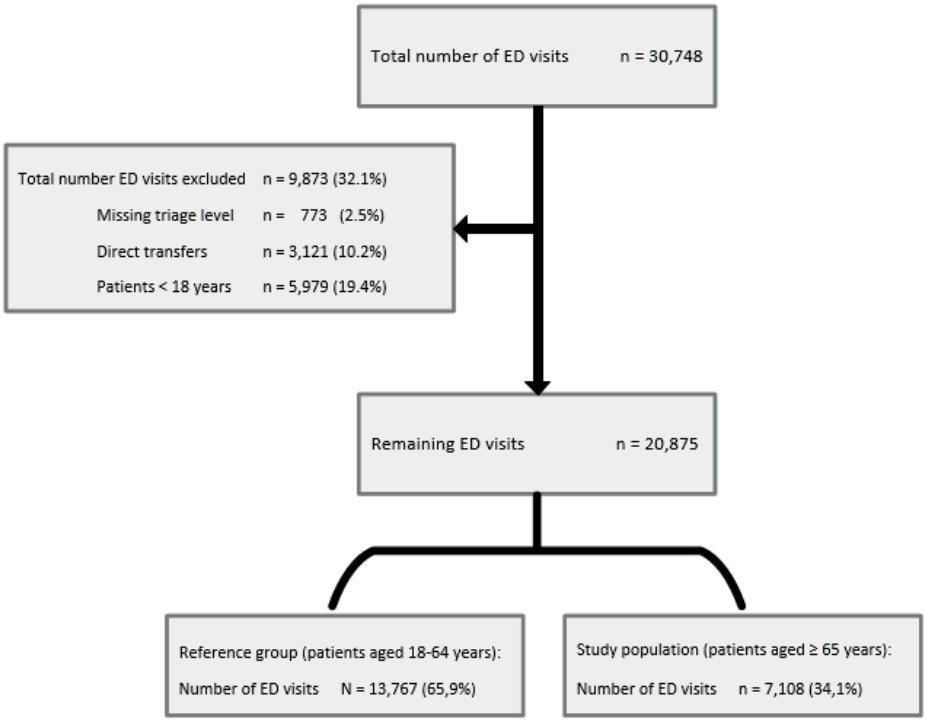

Figure 5.1 Flow chart of the studied population.
ED = emergency department. MTS = Manchester Triage System.

Patient characteristics

The mean age of the entire older study population was 77.0 years (SD 7.6 years). 45.8% were male compared with 55.6% males in the group aged 18-64 years (p<0.001). In both groups, male patients had higher urgency levels than female patients. The primary mode of referral for ED visits by older patients was by GP (57.5%), especially in categories orange, yellow and green (61.7%, 63.4%, and 49.5% respectively, p<0.001). In category red, both older patients and patients aged 18-64 years predominantly arrived by ambulance (55.7% and 60%). In 3,215 ED visits (45.2%), older patients were primarily treated by a surgical specialty and in 3,893 ED visits (54.8%) by medical

specialties (Table 5.1). Patients aged 18-64 years were predominantly treated by a surgical specialty (70.5%) (Supplement Table S5.1).

Table 5.1 Characteristics of emergency department visits by older patients per Manchester Triage System category.

	MTS category			
	Red (n=61)	**Orange (n=1,063)**	**Yellow (n=3,165)**	**Green (n=2,819)**
Mean age in years (SD)**	77.0 (6.9)	77.3 (7.3)	77.4 (7.7)	76.4 (7.7)
Male participants (%)**	34 (55.7%)	575 (54.1%)	1,430 (45.2%)	1,215 (43.1%)
Time of presentation (%)**				
Day	30 (49.2%)	612 (57.6%)	2,021 (63.9%)	1,937 (68.7%)
Evening	17 (27.9%)	300 (28.2%)	874 (27.6%)	757 (26.9%)
Night	14 (23.0%)	151 (14.2%)	270 (8.5%)	125 (4.4%)
Mode of referral (%)**				
General practitioner	24 (39.3%)	639 (61.7%)	1,909 (63.4%)	1,297(49.5%)
Self-referral	2 (3.3%)	85 (8.2%)	302 (10.0%)	652 (24.9%)
Ambulance	34 (55.7%)	237 (22.9%)	464 (15.4%)	177 (6.8%)
Medical specialist	1 (1.6%)	75 (7.2%)	338 (11.2%)	493 (18.8%)
Medical specialty (%)**				
Surgical	9 (14.8%)	160 (15.1%)	1,271 (40.2%)	1,775 (63.0%)
Medical	52 (85.2%)	903 (84.9%)	1,894 (59.8%)	1,044 (37.0%)

MTS = Manchester Triage System; SD = Standard Deviation; ED = Emergency Department; Surgical includes: general surgery, plastic surgery, urology, orthopaedics, otorhinolaryngology, ophthalmology, dermatology, oral surgery, gynaecology; Medical includes: internal medicine, pulmonology, cardiology, neurology, psychiatry, gastroenterology, rheumatology. P-values were calculated using ANOVA and Chi-square test; ** =p<0.001.

ED recording times

The median time in the waiting room was 3 minutes (IQR 0-11 minutes) in older patients and 7 minutes in patients aged 18-64 years (IQR 2-24 minutes) (p<0.001). In both groups, the time in the waiting room increased as the MTS urgency decreased, with the longest time in category green (in older patient 5 minutes, IQR 0-23, and in patients aged 18-64 years 10 minutes, IQR 4-34) (p<0.001). Overall, the median ED length of stay was 136 minutes (IQR 94-180) in older patients, and 99 minutes (IQR 61-146) in patients aged 18-64 years (p<0.001). In ED visits by older patients, the median ED-LOS was longest in category yellow (147 minutes, IQR 109-189), while the median ED-LOS was longest in category orange in patients aged 18-64 years (127 minutes, IQR 94-170) (Table 5.2 and Supplement Table S5.1).

Comparison of the association between the ED-LOS and the MTS category in older patients versus patients aged 18-64 years revealed a better association of the ED-LOS and the MTS category in older patients than in patients aged 18-64 years (Table 5.3).

Table 5.2 Emergency department length of stay, emergency department resource utilisation, hospitalisation and in-hospital mortality per Manchester Triage System category in older patients.

	MTS category			
	Red (n=61)	**Orange (n=1,063)**	**Yellow (n=3,165)**	**Green (n=2,819)**
Median ED-LOS in minutes (IQR)**	105 (59-139)	139 (104-179)	147 (109-189)	120 (75-168)
Number of diagnostic tests**				
mean (SD)	3.1 (2.1)	3.7 (1.8)	2.5 (1.7)	1.3 (1.3)
none (%)	11 (18.0%)	30 (2.8%)	345 (10.9%)	952 (33.8%)
Number of medical procedures**				
mean (SD)	3.4 (1.7)	1.5 (1.1)	1.5 (1.1)	0.9 (0.9)
none (%)	6 (9.8%)	44 (4.1%)	643 (20.3%)	1,166 (41.4%)
Medication administered at the ED**	40 (65.6%)	699 (65.8%)	1,518 (48.1%)	735 (26.1%)
>1 specialty consultations at ED**	8 (13.1%)	225 (21.2%)	553 (17.5%)	234 (8.3%)
Disposition				
Discharge home (%)	-	29 (2.7%)	307 (9.7%)	589 (20.9%)
Discharge home + follow-up (%)	-	54 (5.1%)	613 (19.4%)	1,278 (45.3%)
Admission acute medical unit (%)	6 (9.8%)	663 (62.4%)	1,883 (59.5%)	874 (31.0%)
Admission high care unit (%)	35 (57.4%)	228 (21.4%)	211 (6.7%)	19 (0.7%)
Admission to other hospital ward (%)	9 (14.8%)	87 (8.2%)	150 (4.7%)	58 (2.1%)
LWBS (%)	-	-	-	1 (0.0%)
Died in ED (%)	11 (18.0%)	2 (0.2%)	1 (0.0%)	-
In-hospital mortality# (%)	17 (34.0%)	132 (12.5%)	122 (3.9%)	47 (1.7%)

MTS = Manchester Triage System; SD = Standard Deviation; ED = Emergency Department; IQR = interquartile range; ED-LOS = emergency department length of stay; High care unit = intensive care unit, medium care unit, stroke care unit and cardiac care unit; LWBS = left without being seen by a physician; P-values were calculated using ANOVA, Kruskal-Wallis test and Chi-square test; ** = $p<0.001$; # = patients that have died in the ED are excluded from this analysis.

Table 5.3 Association between outcome measures and the Manchester Triage System category in older patients and patients aged 18-64 years.

Outcome measure	Group	MTS category – relative estimates with 95% confidence intervals			
		Red‡ (n=61)	Orange‡ (n=1,063)	Yellow‡ (n=3,165)	Absolute value in green reference category (n=2,819)
ED-LOS (minutes, difference)¶	18-64 years	36 (18.9-53.1)**	42.9 (38.8-47.0)**	41.3 (38.9-43.7)**	Median 80 (IQR 50-124)
	≥ 65 years	-17 (-34.7-0.4)	20.1 (15.3-25.0)**	28.8 (25.3-32.3)**	Median 120 (IQR 75-168)
Number of diagnostic tests (IDR)^	18-64 years	4.6 (4.0-5.3)**	3.7 (3.6-3.9)**	2.4 (2.3-2.5)**	Mean 0.7 (SD 0.9)
	≥ 65 years	2.4 (2.1-2.8)**	2.9 (2.7-3.0)**	1.9 (1.8-2.0)**	Mean 1.3 (SD 1.3)
Number of medical procedure (IDR)^	18-64 years	4.8 (4.2-5.5)**	2.6 (2.5-2.8)**	1.3 (1.2-1.3)**	Mean 0.8 (SD 0,8)
	≥ 65 years	3.8 (3.3-4.4)**	2.9 (2.7-3.0)**	1.7 (1.6-1.7)**	Mean 0.9 (SD 0.9)
Medication administered (OR)±	18-64 years	21.4 (10.1-45.3)**	5.2 (4.6-6.0)**	3.8 (3.5-4.1)**	N = 1,800 (21.9 %)
	≥ 65 years	5.4 (4.7-6.3)**	5.4 (4.7-6.3)**	2.6 (2.4-2.9)**	N = 735 (26.1%)
>1 specialty consultation (OR)±	18-64 years	13.2 (7.3-23.9)**	8.1 (6.6-9.8)**	4.2 (3.6-5.0)**	N = 242 (2.9%)
	≥ 65 years	1.7 (0.8-3.5)	3.0 (2.4-3.6)**	2.3 (2.0-2.8)**	N = 234 (8.3%)
Hospitalisation (OR) #±	18-64 years	74.9 (31.8-176.1)**	19.2 (16.6-22.3)**	7.0 (6.4-7.8)**	N = 757 (9.3%)
	≥ 65 years	47.4 (11.5-195.3)**	19.4 (15.5-24.2)**	4.8 (4.3-5.3)**	N = 951 (33.7%)
In-hospital mortality (OR)#±	18-64 years	190.9 (68.5-531.8)**	15.4 (6.6-36.0)**	5.1 (2.3-11.6)**	N = 8 (0.1%)
	≥ 65 years	29.7 (15.5-57.0)**	8.2 (5.9-11.5)**	2.3 (1.7-3.3)**	N = 47 (1.7%)

MTS = Manchester Triage System; ED = Emergency Department; ED-LOS = emergency department length of stay; IQR = inter quartile range; SD = standard deviation; IDR = incidence density ratio; OR = odds ratio; ‡ = Comparison of MTS category in both older patients and patients 18-64 years with reference category, which is MTS category green; ¶ = difference with MTS green in minutes, analysed with linear regression, reporting regression coefficients and 95% confidence intervals; ^= analysed with Poisson regression, reporting incidence density ratios; ± = analysed with logistic regression, reporting odds ratio and 95% confidence intervals; # = patients who have died in the ED are excluded from the analyses; ** =p<0.001.

ED resource utilisation

Overall, the mean number of diagnostic tests performed on the ED was 2.2 (SD 1.8) in older patients and 1.2 (SD 1.3) in the reference group (p<0.001). In older patients, the mean number of medical procedures on the ED was 1.4 (SD 2.2) compared with 1.0 (SD 1.0) in patients aged 18-64 years (p<0.001). Older patients assigned to category orange received the highest number of diagnostic tests (mean 3.7, SD 1.8) (Table 5.2). In patients aged 18-64 years, both the mean number of diagnostic tests and the mean number of medical procedures decreased as the MTS urgency decreased (Supplement Table S5.1). Furthermore, in 14.4% of the ED visits by older patients and in 7.1% of the ED visits by patients 18-64 years, >1 specialty consultations took place on the ED. Category orange in older patients (21.2%) and category red in patients 18-64 years (28.6%) received the most specialty consultations (Table 5.2 and Supplement Table S5.1). In both older patients and patients 18-64 years, a higher MTS urgency was associated with a higher ED resource utilisation (Table 5.3). There was a stronger association between the MTS category and the number of diagnostic tests as well as multiple specialty consultations in the reference group than in older patients (Table 5.3).

Hospitalisation

In total, 13.0% of the older patients were discharged home without a follow-up, 27.3% with a follow-up and 14 patients (0.2%) died on the ED (Table 5.2). The ED visits by older patients resulted in more hospital admissions than ED visits by patients 18-64 years (59.4% versus 24.5%, p<0.001). In older patients the median hospital length of stay decreased significantly with a lower MTS urgency from 7.0 days (IQR 2-14) in category red to 5.0 days (IQR 2.0-10.0) in categories yellow and green (p=0.012).
The risk of hospital admission following the ED visit was strongly associated with the MTS category in both older patients and patients 18-64 years. Older patients in the yellow category had a 4.8-fold (95% CI 4.3-5.3) higher risk of hospitalisation than the green category. In patients 18-64 years the risk increase in yellow versus the green category was significantly higher (OR 7.0, 95% CI 6.4-7.8) (Table 5.3). The AUC for the MTS and hospitalisation was 0.74 (95% CI 0.73-0.75) in older patients and 0.76 (95% CI 0.76-0.77) in patients 18-64 years (Figure 5.2). The likelihood of admission to a high care unit was associated with MTS category as well in older patients (Table 5.2), with an AUC of 0.79 (95% CI 0.77-0.81).

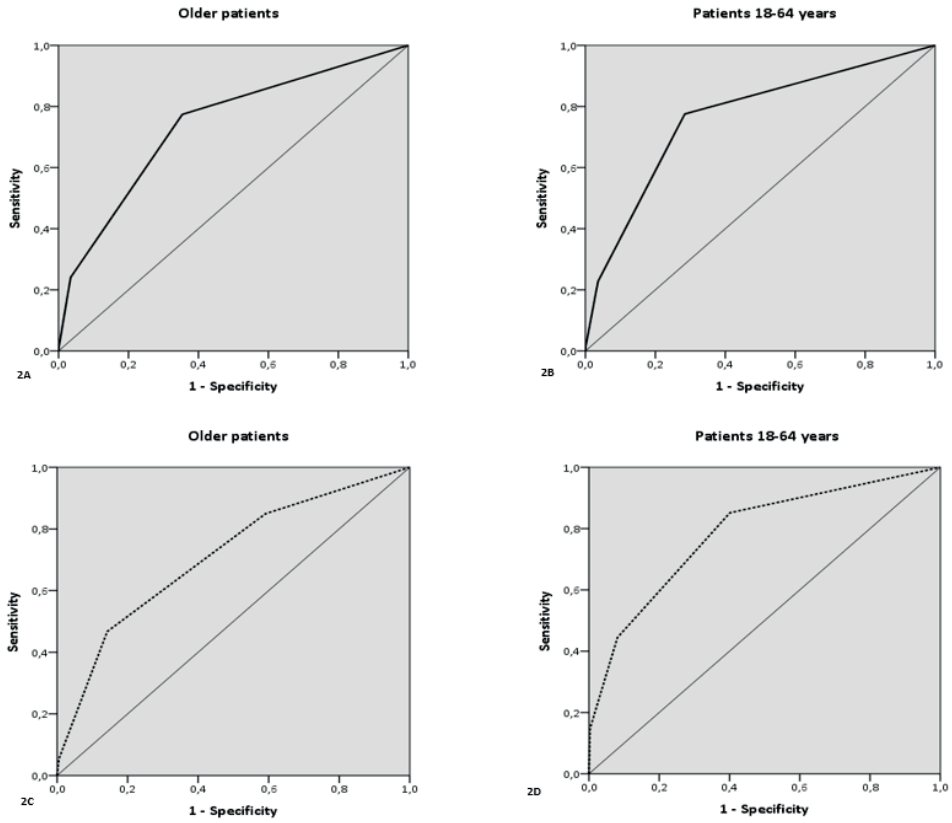

Figure 5.2 Receiver operating characteristics (ROC) curves for the Manchester Triage System and hospitalisation and in-hospital mortality in older patients, and patients aged 18-64 years.
2A: ROC for the MTS and hospitalisation in older patients (AUC 0.74, 95% CI 0.73-0.75).
2B: ROC for the MTS and hospitalisation in patients 18-64 years (AUC 0.76, 95% CI 0.76-0.77).
2C: ROC for the MTS and in-hospital mortality in older patients (AUC 0.71, 95% CI 0.68-0.74).
2D: ROC for the MTS and in-hospital mortality in patients 18-64 years (AUC 0.79, 95% CI 0.72-0.85).

Mortality

In-hospital mortality was 7.5% in older patients compared with 1.7% in patients 18-64 years ($p<0.001$). The mortality risk increased with increasing MTS category in older patients from 1.7% in the green category to 34% in the red category (Table 5.2).
Comparison of the in-hospital mortality in older patients with patients 18-64 years demonstrated similar associations with the MTS category (Table 5.3). The predictive ability of the MTS for in-hospital mortality was fair in older patients as well as patients

18-64 years with AUCs of 0.71 (95% CI 0.68-0.74) and 0.79 (95% CI 0.72-0.85) respectively (Figure 5.2).

Medical specialty

The majority of older patients assigned to the MTS category red, and orange were treated by a medical specialty (85.2% and 84.9% respectively, p<0.001) (Table 5.1). The mean age of older patients was comparable between surgical and medical specialties (76.9 years and 77.1 years, respectively, p=0.259).

Overall, older surgical patients received fewer diagnostic tests and medical procedures on the ED (mean 1.2 and 1.1 respectively) than medical patients (mean 3.0 and 1.7 respectively, p<0.001) (Table 5.4). The association between the MTS category and the number of diagnostic tests was comparable among older surgical patients and older medical patients (Table 5.4). In 11.7% of older surgical patients >1 specialty consultations took place on the ED compared with 16.5% in older medical patients (p<0.001). Overall, the median ED-LOS was considerably shorter in older surgical patients (111 minutes, IQR 71-158) compared with older medical patients (153 minutes, IQR 116-193, p<0.001) (Table 5.4). Hospital admission was more frequent in older medical patients (79.9%) than older surgical patients (35.0%) (Table 5.4). The predictive ability of the MTS for hospitalisation was better in older surgical patients than older medical patients (AUC 0.74, 95% CI 0.72-0.76 versus AUC 0.69, 95% CI 0.67-0.71 respectively). In total, 34 older surgical patients (1.1%) were admitted to a high care unit compared with 459 older medical patients (11.8%) (p<0.001). The AUC for the MTS and admission to a high care unit was 0.84 (95% CI 0.77-0.92) in older surgical patients, and 0.73 (95% CI 0.70-0.75) in older medical patients.

Overall, in-hospital mortality was 5.1% in older surgical patients, and 8.4% in older medical patients (p<0.001). The in-hospital mortality in older medical patients was higher in every MTS category as compared with older surgical patients (p<0.001) (Table 5.4). The difference in in-hospital mortality in older medical patients assigned to category yellow relative to category green was not statistically different (OR 1.4, 95% CI 0.95-2.1) (Table 5.4). The AUC for the MTS and in-hospital mortality was 0.74 (95% CI 0.68-0.81) in older surgical patients, and 0.66 (95% CI 0.62-0.69) in older medical patients.

Table 5.4 Emergency department resource utilisation, hospitalisation and in-hospital mortality per Manchester Triage System category in older surgical and medical patients.

Outcome measure	Group	MTS category – relative estimates with 95% confidence intervals			
		Red‡	Orange‡	Yellow‡	Absolute value in green reference category
		surgical: n=9 medical: n=52	surgical: n=160 medical: n=903	surgical: n=1,271 medical: n=1,894	surgical: n=1,775 medical: n=1,044
ED-LOS (minutes, difference)¶	Surgical	23.4 (-22.5-69.4)	61.8 (50.5-73.2)**	31.8 (26.7-36.8)**	Median 95 (59-140)
	Medical	-56.2 (-73.6- -38.7)	-19.1 (-24.7- -13.5)**	5.2 (0.4-9.9)	Median 158 (119-200)
Number of diagnostic tests (IDR)^	Surgical	3.6 (2.4-5.3)**	3.6 (3.3-4.0)**	2.2 (2.0-2.3)**	Mean 0.8 (0.9)
	Medical	1.5 (1.2-1.7)**	1.8 (1.7-1.9)**	1.4 (1.3-1.4)**	Mean 2.2 (1.4)
Number of medical procedure (IDR)^	Surgical	3.1 (2.1-4.7)**	3.1 (2.8-3.4)**	1.6 (1.5-1.7)**	Mean 0.8 (0.9)
	Medical	3.5 (3.0-4.1)**	2.5 (2.3-2.7)**	1.6 (1.5-1.7)**	Mean 1.0 (0.9)
Medication administered (OR)±	Surgical	4.0 (1.1-15.0)**	6.6 (4.7-9.4)**	3.9 (3.4-4.6)**	N = 423 (23.8%)
	Medical	4.8 (2.7-8.7)**	4.4 (3.7-5.4)**	1.8 (1.5-2.1)**	N = 312 (29.9%)
>1 specialty consultations (OR)±	Surgical	-	9.0 (6.2-13.0)**	2.6 (2.1-3.3)**	N = 117 (6.6%)
	Medical	1.4 (0.7-3.1)	1.7 (1.4-2.3)**	1.8 (1.5-2.3)**	N = 117 (11.2%)
Hospitalisation (OR)#±	Surgical	-	22.9 (15.0-34.9)**	6.2 (5.2-7.3)**	N = 291 (16.4%)
	Medical	-	9.1 (6.8-12.4)**	2.6 (2.2-3.1)**	N = 660 (63.2%)
In-hospital mortality (OR)#±	Surgical	50.4 (9.3-273.3)**	19.7 (8.8-44.3)**	4.1 (2.0-8.5)**	N = 10 (0.6%)
	Medical	15.7 (7.7-32.1)**	4.0 (2.7-5.9)**	1.4 (0.95-2.1)	N = 37 (3.5%)

MTS = Manchester Triage System; ED = Emergency Department; Surgical includes general surgery, plastic surgery, urology, orthopaedics, otorhinolaryngology, ophthalmology, dermatology, oral surgery, gynaecology; Medical includes internal medicine, pulmonology, cardiology, neurology, psychiatry, gastroenterology, rheumatology; SD = standard deviation; IQR = interquartile range; ED-LOS = emergency department length of stay. ‡ = Comparison of MTS category in older surgical and medical patients with reference category, which is MTS category green; ^= analysed with Poisson regression, reporting incidence density ratios; ± = analysed with logistic regression, reporting odds ratio and 95% confidence intervals; ¶ = difference with MTS green in minutes, analysed with linear regression, reporting regression coefficients and 95% confidence intervals; # = patients who have died in the ED are excluded from the analyses; ** =p<0.001.

Discussion

In our retrospective cohort, we have demonstrated that the MTS is associated with the ED resource utilisation, risk of hospitalisation and in-hospital mortality in older patients (≥65 years old). However, the performance of the MTS as a predictor of ED resource utilisation and in-hospital mortality in older patients was not as good as in patients aged 18-64 years (i.e. reference population). Stratifying the performance of the MTS by specialty revealed a better predictive ability of the MTS for hospitalisation and in-hospital mortality in older surgical patients than older medical patients.

Research on the validity of triage tools is complicated by the lack of a gold standard for true patient acuity. We based the performance of the MTS on its ability to predict hospitalisation and in-hospital mortality as a surrogate for acuity. In addition, we used the ED resource utilisation and the ED-LOS as a proxy for workload. These outcome measures are clinically relevant and correspond to the objective of the MTS, which is to prioritize patients based on clinical acuity in a setting with limited resources and persistent time pressure.[13]

Our study confirms previous findings of worse performance of the MTS in older patients compared with younger patients.[21,22] These results are also consistent with previous studies on the validity of another triage system, the Emergency Severity Index (ESI), in older patients, which demonstrated that older patients are at risk of undertriage.[7,27] These findings emphasize that older patients represent a special population on the ED with distinct care needs, similar to the paediatric population in which the performance of the MTS has been investigated.[15,16] However, it is possible that increased complexity due to multi-morbidity could explain the lower performance of the MTS in older patients rather than chronological age (28). Multi-morbidity, which is more common in older patients, often results in a challenging and time-consuming triage process.[29,30] Additionally, acute medical illnesses in older patients might be masked by an atypical presentation, such as generalized weakness or altered mental status, possibly contributing to a higher risk of undertriage.[7,21,22,29,31] Therefore, it is imperative that ED personnel are aware of the weaker performance of the MTS in older patients in order to prevent possible risks associated with inadequate triage in older ED patients, especially in medical patients.

Consistent with previous studies, the ED-LOS increased across MTS categories green to orange and was shortest in category red in older patients.[19] The association between the ED-LOS and the MTS was better in the older patients. However, the ED resource utilisation appeared to be less evidently associated to MTS category in older patients than in patients aged 18-64 years. The demand on resources by older patients at the ED is high, even in the green MTS category. Furthermore, over one third of older patients

in category green were hospitalised following the ED visit. These findings might elucidate the complexity of emergency care evaluation of older patients, as well as their impact on emergency care processes.

The predictive ability of the MTS for hospitalisation in our cohort of older patients (AUC 0.74) was fair, which is consistent with a previous study in the general population.[19] The admission rate in our older population was considerably higher (60%) than the 40-46% seen in other studies that focus solely on older patients,[27,32] which might be caused by the high admission rate in non-urgent patients, such as category green (33.8%) compared with other studies.[7,30] This could be explained by the difference in the health care system. The emergency care system in the Netherlands cooperates intensely with GPs, who offer around the clock emergency care,[24] which may result in referral of the more severely ill patients.

In both older patients and patients aged 18-64 years, the in-hospital mortality increased with an increasing MTS urgency, which is consistent with existing literature.[19,33] However, we found a difference in the predictability of the MTS for in-hospital mortality in older patients compared with patients aged 18-64 years (AUC 0.71 versus 0.79). A possible explanation is the relative higher in-hospital mortality rate in older patients in non-urgent categories yellow and green (3.9% and 1.7%) compared with patients aged 18-64 years (0.5% and 0.1%), which might be a reflection of advanced age, higher comorbidity level or more severe unrecognized illness in older patients.[11,29,34]

Our study demonstrated a difference in the performance of the MTS in older surgical patients compared with older medical patients. The ED resource utilisation was higher in older medical patients compared with surgical patients. Furthermore, the admission rate in medical patients was considerably higher than in surgical patients (80% versus 35%), which might be elucidated by a higher percentage of elective admission for surgical patients. Moreover, in-hospital mortality in older patients categorised yellow and green was significantly higher in medical specialties than surgical specialties (4.9% versus 2.3% and 3.5% versus 0.6%, respectively). In contrast with previous research, the MTS performed better in older surgical patients than medical patients regarding the number of diagnostic tests performed, and the ED-LOS.[14] In addition, the MTS appeared to more accurately predict hospitalisation (AUC 0.74 versus 0.69), admission to a high care unit (AUC 0.84 versus 0.73), and in-hospital mortality (AUC 0.74 versus 0.66) in older surgical patients than older medical patients. These findings might be explained by a higher complexity of older medical patients than surgical patients and more severe underlying illness requiring more resources, resulting in a longer ED-LOS and a higher admission rate.[33]

Limitations

Our results may have been influenced by several limitations. Firstly, owing to the retrospective observational design of the study, there is a risk of bias. The perception of acuity may differ from the real urgency of a patient's condition, which is difficult to identify based on administrative data. Secondly, our findings may be less generalisable to other hospitals and countries, because of the single-centre setting and distinct health care organisation in the Netherlands. Therefore, the organisation of emergency care in other countries should be considered when interpreting our findings. The majority of patients presenting with emergency cardiac and gynecological complaints were not included in this study, therefore our results may be less applicable to these patients. Thirdly, the impact of comorbidity on the difference performance of the MTS in older and younger patients was not taken into account in our study. Fourthly, only including admission to a high care unit or the need for immediate lifesaving intervention in the assessment of the performance of the MTS might be insufficient in older patients to identity actual acuity. This might result in an overestimation of the performance of the MTS, because of possible confounding by treatment constraints, such as a do not resuscitate order or a no ICU admission order. Last, the chance of a type 1 error was larger than 0.05 due to multiple testing.

Conclusion

In our retrospective cohort, the MTS appeared to perform worse in older patients (≥65 years old) as compared with younger patients (18-64 years old). Although, the MTS was associated with ED resource use, ED-LOS, hospitalisation and in-hospital mortality in older patients, the predictive ability of the MTS for in-hospital mortality was worse in older patients than in patients aged 18-64 years. The MTS demonstrated a better performance in older surgical patients than older medical patients regarding hospitalisation and in-hospital mortality. These findings emphasise the need for an increased awareness of the higher risk of adverse outcome in older emergency department patients, particularly, in older medical patients.

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Table S5.1 Characteristics of emergency department visits by patients aged 18-64 years per Manchester Triage System category.

	MTS category			
	Red (n=56)	**Orange (n=1,084)**	**Yellow (n=4,412)**	**Green (n=8,215)**
Mean age in years (SD)**	46.3 (13.8)	43.9 (14.3)	43.2 (13.7)	39.3 (14.1)
Male participants (%)**	35 (62.5%)	568 (54.1%)	2,223 (50.4%)	4,806 (58.5%)
Mode of referral (%)**				
General practitioner	17 (30.9%)	367 (35.2%)	1,757 (42.2%)	1,791 (23.0%)
Self-referral	4 (7.3%)	222 (21.3%)	1,458 (35.0%)	4,624 (59.4%)
Ambulance	33 (60.0%)	396 (37.9%)	579 (13.9%)	277 (3.6%)
Medical specialist	1 (1.8%)	59 (5.7%)	373 (9.0%)	1,094 (14.1%)
Specialty (%)**				
Surgical	12 (21.4%)	426 (39.3%)	2,398 (54.4%)	6,863 (83.5%)
Medical	44 (78.6%)	658 (60.7%)	2,014 (45.6%)	1,352 (16.5%)
Median ED-LOS in minutes (IQR)**	103 (70-170)	127 (94-170)	126 (87-171)	80 (50-124)
ED resource utilisation				
Mean number of diagnostic tests (SD)**	3.3 (1.9)	2.7 (1.7)	1.7 (1.4)	0.7 (0.9)
Mean number of medical procedures (SD)**	3.7 (1.6)	2.0 (1.2)	1.0 (1.0)	0.8 (0.8)
Medication administered (%)**	48 (85.7%)	644 (59.4%)	2,269 (51.4%)	1,800 (21.9%)
>1 specialty consultations on ED (%)**	16 (28.6%)	213 (19.6%)	504 (11.4%)	242 (2.9%)
Disposition (%)**				
Discharge home	2 (3.6%)	190 (17.5%)	938 (21.3%)	3,003 (36.6%)
Discharge home + follow-up	-	161 (14.9%)	1,629 (36.9%)	4,437 (54.0%)
Admission acute medical unit	10 (17.9%)	490 (45.2%)	1,581 (35.8%)	686 (8.4%)
Admission other hospital ward	39 (69.6%)	239 (22.0%)	258 (5.8%)	71 (0.9%)
LWBS	-	3 (0.3%)	6 (0.1%)	17 (0.2%)
Died in ED	5 (8.9%)	1 (0.1%)	-	-
In-hospital mortality[#] (%)**	10 (19.6%)	17 (1.6%)	22 (0.5%)	8 (0.1%)

MTS = Manchester Triage System; SD = Standard Deviation; ED = Emergency Department; Surgical includes: general surgery, plastic surgery, urology, orthopaedics, otorhinolaryngology, ophthalmology, dermatology, oral surgery, gynaecology; Medical includes: internal medicine, pulmonology, cardiology, neurology, psychiatry, gastroenterology, rheumatology; ED-LOS = emergency department length of stay; IQR = interquartile range. P-values were calculated using ANOVA, Kruskal-Wallis test and Chi-square test; ** =p<0.001; # = patients who have died in the ED are excluded from this analysis.

Part II

Patient-related factors influencing emergency care

Chapter 6

Hyponatraemia in elderly emergency department patients: A marker of frailty

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Abstract

Background

Details on hyponatraemia in the emergency department are limited, especially regarding older patients, a population more susceptible to hyponatraemia and its effects. Our objective was to gain insight into the prevalence, aetiology, treatment and prognosis of clinically relevant hyponatraemia in elderly emergency department patients. The impact of the severity of hyponatraemia on outcome was a secondary objective.

Methods

A retrospective cohort study of 1438 internal medicine patients aged ≥65 years presenting to the emergency department between 1 September 2010 and 31 August 2011 was performed. Clinically relevant hyponatraemia was defined as a serum sodium level <130 mmol/l. The reference group had a serum sodium level of 130-145 mmol/l. Hyponatraemia was subdivided into moderate (129-125 mmol/l), and severe (<125 mmol/l).

Results

Ninety-one elderly patients (6.3%) were hyponatraemic at presentation to the emergency department. The main causes were the use of diuretics, hypovolaemia, and the syndrome of inappropriate antidiuretic hormone secretion (57.1%). Hyponatraemia was associated with higher admission rates (93.4 vs. 72.9%) and longer hospital stay (8 vs. 6 days) vs. the reference group. Three-month survival rate in hyponatraemic elderly patients was 74% (95% CI 64-84%) vs. 83% (95% CI 81-85%) in the reference group. Moderate hyponatraemia was associated with an increased risk of death (HR 1.7, 95% CI 1.2-2.4) vs. the reference group after multivariable adjustment for age and comorbidity.

Conclusion

Hyponatraemia, a common electrolyte disturbance among elderly internal medicine patients presenting to the emergency department, was associated with higher admission rates, longer hospital stay, and higher mortality rates. In particular, moderate hyponatraemia was a marker of underlying frailty and predictive of mortality.

Introduction

Hyponatraemia is the most common electrolyte disturbance encountered in clinical practice.[1] The prevalence of hyponatraemia varies widely depending on the clinical setting. The highest frequencies are observed in intensive care unit (ICU) patients, in the postoperative setting, and in older patients admitted to geriatric wards.[2,3] The elderly are particularly susceptible to developing hyponatraemia, due to age-related physiological changes in water and electrolyte balance, the presence of comorbid conditions, and polypharmacy.[4-6]

Diagnostic evaluation of hyponatraemia can be challenging, especially in elderly patients with multi-morbidity, and requires a systematic approach, including assessment of the extracellular volume status and distinction between acute and chronic hyponatraemia.[7-9] Although mild stable hyponatraemia is often considered to be of little clinical significance, recent studies have identified an association between hyponatraemia and complications, such as falls due to gait instability, attention deficits, and an increased risk of fractures due to osteoporosis.[1,10,11] These complications may be of special significance to frail older patients with hyponatraemia. Furthermore, severe hyponatraemia is a marker of serious disease and an indicator of poor prognosis.[12-15] Nonetheless, it remains unclear whether the higher mortality rates encountered in severe hyponatraemia are directly related to deviations in sodium levels or to underlying conditions.[14,16]

Information on the frequency of hyponatraemia and its impact on outcome in elderly patients in an emergency department setting is limited. Yet, this information is essential in implementing a strategy to prevent adverse health outcome in this vulnerable population. The primary goal of our study was to gain insight into the prevalence, aetiology, clinical presentation, and treatment of clinically relevant hyponatraemia in elderly medical patients presenting to the emergency department. Differences in the presentation and outcome of elderly patients with hyponatraemia versus elderly patients with normal serum sodium levels and the impact of the severity of hyponatraemia on patient outcome were secondary objectives.

Materials and methods

Study design, setting and selection of participants

A retrospective cohort study was conducted at a 500-bed teaching hospital in the Netherlands. The majority of emergency department patients are referred by a general

practitioner. Other modes of presentation are referral by a medical specialist, ambulance arrival in high emergency patients, and self-referral. Patients presenting to the emergency department are assessed by an intern, a non-trainee resident, or a trainee resident supervised by a medical specialist or emergency physician.
Data on all visits of patients aged 65 years or older referred to the emergency department for internal medicine between 1 September 2010 and 31 August 2011 were extracted by two abstractors with a medical background. The abstractors were not blinded to the study hypothesis. Patients were excluded if internal medicine was not the principle treating speciality in the emergency department. The presence of hyponatraemia was identified by laboratory investigation in the emergency department. After identification of elderly patients with hyponatraemia in the emergency department, only data on the index visit were extracted. Follow-up lasted from the date of the emergency department visit until the end of at least one year of follow-up, the date of death, or the date of last available information. Institutional Review Board exemption of approval was acquired.

Covariates

Information on baseline characteristics, medical history, and medication use as assessed in the emergency department, the date and time of the visit, clinical characteristics at presentation to the emergency department, laboratory investigation performed in the emergency department, diagnosis and hospital discharge diagnosis, serum sodium levels during admission, discharge date, and the date of last follow-up or the date of death were retrieved from patient records. The index visit was defined as the first emergency department visit of each patient between 1 September 2010 and 31 August 2011. Triage at presentation was performed using the five-level Manchester Triage System (MTS).[17,18] Medical history and comorbidity as recorded in patients' emergency department records were classified according to the International Classification of Disease-10 (ICD-10) and according to the Charlson Comorbidity Index (CCI), which consists of the following categories: myocardial infarction, congestive heart failure, peripheral vascular disease, cerebrovascular accidents, pulmonary disease, connective tissue disease, peptic ulcer disease, liver disease, severe liver disease, diabetes mellitus (with and without complications), hemiplegia or paraplegia, cancer, metastatic cancer, and human immunodeficiency virus (HIV).[19] Polypharmacy was defined as the use of five or more different medications.[20]

Outcomes

The focus of the study was clinically relevant hyponatraemia, defined as a serum sodium level <130 mmol/l. Moderate and severe hyponatraemia were defined as serum sodium levels between 129-125, and <125 mmol/l, respectively. Elderly patients with a serum sodium level between 130-145 mmol/l were the reference group. Normonatraemia was defined as a serum sodium level between 135-145 mmol/l. Hypernatraemia was defined as a serum sodium level >145 mmol/l.[8]
The objective of the study was to estimate the prevalence, aetiology, treatment, and correction rate of clinically relevant hyponatraemia, hospital admission, the length of hospital stay, in-hospital mortality rate, and three-month and one-year survival. In a secondary analysis, we compared hyponatraemic patients with the reference group. Data on vital status to at least one-year follow-up were obtained from patient records or by contacting their general practitioners. If the date of death was unknown, the date in between the date of the last follow-up and the date of contact with the general practitioner was selected.

Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics for Windows, Version 19.0. Armonk, New York. Comparisons of baseline patient characteristics between hyponatraemic patients and the reference group and between the hyponatraemic severity groups were made using the Chi-square for categorical variables. Numerical variables were tested using one-way analysis of variance, the Kruskal-Wallis test, Mann-Whitney U test, and unpaired T-test, depending on the number of groups compared and the distribution pattern of the variable. Missing data were categorised as 'unknown' and included in the analyses. The prevalence of hyponatraemia was calculated by dividing the number of hyponatraemic elderly patients by the total number of elderly patients included in the study; 95% confidence intervals (95% CI) of the prevalence were estimated assuming a normal distribution.[21] Overall survival was estimated using the Kaplan-Meier survival analysis. The log-rank test was used to compare survival curves. Univariable and multivariable Cox regression analyses were performed in order to estimate the effect of covariates on patient outcome, expressed as hazard ratio (HR) and 95% CI. Multivariable analysis included all variables associated with the outcome in the univariable analysis at a p-value of 0.1 and changing the point estimate by > 10% in bivariable analysis, or variables considered as clinically relevant. Effect modulation was investigated. A p-value <0.05 was considered significant. A sensitivity analysis was performed to evaluate the effect of missing sodium values on

patient survival by including patients with missing values in the reference group in the analysis.

Results

Characteristics of study subjects

During the study period, 1438 index visits of patients aged 65 years and older presenting to the emergency department for internal medicine were identified. The reference group consisted of 1218 elderly patients. Ninety-one elderly patients were hyponatraemic (mean age 78.4 years), representing a prevalence of 6.3% (95% CI 5.2-7.7%). Serum sodium level was unknown in 84 elderly patients and 45 elderly patients were hypernatraemic. In 91 hyponatraemic patients, 58 (63.7%) were classified as moderate, and 33 (36.3%) as severe hyponatraemia.

In seven patients (7.7%), the main reason for the emergency department visit was hyponatraemia. Malaise was the most prevalent symptom, namely in 15 patients (16.5%). Other reasons for the visit in hyponatraemic elderly patients included confusion or delirium in seven patients (7.7%), hyperglycaemia in three patients (3.3%), collapse or fall in four patients (4.4%), and somnolence in two patients (2.2%). Most patients presented with symptoms unrelated to hyponatraemia.

Twenty-four hyponatraemic patients (26.4%) were male compared with 565 (46.4%) in the reference group ($p<0.001$) (Table 6.1). The comorbidity index was comparable among hyponatraemic elderly patients and the reference group (mean CCI 2.5 vs. 2.2, respectively, $p=0.335$). Diuretic use was more frequent in hyponatraemic patients than in the reference group (55.6 vs. 36.1%, respectively, $p<0.001$). Hyponatraemic elderly patients were more often diabetic compared with the reference group (Table 6.1). Hyponatraemic elderly patients had a higher C-reactive protein level (44.5 vs. 23 mg/l, respectively, $p = 0.022$) than the reference group. Primary diagnoses made in the emergency department were similar in hyponatraemic elderly patients and the reference group. Fifty-three elderly patients (3.7%) were lost to follow-up, of which 47 (3.9%) patients were in the reference group, one (1.1%) was hyponatraemic, two (4.4%) were hypernatraemic, and for three (3.6%) patients, sodium level was unknown.

Elderly patients with unknown serum sodium levels (n=84) were younger (75.9 vs. 77.7 years, respectively, $p=0.035$) than elderly patients in the reference group. They had lower comorbidity levels (mean CCI 1.5 vs. 2.2, respectively, $p=0.005$) and were less frequently admitted to the hospital (29.8 vs. 72.9%, respectively, $p<0.001$). The most

common presenting symptom was (suspected) deep venous thrombosis (n=23, 27.4%), as opposed to malaise in patients for whom sodium data were available.

Table 6.1 Baseline characteristics of elderly patients presenting at the emergency department.

	Total (n=1309)	Hyponatraemia (n=91)	Reference group (n=1218)	p-value
Mean age in years (SD)	77.8 (7.7)	78.4 (7.5)	77.7 (7.8)	0.447
Range	65–99	65–94	65–99	
Male patients (%)	589 (45.0%)	24 (26.4%)	565 (46.4%)	<0.001
Medical history (%)				
No history	11 (0.8 %)	1 (1.1%)	10 (0.8%)	0.860
Unknown	3 (0.3%)	-	3 (0.3%)	
Diabetes mellitus	308 (23.5%)	31 (34.1%)	277 (22.7%)	0.040
Dementia	76 (5.8%)	2 (2.2%)	74 (6.1%)	0.235
Heart failure	121 (9.2%)	11 (12.1%)	110 (9.0%)	0.488
Malignancy	358 (27.3%)	29 (31.9%)	329 (27.0%)	0.480
Respiratory condition	192 (14.7%)	10 (11.0%)	182 (14.9%)	0.443
Mean CCI (SD)	2.2 (2.1)	2.45 (2.3)	2.2 (2.1)	0.335
Medication use (%)				
Polypharmacy	766 (58.5%)	59 (64.8%)	707 (58.0%)	0.448
Unknown	119 (9.1%)	7 (7.7%)	112 (9.2%)	
Diuretics	489 (37.4%)	50 (55.6%)	439 (36.1%)	0.001
Antipsychotics	42 (3.2%)	3 (3.3%)	39 (3.2%)	0.719
Antidepressants	102 (7.8%)	6 (6.6%)	96 (7.9%)	0.616
Mean number (SD)	6.29 (3.8)	6.7 (3.8)	6.3 (3.8)	0.270
Referral (%)				0.189
General practitioner	955 (73.0%)	73 (80.2%)	882 (72.4%)	
Medical specialist	87 (6.6%)	7 (7.7%)	80 (6.6%)	
Ambulance	131 (10.0%)	7 (7.7%)	124 (10.9%)	
Self-referral	136 (10.4%)	4 (4.4%)	132 (10.8%)	
Triage by MTS				0.700
Red	16 (1.2%)	1 (1.1%)	15 (1.2 %)	
Orange	133 (10.2%)	11 (12.1%)	122 (10.0%)	
Yellow	744 (56.8%)	56 (61.5%)	668 (56.5%)	
Green	413 (31.6%)	23 (25.3%)	390 (32.0%)	
Blue	-	-	-	
No triage	3 (0.2%)	-	3 (0.3%)	

SD = standard deviation, CCI = Charlson Comorbidity Index, MTS = Manchester Triage System: red = immediate resuscitation, orange = very urgent, yellow = urgent, green = standard, blue =non-urgent. P-value for comparison of elderly patients with hyponatraemia and the reference group. P-values were estimated using the unpaired T-test, Mann-Whitney U test, and Chi-square test.

Aetiology and treatment

A minority of patients received an advanced diagnostic work-up in the emergency department to determine the cause of hyponatraemia, such as measurement of blood

osmolality (22.0%), urine osmolality (23.1%), and urine sodium (45.1%). The presumed cause of the hyponatraemia was specified in the emergency department charts of 62 patients (68.1%). The use of diuretics was considered the primary cause (n=25, 27.5%), followed by hypovolaemia (n=14, 15.4%) and syndrome of inappropriate antidiuretic hormone secretion (SIADH) (n=13, 14.3%). Other causes were hyperglycaemia (n=2, 2.2%), renal insufficiency (n=2, 2.2%), and heart failure (n=3, 3.3%).

In 83.5% of the hyponatraemic elderly patients (n=76), therapy to correct the serum sodium was started in the emergency department. The most frequently used method of correction (n=28, 30.8%) was a combination of the infusion of isotonic sodium chloride (0.9% NaCl) and cessation of medication; 26.4% of elderly patients (n=24) received 0.9% NaCl infusion. Other methods of correction were cessation of medication (n=6, 6.6%), fluid restriction (n=7, 7.7%), hypertonic sodium chloride infusion (3% NaCl) (n=4, 4.4%), or other combination therapy (n=7, 7.7%). Treatment time in the emergency department was similar for hyponatraemic patients and the reference group (median 161 vs. 162 minutes, respectively, p=0.450) and hyponatraemic patients with and without a cause specified (162 vs. 159 minutes, respectively, p=0.655).

The median initial rate of sodium correction in the severe hyponatraemia group (n=32) was 0.53 mmol/l/hour (range 0.06-2.8 mmol/l/hour) during the first ten hours of correction. In nine patients with severe hyponatraemia (27.3%), the rate of correction exceeded 10 mmol/l/24 hours. No patients developed osmotic demyelination syndrome. Six (6.6%) elderly patients were discharged home from the emergency department with hyponatraemia. Eleven hyponatraemic patients (15.3%) still had a serum sodium level <130 mmol/l at time of hospital discharge.

Patient outcome

Hyponatraemia in elderly emergency department patients was associated with higher admission levels (93.4 vs. 72.9%, respectively, p<0.001) and longer median hospital stay (8 vs. 6 days, respectively, p=0.021) compared with the reference group (Table 6.2). Hospitalised elderly patients with hyponatraemia (n=85) had higher triage levels compared with hyponatraemic patients who were discharged home from the emergency department (n=6). Comorbidity levels and medication use were comparable among hospitalised and discharged hyponatraemic elderly patients. The three-month survival rate of hyponatraemic elderly patients directly discharged from the emergency department was 100 vs. 72% (95% CI 62-82%) in hospitalised hyponatraemic elderly patients. The in-hospital mortality rate of elderly patients with hyponatraemia was

15.3% (n=13), in contrast to 9.3% (n=83) in older patients from the reference group (p=0.087).

Three-month and one-year survival in all hyponatraemic elderly patients were 74% (95% CI 64-84%) and 53% (95% CI 43-63%) vs. 83% (95% CI 81-85%) and 69% (95% CI 67-71%) respectively in the reference group. Complete (n = 61) or incomplete (n=11) correction of the sodium level during hospitalisation did not influence one-year survival (57%, 95% CI 45-69% vs. 73%, 95% CI 48-98%, respectively). After multivariable adjustment for age and CCI, and a combination of age, CCI and C-reactive protein, hyponatraemia was independently associated with higher mortality rates among elderly patients (HR 1.5, 95% CI 1.1-2.1 and HR 1.5, 95% CI 1.1-2.0) compared with the reference group (Table 6.3). Sensitivity analysis, performed to evaluate the effect of missing sodium values on patient outcome, revealed no change in one-year survival (70%, 95% CI 68-72%), when considering all patients with unknown sodium values as part of the reference group.

Table 6.2 Outcome in hyponatraemic elderly patients versus the reference group.

	Total elderly (n=1309)	Hyponatraemia (n=91)	Reference group (n=1218)	p-value
Hospital admission (%)	973 (74.3%)	85 (93.4%)	888 (72.9%)	<0.001
Median length of hospital stay in days (range)	6 (1–91)	8 (1–64)	6 (1–91)	0.021
ICU/MCU admission (%)	32 (3.3%)	2 (2.4%)	30 (3.4%)	0.051
Death during admission (%)	96 (9.9%)	13 (15.3%)	83 (9.3%)	0.087
ED return visits <3 months (%)	316 (24.1%)	14 (15.4%)	302 (24.8%)	0.085
Three-month survival (95%CI)	82% (80–84%)	74% (64–84%)	83% (81–85%)	
One-year survival (95%CI)	68% (66–70%)	53% (43–63%)	69% (67–71%)	

ICU = Intensive Care Unit, MCU = Medium Care Unit, SD = standard deviation, 95%CI = 95% confidence interval. P-values for comparison of outcome in elderly patients with hyponatraemia and the reference group. P-values were estimated using the Mann-Whitney U test and Chi-square test. One-year survival was calculated with Kaplan Meier analysis.

Subgroup analysis of hyponatraemia categories

CCI and diuretic use were comparable among patients with moderate and severe hyponatraemia (Table 6.4). Severely hyponatraemic patients presented more often to the emergency department with symptoms related to hyponatraemia (36.4%) compared with moderately hyponatraemic patients (22.4%). Diagnostic work-up was increasingly complete with worsening of serum sodium (Table 6.4). The C-reactive protein level was 78.5 mg/l in moderate, and 12 mg/l in severe hyponatraemia. In 29 (87.9%) of the severely hyponatraemic patients, the aetiology of the sodium disorder was registered in the emergency department, compared with 33 (56.9%) in moderate hyponatraemia (p<0.002). The primary cause of severe hyponatraemia was

the use of diuretics (n=12, 36.4%), followed by SIADH (n=10, 30.3%) and hypovolaemia (n=4, 12.1%). Treatment was started in the emergency department in 32 (97.0%) of the patients with severe hyponatraemia, and 44 (75.9%) of the patients with moderate hyponatraemia (p=0.015). Admission rates were similar among hyponatraemia categories (Table 6.4).

One-year survival was 50% (95% CI 36-64%), and 58% (95% CI 40-76%) for moderate, and severe hyponatraemia, respectively. Adjustment for age, CCI and a combination of age, CCI, and C-reactive protein levels revealed an increased risk of death in patients with moderate hyponatraemia (HR 1.7, 95% CI 1.2-2.4 and HR 1.5, 95% CI 1.1-2.2, respectively) vs. elderly patients in the reference population (Figure 6.1) (Table 6.3).

Table 6.3 Unadjusted and adjusted hazard ratio and 95% confidence intervals for mortality in hyponatraemic elderly patients compared with the reference group.

	Total (n=91)	**Moderate (n=58)**	**Severe (n=33)**
Crude HR	1.5 (1.1–2.0)	1.7 (1.2–2.4)	1.2 (0.7–2.1)
Age-adjusted	1.5 (1.1–2.0)	1.6 (1.1-2.2)	1.2 (0.7–2.1)
CCI-adjusted	1.6 (1.2–2.2)	1.8 (1.2–2.5)	1.3 (0.8–2.2)
Malignancy-adjusted	1.5 (1.1–2.1)	1.6 (1.1–2.3)	1.4 (0.8–2.4)
CRP-adjusted	1.4 (1.0-1.9)	1.5 (1.1-2.2)	1.1 (0.7-2.0)
Multivariable adjusted [1]	1.5 (1.1-2.1)	1.7 (1.2-2.4)	1.3 (0.8-2.3)
Multivariable adjusted [2]	1.5 (1.1–2.0)	1.5 (1.1-2.2)	1.3 (0.7-2.2)

[1] Adjusted for age and CCI, [2] Adjusted for age, CCI, and CRP levels. HR = hazard ratio, 95%CI = 95% confidence interval, CCI = Charlson Comorbidity Index, CRP = C-reactive protein. Variables initially considered as potential confounders: referral pattern, gender, history of diabetes, respiratory condition and heart failure, total number of medications, polypharmacy, and diuretics.

Table 6.4 Characteristics of elderly patients, subdivided into moderate, and severe hyponatraemia.

	Moderate (n=58)	Severe (n=33)	p-value
Mean age in years (SD)	78.8 (7.8)	77.6 (7.0)	0.191
Male patients	15 (25.9%)	9 (27.3%)	1.000
Medical history (%)			
Heart failure	8 (13.8%)	3 (9.1%)	0.740
Dementia	1 (1.7%)	1 (3.0%)	1.000
Diabetes mellitus	18 (31.0%)	13 (39.4%)	0.492
Malignancy	22 (37.9%)	7 (21.2%)	0.109
Respiratory condition	4 (6.9%)	6 (18.2%)	0.160
Mean CCI (SD)	2.5 (2.1)	2.3 (2.5)	0.640
Medication use (%)			
Polypharmacy	37 (63.8%)	22 (66.7%)	0.837
Unknown	4 (6.9%)	3 (9.1%)	
Diuretics	32 (56.1%)	18 (54.5%)	0.964
Total number (SD)	6.6 (4.0)	7.0 (3.6)	0.671
Diagnostic work-up on ED (%)			
Blood osmolality	8 (13.8%)	12 (36.4%)	0.018
Urine osmolality	10 (17.2%)	11 (33.3%)	0.119
Urine sodium	19 (32.8%)	22 (66.7%)	0.002
Cause of hyponatraemia (%)			0.002
No cause specified	25 (43.1%)	4 (12.1%)	
Diuretics	13 (22.4%)	12 (36.4%)	
Hypovolaemia	10 (17.2%)	4 (12.1%)	
SIADH	3 (5.2%)	10 (30.3%)	
Hyperglycaemia	1 (1.7%)	1 (3.0%)	
Renal insufficiency	2 (3.4%)	-	
Heart failure	2 (3.4%)	1 (3.0%)	
Other	2 (3.4%)	1 (3.0%)	
Admission (%)	53 (91.4%)	32 (97.0%)	0.411
Median hospital LOS in days (range)	9 (1-64)	7 (1-29)	0.492
Death during admission (%)	10 (18.9%)	3 (9.4%)	0.290
Three-month survival (95%CI)	74% (62-86%)	73% (57-89%)	

SD = standard deviation, ED = emergency department, CCI = Charlson Comorbidity Index, SIADH = syndrome of inappropriate antidiuretic hormone secretion, LOS = length of stay, CI = confidence interval. P-value for trend in comparison of moderate, and severe hyponatraemia. P-values were estimated using one-way analysis of variance (ANOVA), Kruskal-Wallis test, and Chi-square test.

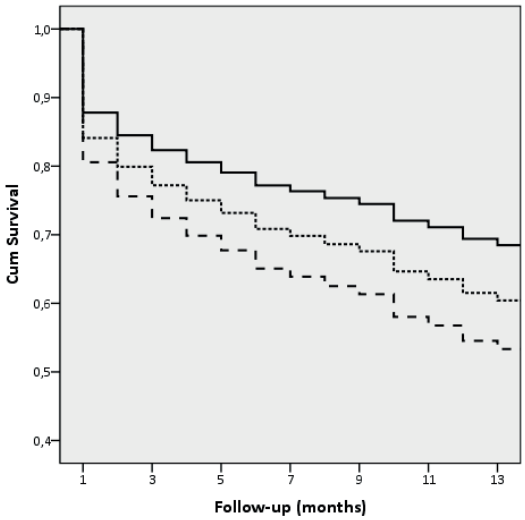

Figure 6.1 Survival in patients with moderate, and severe hyponatraemia and the reference group after adjustment for age and CCI.
CCI = Charlson Comorbidity Index.
——— = Reference group; ····· = Severe hyponatraemia; - - - -= Moderate hyponatraemia.

Discussion

In this retrospective cohort study, we report a prevalence of clinically relevant hyponatraemia (serum sodium level <130 mmol/l) of 6.3% in elderly internal medicine patients presenting to the emergency department. Research in hospitalised patients, focusing solely on elderly patients, reported a prevalence of 16.7-34.5%,[13,16,22,23] which is considerably higher than our results. However, comparison of our results remains difficult, since the cut-off value for hyponatraemia as well as the clinical setting vary among studies resulting in different prevalence rates.[7,24-27]

Few elderly patients presented to the emergency department solely for analysis of hyponatraemia. This corresponds with findings that hyponatraemia was not an isolated disease, but rather an additional factor to an underlying disorder.[13] Remarkably, only a minority of patients received an appropriate diagnostic work-up according to the emergency department guideline.[28] In addition, the cause of hyponatraemia was specified in only 68.1% of hyponatraemic patients in the emergency department. Although both observations apply particularly to cases with moderate hyponatraemia, incomplete or lack of analysis could possibly lead to inadequate treatment in this group and consequently adverse patient outcome. However, due to the retrospective nature

of the study, some of the clinical assessment steps in the emergency department were perhaps not accurately documented but were in fact part of diagnostic work-up and treatment. In addition, we found an adequate median correction rate of 0.53 mmol/l/hour during the first ten hours of correction in severely hyponatraemic patients, the subgroup with the highest risk of complications.[28] Furthermore, even though the advised correction rate of 10 mmol/l/24 hours was exceeded in nine patients with severe hyponatraemia, no cases of osmotic demyelination syndrome occurred. Blood osmolality, however, was known in only 22.0% of hyponatraemic elderly, and therefore it was not possible to accurately identify pseudohyponatraemia or hyperosmolar hyponatraemia. Still, our analysis of all sodium values showed that hyponatraemia regardless of underlying pathophysiology is an adverse prognosticator in elderly emergency department patients.

Our study confirms previous findings that hyponatraemia is an indicator of poor prognosis, such as longer hospital stay and higher mortality rates.[14,24,26] In particular, patients with moderate hyponatraemia had the highest mortality rate compared with the reference group, even after adjustment for age, CCI, and C-reactive protein levels. We found no relationship between mortality in moderate hyponatraemia and the presence of an acute critical illness at emergency department presentation as is reflected by comparable triage levels among hyponatraemia groups. The increased mortality risk in elderly patients with moderate hyponatraemia may be due to a lack of guideline adherence, leading to underdiagnosing and undertreating of elderly patients with moderate hyponatraemia.[29] In addition, moderate hyponatraemia was frequently an additional finding in other underlying disorders. The therapy indicated for these disorders may not be appropriate for hyponatraemia. Moreover, the failure of physicians to identify the increased health risk associated with asymptomatic hyponatraemia in this frail population may contribute to adverse patient outcome. Since hyponatraemia, especially moderate hyponatraemia, is probably a good marker of frailty and a poor prognosis in older patients as is consistent with previous research,[23] it emphasises the need to adequately assess and treat hyponatraemia in elderly patients, in addition to careful monitoring of their general condition.

Our findings may have been influenced by several limitations. Firstly, due to the single-centre setting, our findings may not be generalisable to other populations. Secondly, there is a potential for bias, because of the retrospective observational design and as a result of incomplete data. Furthermore, the inability to determine the specific reason for measuring sodium levels in this retrospective cohort is a potential source of bias. Additionally, because of the availability of nursing home physicians in the Netherlands, elderly nursing home residents may have been underrepresented, since these patients are less likely to be sent to the emergency department for evaluation. Therefore, the

results of our study may not be applicable to this patient group. Moreover, despite our efforts to correct for confounders detected in previous research or encountered in this study, residual bias may remain. Lastly, the relatively small number of patients with severe hyponatraemia may contribute to reduced reliability of our results.

Future prospective research should focus on the impact of hyponatraemia on patient outcome specifically relevant to the elderly, such as the risk of cognitive and functional decline. In addition, whether improvement in the care of elderly hyponatraemic patients on the emergency department can result in a reduction of adverse outcome remains an important research question.

In summary, hyponatraemia is common among elderly internal medicine patients visiting the emergency department and is associated with adverse outcome. Moderate hyponatraemia seems to be of special importance to the elderly, as it appears to be a marker for frailty and predictive of mortality in this population. Improvement in adequately diagnosing and treating hyponatraemia in elderly emergency department patients is important, yet more attention to the general condition of this frail population is essential.

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Chapter 7

Summary and General Discussion

Summary and general discussion

Due to ageing of the population and increasing multimorbidity the number of older patients presenting to the emergency department (ED) will undoubtedly increase. Therefore, it is important to gain insight into several aspects regarding the quality and efficiency of emergency care for older patients. Older patients (in this thesis defined as aged ≥ 65 years) constitute a complex population with challenging needs in the ED setting.[1,2] In addition, they are at an increased risk of adverse outcomes following an ED visit.[3]

The main aim of this thesis was to contribute to the knowledge on emergency care processes that, as described in **chapter 1**, can be largely divided in organisational factors on the one hand and patient-related factors on the other. The studies in this thesis were performed to obtain more information regarding current emergency care use by older patients and address some knowledge gaps, that helps to identify factors for improvement and ultimately may improve the care of older patients in the ED. The specific knowledge gaps that have been studied are presented in Figure 7.1 (with corresponding chapters), which visualizes the challenging aspects of the increase in older patients in the ED. In addition, Figure 7.1 shows the (complex) interplay of organisational factors and patient-related factors and their impact on patient outcome.

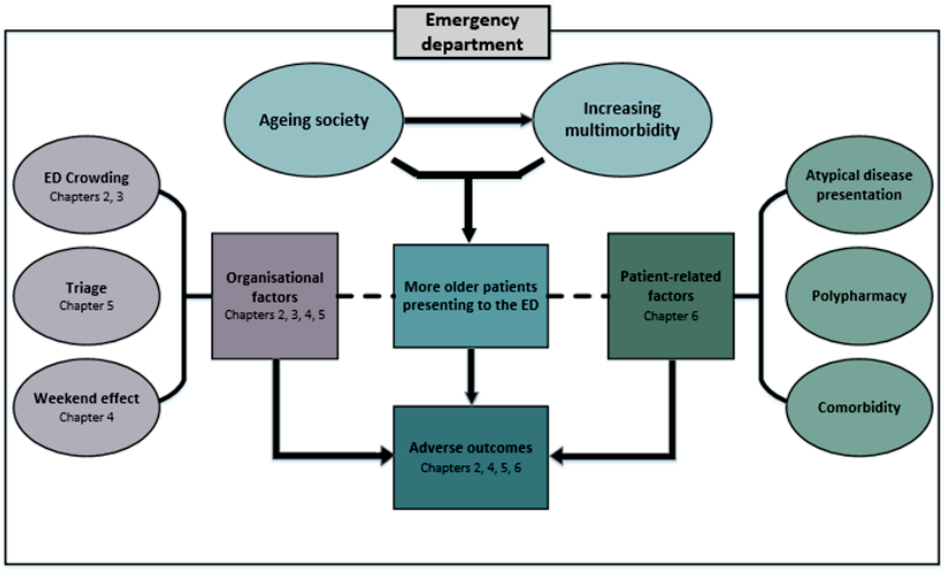

Figure 7.1 Overview of challenging aspects of the increase in older patients in the emergency department. ED = emergency department.

First, and as can be seen in Figure 1, some of the studies included in this thesis focussed on organisational factors, namely ED crowding, the weekend effect and triage and their associations with outcome. Second, in another study of this thesis, hyponatraemia -as surrogate for patient-related factors, such as atypical disease presentation and polypharmacy- and its influence on outcome such as hospital admission rates and 3-month mortality, was investigated in older patients presenting to the ED.

In this chapter, we summarize the main findings of each chapter and then discuss them while integrating information from the different chapters. Finally, some of the methodological considerations will be highlighted, overall conclusions will be drawn and future perspectives will be provided.

Organisational factors influencing emergency care

The studies investigating the organisational factors were conducted using retrospectively collected data of patients presenting to the ED of Máxima Medical Centre between 2010 and 2012.

ED Crowding

Emergency department length of stay

In **Chapter 2**, we investigated emergency department length of stay (ED-LOS) in older versus younger adult patients and explored the role of several organisational factors and their association with ED-LOS. We used a cohort of 1,782 older internal medicine patients that visited the ED and compared it to a random convenience sample of 597 younger adult internal medicine patients. Given the lack of a definition of prolonged ED-LOS, it was defined as ≥75 percentile of ED-LOS in the total study population. We showed that older patients, compared to younger adult patients, stayed considerably longer in the ED (25 minutes), with a median ED-LOS 172 minutes in older patients versus 147 minutes in younger adult patients. Furthermore, ED-LOS was clearly associated with several organisational factors in older patients, such as the number of consultations (13% of the older patients had more than one other specialty consultation, Odds Ratio (OR) 3.1 (95% confidence interval (CI) 2.3-4.2)), number of diagnostic tests ordered (mean number 3.2, OR 1.2 (95% CI 1.1-1.3)) and lower seniority of the physician (medical student or non-trainee resident compared with a medical specialist, OR 4.2 (95% CI 2.0-8.8) and OR 2.3 (95% CI 1.4-3.9) resp.).

The clear relationship between ED-LOS and organisational factors is in accordance with other studies.[4,5] It again shows that although an extensive diagnostic work-up seems beneficial, it is an important contributor to ED-LOS and therefore may also contribute to the phenomenon of ED crowding, which in turn may be associated with treatment delay and with adverse outcomes.[6-11] The finding that ED-LOS is associated with seniority of the staff is not surprising[12,13] and may suggest a possible mechanism of action, i.e. more senior staff will order fewer diagnostic tests and/or will need less other speciality consultations.
Altogether, these findings have important clinical implications, as it is common to place the youngest healthcare professional in the ED and the ED is a popular internship for medical students. This common practice is very counter-intuitive as the youngest and most inexperienced staff is taking care of the most severely ill and complex population. Nevertheless, this is the current reality and therefore, future research should focus on whether adding more experienced physicians (or physicians specifically trained for complex population, such as geriatricians, internists geriatric medicine or internists acute medicine) may reduce ED-LOS and ultimately improve patient outcomes.

ED crowding measures

While it is obvious that prolonged ED-LOS is a result of the phenomenon of ED crowding, a generally accepted definition or gold standard to measure ED crowding is lacking.[14] In order to better monitor and manage ED crowding and given the association with adverse patient outcomes,[6,15-17] an adequate crowding measure is needed. Therefore, we investigated the use of the Emergency Department Work Index (EDWIN) as a measure to track ED occupancy, and its ability to detect fluctuations in ED occupancy in **Chapter 3.** In addition, the discriminatory value of the EDWIN in identifying ED crowding, as compared with the occupancy rate and prolonged ED-LOS was investigated. Concerning its contents, several adjustments were necessary to make the EDWIN applicable to the conditions of emergency care in the Netherlands, given the lower patients volumes, the limited occurrence of ED boarding and different triage system as compared with the USA where the EDWIN was initially developed and validated.[18,19] This resulted in the modified EDWIN (mEDWIN). Because of these alterations and the fact that we assumed that the predefined cut-off values of the EDWIN were not applicable to our ED,[20] we also had to change the threshold of ED crowding and based it on the 75th percentile of the hourly mEDWIN, which was ≥0.28. In total, 28,220 ED visits were included and analysed, which were all ED visits during one year. The mEDWIN was calculated for each hour of the day, and for each patient the mEDWIN was calculated based on the hour of ED arrival.

The distribution of the mEDWIN and percentage of ED crowding varied considerably per day, with a higher median mEDWIN (0.15 vs. 0.14, p=0.021) and percentage of ED crowding (26.6% vs. 21.5%, p<0.001) on weekdays as compared to weekends. We also found a peak in median mEDWIN (0.30-0.33, IQR 0.20-0.49) and ED crowding (52.9-63.4%) between 13:00 and 18:00h. The mEDWIN had good discriminatory value when comparing it with the occupancy rate (area under the curve (AUC) of 0.86, 95%CI 0.85-0.87). However, mEDWIN did not have any discriminatory value with regard to prolonged ED-LOS (i.e. ED-LOS ≥4 hours), with an AUC 0.50, 95%CI 0.40-0.60.
To summarize, we found evidence supporting the use of mEDWIN as monitoring tool to track occupancy and ED crowding in particular. Consistent with previous studies that used different triage systems or that made alterations to the calculation to avoid computational errors,[21,22] adjustments were made in order to fit the Dutch healthcare system. When interpreting these results, it is important to realize that if we had used the predefined cut-off values based on the original research by Bernstein,[20] the majority of fluctuations in ED occupancy and crowding would have been unobserved. In line with this, while our study was single centre and retrospective and observational by design, the calculated cut-off value for mEDWIN for ED crowding of 0.28 (based on the 75th percentile) has to be interpreted with caution, as it might vary considerably between different EDs, even within the Netherlands. Therefore, future prospective studies should focus on the further validation of mEDWIN, identification of threshold values and eventually, on establishing a fixed cut-off value for EDs in the Netherlands. In addition, comparison of the mEDWIN with physician and patient perception of ED crowding may add valuable information. Another unresolved issue focusses on the value of mEDWIN as monitoring tool that allows EDs to anticipate and adapt to an altered patient flow in peak hours.

Weekend effect

In **chapter 4**, the hypothesis whether older patients are more prone to develop adverse outcomes associated with the different organisation (decreased staffing levels and reduced availability of resources) of acute care during the weekends, also labelled as the "weekend effect", was explored.[23-27] The effect of hospital admission after an ED visit during the weekends on outcome in older internal medicine patients (≥65 years old) was investigated by comparing mortality rates (in-hospital mortality, 2-day mortality and 30-day mortality) in 629 weekend admissions with 2,114 weekday admissions of older patients. Our study revealed a weekend effect in older hospitalized internal medicine patients, showing a higher two-day mortality rate with an OR of 1.7, 95%CI 0.99-2.9, and higher in-hospital mortality with an OR of 1.3, 95%CI 0.99-1.8,

albeit not statically significant. After adjustment for important confounding factors, such as comorbidity and urgency level (which were both higher during the weekends), the 'weekend effect' was negated somewhat further with a two-day mortality rate ORadj of 1.5, 95%CI 0.8-2.6 and an in-hospital mortality ORadj of 1.2, 95%CI 0.9-1.7, respectively.

The lack of an obvious (and statistically significant) weekend effect in this study is in contrast with previous research.[25-28] A possible explanation is the difference in case-mix, as previous studies demonstrating a weekend effect focussed on specific acute conditions, such as ruptured aortic aneurysm, traumatic brain injury, stroke or myocardial infarction,[23,24,29] which are all diseases requiring immediate assessment and intervention and are not primarily managed by an internist and therefore not included in our study. Furthermore, the discrepancy with other studies may be due to differences in health care organisation, as the majority of studies on the weekend effect have been conducted in the United States, Canada and the United Kingdom.[23-27] These countries have a very different health care system than the Netherlands, where general practitioners (GPs) offer a gatekeeping role for the acute care system and EDs cooperate intensively with the ambulance services and GPs.[18].

We believe our findings offer important insights to the current existing literature. Although we found no apparent weekend effect for older hospitalized internal medicine patients. This is an interesting finding in itself, as patients with other index diseases (eg. myocardial infarction, stroke) seem to suffer more from the weekend effect. This instigates the discussion on whether studying the weekend effect should focus on specific patient populations/index diseases or that it should focus on reduced access of necessary resources. Another consideration relates to the perspective of outcome measurement. Although previous studies have mainly focussed on mortality rates when investigating the weekend effect, it is arguable whether this is an appropriate outcome measure to assess quality of care, especially in older patients. Therefore, future research ought to focus on other outcome measures that are more suitable to the older population, such as functional decline (limitations to activities of daily living), hospital length of stay, readmissions and health-related quality of life.[30] Finally, when assessing the weekend effect, further exploration of the entire patient pathway should be considered. Although it is fair to assume that a reduced access of necessary resources and possible treatment delay during weekends will negatively impact health outcome, it is unlikely that this is solely an 'ED-problem' and therefore, the whole care pathway, starting from ED referral to inpatient care, should be hold accountable for this, according to the in-, through-, and output model.

Triage

Triage systems aim to detect the most critically ill patients in need of immediate treatment in a setting with limited resources and continuous time pressure. The Manchester Triage System (MTS), a frequently used triage system in the Netherlands, is a five-level triage system initially developed in the United Kingdom by a multidisciplinary consensus group.[31] It comprises of 52 flowcharts corresponding to pre-defined complaints, such as abdominal pain, falls or shortness of breath. Furthermore, each flowchart contains key indicator questions, such as severe pain or danger to life or unresponsiveness, By answering these questions a distinction can be made by the triage nurse between one of the five triage categories (see Table 7.1).[31]

Table 7.1 The Manchester Triage System.

Colour code	Triage category	Target time for first assessment by physician (minutes)
Red	Immediate	0
Orange	Very urgent	10
Yellow	Urgent	60
Green	Standard	120
Blue	Non-urgent	240

In **chapter 5**, we assessed the performance of the MTS in older patients (≥65 years) by evaluating the predictive ability of the MTS for ED resource utilisation, ED-LOS, hospitalisation, and in-hospital mortality rate. A secondary objective was to investigate the performance of the MTS in two groups of older patients: older surgical versus medical patients. In total, 7,108 ED visits by older patients and 13,767 ED visits by younger adult patients (18-64 years) were included. In our Dutch ED population the ED resource use, hospitalisation rate and in-hospital mortality rate were higher in older patients than in younger adult patients, irrespective of triage category**.** The predictive ability of the MTS for in-hospital mortality was less in older patients compared with younger adult patients (AUC 0.71, 95%CI 0.68-0.74 versus 0.79, 95%CI 0.72-0.85). Furthermore, after stratification by specialty, the MTS was more accurate in predicting hospitalisation and in-hospital mortality in older surgical patients than in older medical patients (AUC 0.74, 95%CI 0.72-0.76 and 0.74, 95%CI 0.68-0.81 versus 0.69, 95%CI 0.67-0.71 and 0.66, 95%CI 0.62-0.69). These data imply that in up to 30% of the patients, the MTS does not adequately predict severity of illness, especially in older medical patients, which may result in increased morbidity and mortality due to delayed treatment.

The finding that the MTS performed worse in older than in younger patients, is in accordance with previous studies on other triage tools, such as the Emergency Severity Index (ESI) and Canadian Triage and Acuity Scale (CTAS), which have all revealed an

11-23% risk of undertriage in older patients.[32] A possible explanation might be that the overall higher complexity of older, in particular medical, patients is caused by more severe underlying diseases requiring more resources and resulting in higher hospitalisation and in-hospital mortality rates.

These findings regarding the low predictive ability of MTS in older, medical, ED patients have important implications for current clinical practice, as not only the speed of treatment initiation is guided by triage category, but the efficiency of the organisation of ED resources is based on triage as well. On the one hand, misclassification of severely ill patients (undertriage) may lead to treatment delay. On the other hand, incorrect categorisation of low urgency patients impacts patient flow in the ED, and may result in increased waiting times for severely ill patients, particularly in the event of ED crowding.

Triage partly relies on the subjective assessment of trained ED personnel, especially in the MTS, as it is a symptom-based triage tool with limited use of vital parameters compared with the ESI.[33] The impact of this subjectivity may be particularly noticeable in older patients given their often atypical disease presentation of acute medical conditions.[33-38] Improving the performance of current triage systems in older patients presenting to the ED is imperative in order to prevent adverse outcomes. Since a study by Zelis et al. showed that clinical intuition had added value in predicting mortality and other adverse outcomes, such as prolonged hospital LOS and loss of independent living,[39] future research should be directed at the incorporation of clinical intuition into current triage systems in order to optimize predictive power and prevent adverse outcomes in older patients and improve ED patient flow.

Patient-related factors influencing emergency care

Emergency care for older patients is influenced by multiple patient-related factors, such as an atypical disease presentation, multimorbidity and polypharmacy (Figure 7.1). Since it is not possible to study every medical condition on its own, hyponatraemia was used as an example, of a patient-related factor as it is a frequently occurring and complex problem in older patients in the ED which often requires an often extensive diagnostic work-up.

Hyponatraemia

Older individual patients are inherently prone to develop hyponatraemia due to comorbidity, polypharmacy and age-related physiological changes. The prevalence,

presentation, treatment, and outcome of older patients presenting to the ED with clinically relevant hyponatraemia, defined as a serum sodium level <130 mmol/l, was assessed in **Chapter 6.** Secondary objectives were the impact of the severity of hyponatraemia on patient outcome and the difference in presentation of older patients with hyponatraemia versus older patients with normal serum sodium levels. The study population consisted of 1,309 older internal medicine patients, of which 91 (6.3%) had clinically relevant hyponatraemia at ED presentation. The remaining 1,218 patients were categorized as reference group (serum sodium level of 130-145 mmol/l). Hyponatraemia was further subdivided into moderate hyponatraemia (125-129 mmol/l) and severe hyponatraemia (<125 mmol/l), which was present in 63.7%, and 36.3% of this subset of patients, respectively.

In our study, older patients with hyponatraemia often presented with non-specific symptoms, for instance malaise (16.5%), confusion or somnolence (9.9%), and collaps or fall (4.4%). In only a minority of patients, a systematic work-up was conducted to determine the cause, such as measurement of urine sodium (45.1%), and blood and urine osmolality (22.0% and 23.1%, respectively). We also showed that older patients with hyponatraemia had longer hospital stay (median 8 days) compared to those without hyponatraemia (median 6 days). Furthermore, our study revealed a three-month survival rate in patients with hyponatraemia of 74% (95% CI 64-84%) compared to 83% (95% CI 81-85%) in the reference group. After adjustment for age and comorbidity, moderate hyponatraemia was associated with an increased risk of death (HRadj 1.7, 95% CI 1.2-2.4) compared with the reference group, while severe hyponatraemia showed a HRadj of 1.3, 95% CI 0.8-2.3.

In the majority of older patients in our study, hyponatraemia was not the main reason for ED presentation, which is in accordance with previous studies and emphasizes that hyponatraemia is an additional factor to an underlying illness rather than an isolated disease.[40,41] Although the cut-off value for hyponatraemia and the clinical setting differ among studies, our finding that hyponatraemia is associated with adverse outcome, such as longer hospital length of stay and higher mortality rate, is consistent with previous research.[42-45]

Intuitively, it seems surprising that patients with moderate hyponatraemia have an increased mortality risk, while patients with severe hyponatraemia do not. Although our study might be underpowered to investigate this issue comprehensively, several possible explanations of these findings need further exploring. First, with increasing severity of hyponatraemia, the diagnostic work-up was more thorough leading to identifying an underlying cause. Consequently, adequate therapy could have been initiated faster which in turn might have reduced the initially increased mortality risk. Second, and in line with this, while severe hyponatraemia more often has a directly

identifiable (pathophysiological) cause, moderate hyponatraemia might act as a marker of frailty and thus might be a better predictor of mortality. It still needs to be determined whether improving the diagnostic work-up, especially in the moderate group, improves patient outcome. Not in the least because recent studies have suggested that volume status and whether patients have a hyper-, hypo- or euvolaemic hyponatraemia seems a better predictor of mortality.[46,47] Not surprising was the finding that hypervolemic hyponatraemia, usually an expression of (end-stage) congestive heart failure, was associated with the largest increase in mortality risk.

Because of the frequent occurrence of hyponatraemia in older patients, the previously mentioned findings have important clinical implications. Given its association with poor outcome, hyponatraemia may have considerable consequences other than higher mortality rates, influencing quality of life of older patients. Cognitive deficits, unsteady gait and increased risks of falling are associated with hyponatraemia and are particularly relevant in older patients.[48] These associations emphasize the need for and increased awareness among physicians regarding the increased health risks associated with hyponatraemia in this frail population. In addition to a thorough assessment and adequate treatment of hyponatraemia in older patients, prevention of hyponatraemia, taking modifiable risk factors, such as medication use into account, is warranted in order to prevent adverse outcomes.

Future research should focus on the influence of hyponatraemia (and its treatment) on outcome measures specifically relevant to older patients, such as the risk of cognitive and functional decline. Furthermore, a more active and targeted approach to the correction of both moderate and severe hyponatraemia is needed and prospective studies should be encouraged to investigate whether such an approach also translates to the improvement of patient outcomes.

Methodological considerations

The main strengths and limitations of the studies in this thesis have been discussed in detail in the respective chapters. Nevertheless, before some overall conclusions can be drawn, a general reflection on several methodological considerations of the studies included in this thesis is required and these are highlighted in this paragraph.

In this thesis, we used data from patients that presented to the ED of the Máxima Medical Centre (MMC), Veldhoven, the Netherlands, between 2010 and 2012. In the different chapters, different study samples that were deemed appropriate per research question were selected.

First, as all studies took place in a single centre, one can question whether the patients that were included are representative for all (older) ED patients. The results in this thesis may therefore not be generalizable to other hospitals, as the organisation of ED care on the one hand and the complexity of patients that present to the ED on the other may vary between hospitals, and EDs in particular. Nevertheless, since MMC Veldhoven serves as a regional second-line and teaching hospital with a large ED (nearly 30,000 ED visits annually) and ageing of the population occurs in all regions of the Netherlands, we may safely assume that the issues addressed in this thesis are generic and will also occur in other EDs in the Netherlands. The same may not be assumed for the generalizability to other countries as differences in how ED care and primary care are organised, withhold an adequate comparison between countries. Notwithstanding that, most of the topics studied in this thesis (such as ED crowding, the weekend effect and the importance of triage) are universal [19].

Second, the retrospective and observational design of the studies in this thesis also require attention when interpreting the results. By retrospectively collecting administrative data, such as vital parameters or presenting complaint, we might fail to 'correctly' score the real severity of illness of individual patients in the ED. This is important, since the real urgency of a patient's condition affects both organisational factors and outcome significantly. Furthermore, the already atypical disease presentation of older patients contributes to an even worse recognition of 'the real severity of illness'.[37] If on top of that older patients present with nonspecific complaints, it is not surprising that they have a more complex and time-consuming diagnostic work-up resulting in longer ED-LOS, have an increased risk of hospitalization and even have higher mortality rates.[36] In view of the above, future work should focus on collecting high-quality real-time data of patients presenting to the ED and a structured approach to (older) patients with nonspecific complaints is warranted to improve efficiency and patient outcome.

Third, another aspect that deserves attention when interpreting the results in this thesis, especially when assessing outcome, is the absence of a gold standard, for ED crowding (chapters 2 and 3) and for triage (chapter 5). The absence of a gold standard is problematic as it is consequently difficult to estimate the added (or incremental) value of the measurement or diagnostic test undertaken. Although technically and statistically intricate methodological approaches are available to calculate such an incremental value, we deliberately chose to include surrogate outcomes to obtain more clinically relevant information. For example, when assessing ED crowding, ED-LOS and the mEDWIN were used as surrogate outcome, while when assessing the MTS, ED

resource utilisation was used as a surrogate for workload, and hospitalisation and in-hospital mortality as a proxy for acuity.

Finally, the data collection for all studies in this thesis took place between 2010 and 2012. It is important to realize that since then, several initiatives, such as the implementation of acute geriatric units outside of the hospital (Amsterdam) and use of the acutely presenting older patient (APOP) screening tool,[49,50] were undertaken to optimize the organisation of EDs throughout the Netherlands, in order to secure and further improve good quality ED care. Furthermore, the patient case-mix has already changed as well with more older multimorbid patients presenting to the ED. Nevertheless, with further ageing of the population and the increasing complexity of frail, older individuals presenting to the ED, our findings on ED-LOS, crowding, triage, and weekend effect are timely and relevant like never before.

Conclusions and future perspectives

This thesis contributes to the knowledge on several aspects of the quality and efficiency of emergency care for older patients. Due to ageing of the population and consequently increasing incidence of multimorbidity, a huge influx of older patients to the ED will be inevitable. Therefore, we focused on organisational and patient-related factors that currently might withhold healthcare professionals to provide efficient and high-quality care to older patients in the ED. As such, we showed that (I) ED-LOS was associated with several organisational factors, such as number of specialty consultations, number of diagnostic tests performed and seniority of the physician; (II) the mEDWIN was able to track fluctuations in ED occupancy and identify periods of relative crowding; (III) the MTS is not suitable in older (medical) patients; (IV) hyponatraemia, as example of patient-related factors, was a frequently occurring condition in older patients with a complex work-up, and showed to be a marker of underlying frailty and predictor of mortality.

Although we believe this thesis makes a valuable contribution and provides insight into the current knowledge on organisational and patient-related factors, it is of vital importance to come up with a long-term improvement plan for managing older patients in the acute care, and in the ED. Such a plan should at least include recommendations for improvement of clinical practice and future research work, with the goal of improving emergency care processes for older patients, which is needed to ultimately improve ED care for older patients. Recommendations should therefore

focus, among other things, on (I) attempts to minimize the organisational burden of older ED patients with multimorbidity and complex diagnostic work-ups; (II) the awareness of healthcare professionals that current triage methods used in the ED underestimate the 'real' severity of illness of older patients and that triage methods may need to be optimized by incorporating cognitive or functional status or clinical intuition; (III) improving the infrastructure of acute care, for instance by developing a nonspecific complaints care pathway and (IV) creating a robust research infrastructure, including the possibility to prospectively collect (real-time) data and opportunity to continuously evaluate (newly) implemented healthcare pathways.

The results of thesis and (some of the) recommendations are summarized in Figure 7.2. These recommendations may lead to actions that might relieve this already overburdened healthcare system in order to ultimately improve the quality of care and outcome for all (older) patients presenting to the ED.

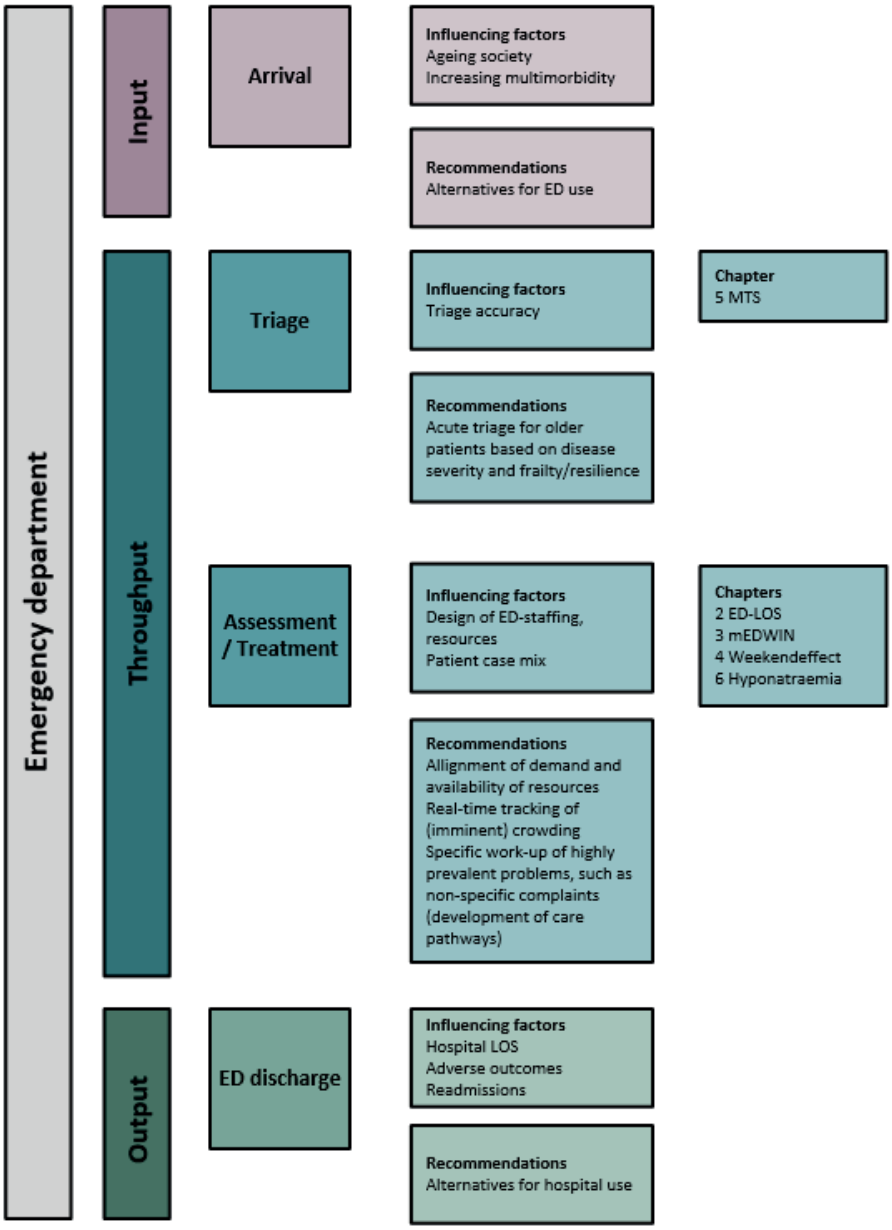

Figure 7.2 Overview of this thesis and proposed recommendations.
ED-LOS = emergency department length of stay; MTS = Manchester Triage System; ED = emergency department; mEDWIN = modified emergency department work index; LOS = hospital length of stay.

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Appendix

Impact paragraph

Impact paragraph

Given the ageing of the population and the anticipated increase in emergency department visits by (frail) older patients, increasing knowledge regarding their current emergency care use and their outcome is particularly relevant, since this population will increase pressure on an overstrained emergency care system. This thesis contributes to a better understanding of several aspects regarding the quality and efficiency of emergency care for older patients and to the knowledge on emergency care processes, divided in organisational and patient-related factors. In this final paragraph, a reflection on the impact of this thesis for society is given by discussing some overarching societal, economic, scientific and clinical implications.

Potential societal and economic impact

Assessing health is not only important from the patient perspective, but also from a societal and economical perspective, as this provides valuable information for healthcare insurers and other policy makers. Considering the ever-growing economic burden of healthcare in general, and the emergency department (ED) in particular, it becomes increasingly important to reflect on priorities and rational healthcare (and research) resource allocations, especially in times where healthcare expenditure is becoming increasingly restricted.

We have shown that several organisational factors, such as number of specialty consultations and number of performed diagnostic tests are associated with ED length of stay (ED-LOS) in older patients. Eventually, ineffective and inefficient emergency care will inevitably lead to increased and consequently unnecessary healthcare costs. Implementation of targeted healthcare pathways may help reduce these costs without handing in on (but likely even further improving) the quality and efficiency of emergency care. While this cost reduction is undeniably of utmost importance, such system changes will also contribute to a more positive patient experience, for example by reducing ED-LOS, prevention of treatment delay.
Another aspect that can be taken care of immediately if such as system change is at hand is the tremendous problem with shortages of staff in the entire health care system, of which emergency departments are not exempted. Monitoring tools, such as the mEDWIN, could be of value to better anticipate to patient flow and efficiently schedule ED personnel on the one hand, and by optimizing appropriateness of the clinicians attending the ED on the other hand. Recruiting internists geriatric or acute medicine, or emergency physicians, specifically trained for this complex population,

able to holistically assess multimorbid older patients presenting with frailty syndromes and non-specific complaints, may improve the emergency care process by reducing the need for multiple specialty consultations and also has the potential to optimize the diagnostic trajectory. One of the key competencies of such an acute generalist should therefore be that he/she is able to assess and provide the right care, both the diagnostic trajectory and treatment plan, at the right time and place.[1]

Because of the current challenges in health care and expected overburdening of emergency care due to an ageing population, changes are inevitable in order to guarantee the quality, accessibility, and affordability of emergency care now and in the future.

Potential scientific impact

The findings of this thesis may have possible implications for future research. By assessing current emergency care use by older patients, we have identified factors for improvement in order to increase quality of care, such as triage and the efficiency of care for older multimorbid patients. To evaluate whether these improvements also have the intended effects on efficiency and quality of care (and even outcome), further research is needed. As such, a robust research infrastructure is important, including prospectively collected (real-time) data, in order to assess current quality and efficiency of emergency care, in particular for older patients. Luckily, there are now national quality registries, such as the Dutch Registry for Acute and Internal Medicine (DRAIM) and the Netherlands Emergency Evaluation Database (NEED) that provide insight into current care of the participating emergency departments. Both quality registries are set up and maintained by different physicians, i.e. internists for DRAIM and emergency physicians for NEED. As such, further collaboration between both registries, especially in order to better coordinate which data should be collected, provides an important opportunity to further improve quality and increase transparency of emergency care. In addition, the gathered data could be used to evaluate implemented health care pathways and tailoring evidence-based up-to-date guidelines regarding emergency care for older patients with multimorbidity.

Future research should focus on whether the experience level of ED personnel regarding emergency care evaluation and treatment of older patients improves efficiency, as well as patient outcomes and patient experience, in which outcome measures more suitable to the older population such as evaluation of care needs, functional decline, readmissions and hospital length of stay need to be incorporated.

Potential clinical impact

Besides the potential societal, economical and scientific impact, this thesis may have several clinical implications as well. The findings are relevant for the older patient, as well as a large variety of health care professionals, as a broad spectrum of physicians and nurses are involved in the acute care pathway of an older patient, from referral to the ED by a general practitioner or physician in a long-term care facility to hospital admission. In our opinion, two factors need special consideration.

First, understanding of the distinct needs of older patients, patterns of their emergency care use and outcome ought to be increased among health care professionals. An emergency department visits is a major event for an older patient, as it is associated with an increased risk of delirium, functional decline and mortality, and is accompanied with great worries regarding condition and outcome. [2-4] By improving knowledge regarding the distinct needs, patterns of ED use and outcomes of older patients and by addressing their worries and unmet needs, the total patient experience of older patients in the ED might be improved.

Second, the current disease-oriented model in emergency care is not suitable for the older multimorbid patient with an atypical disease presentation and often nonspecific complaints. This is also illustrated by the fact that current triage methods used in the ED, such as the Manchester Triage System, lead to an underestimation of the 'real' severity of illness of older patients. Increasing the awareness of ED personnel of this phenomenon on the one hand and incorporating a more holistic approach, including cognitive and functional status, are necessary in order to improve patient outcome and experience.

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Appendix

Nederlandse samenvatting

Nederlandse samenvatting

De invloed van vergrijzing op de spoedzorg

Eén van de belangrijkste uitdagingen van de gezondheidszorg, inclusief de spoedeisende zorg, is op dit moment de vergrijzing van de samenleving. Ondanks dat de totale levensverwachting in de afgelopen decennia is gestegen, is de gezonde levensverwachting afgenomen. Het aantal mensen met chronische aandoeningen stijgt hierdoor.[1,2] Als gevolg van de vergrijzing en toename van multimorbiditeit zal een grote toeloop van oudere patiënten naar de spoedeisende hulp (SEH) onvermijdelijk zijn. Daarom is het van belang om meer inzicht te verwerven in de kwaliteit en efficiëntie van spoedeisende zorg voor oudere patiënten. Zij vormen namelijk een complexe groep met specifieke zorgbehoeften, vanwege een vaak atypische ziektepresentatie, de aanwezigheid van cognitieve stoornissen, en de toegenomen ziekte-ernst.[3,4]

Het doel van dit proefschrift was een bijdrage leveren aan de huidige kennis omtrent spoedeisende zorgprocessen, verdeeld in organisatorische factoren en patiënt-gerelateerde factoren. Om dit te bewerkstellingen besteedden we in de studies in dit proefschrift specifieke aandacht aan het huidige zorggebruik door oudere patiënten (≥65 jaar) op de SEH enerzijds en het identificeren van verbeterpunten voor deze doelgroep anderzijds. Als zodanig onderzochten we de invloed van organisatorische factoren, zoals SEH crowding (drukte op de SEH), het weekendeffect (slechtere patiëntuitkomsten door verandering van zorg gedurende het weekend) en triage en patiënt-gerelateerde factoren, zoals een atypische ziektepresentatie en polyfarmacie (gelijktijdig gebruik van ≥5 geneesmiddelen) op patiëntuitkomsten, zoals ziekenhuis-opname, en overlijden.

Organisatorische factoren die de spoedzorg beïnvloeden

Verschillende organisatorische factoren zijn van invloed op de spoedeisende zorg voor oudere patiënten en kunnen als gevolg ook de uitkomst van oudere patiënten beïnvloeden.

SEH verblijfsduur

SEH crowding, gedefinieerd als een situatie waarbij de behoefte aan spoedeisende hulp de beschikbare middelen voor patiëntenzorg op de SEH, in het ziekenhuis of beiden overschrijdt, is een groot probleem voor de spoedeisende zorg wereldwijd.[5-7] Naast de associatie tussen SEH crowding met ongewenste uitkomsten, zoals langere SEH verblijfsduur (tijd van binnenkomst op de SEH tot ontslag van de SEH) en vertraging in

behandeling[8-10], wordt SEH crowding gezien als een indicator voor de kwaliteit van spoedeisende zorg.[9,11,12] Oudere patiënten kunnen hier een rol in spelen, omdat er vanwege een atypische ziektepresentatie, uitgebreide comorbiditeit en aanwezigheid van psychosociale problemen, vaak een uitgebreide en tijdrovende beoordeling nodig is wat leidt tot een langere verblijfsduur op de SEH en extra druk legt op de spoedeisende zorg.

In **hoofdstuk twee** onderzochten we de SEH verblijfsduur bij oudere versus jongere volwassen patiënten en de rol van verschillende organisatorische factoren hierbij. We gebruikten een retrospectief cohort van 1.782 oudere interne geneeskunde patiënten en vergeleken dit met een willekeurige steekproef van 597 jongere volwassen interne geneeskunde patiënten die allen de SEH bezochten. Vanwege het ontbreken van een definitie van verlengde SEH verblijfsduur, werd deze gedefinieerd als ≥ 75 percentiel van SEH verblijfsduur in de totale onderzoekspopulatie. We toonden aan dat oudere patiënten, vergeleken met jongere volwassen patiënten, aanzienlijk langer op de SEH bleven. De SEH verblijfsduur was duidelijk geassocieerd met verschillende organisatorische factoren bij oudere patiënten, zoals het aantal consulten, het aantal diagnostische tests en ervaring van de arts (medische student of niet-in opleiding zijnde arts t.o.v. medisch specialist).

De duidelijke relatie tussen SEH verblijfsduur en organisatorische factoren toont opnieuw aan dat, hoewel uitgebreide diagnostiek gunstig lijkt, dit een belangrijke bijdrage levert aan een langere SEH verblijfsduur en daarom ook kan bijdragen aan het fenomeen van SEH crowding. Daarnaast lijkt de huidige praktijk, waarbij vaak de “jongste” minst ervaren artsen op de SEH zorg dragen voor de meest complexe en zieke patiënten contra-intuïtief. Toekomstig onderzoek moet zich richten op de vraag of de inzet van meer ervaren artsen (artsen die specifiek zijn opgeleid voor complexe populaties, zoals internisten ouderengeneeskunde, internisten acute geneeskunde, of geriaters) de SEH verblijfsduur verkort en uiteindelijk patiënt uitkomsten kan verbeteren.

SEH crowding meetinstrument

Hoewel het duidelijk is dat een lange SEH verblijfsduur bijdraagt aan het fenomeen SEH crowding, ontbreekt een algemeen aanvaarde definitie of gouden standaard om SEH crowding te meten.[5] Om SEH crowding beter te monitoren en te beheersen en vanwege de associatie met ongunstige patiënt uitkomsten is een betrouwbaar meetinstrument nodig.[8,9] Daarom hebben we in **hoofdstuk drie** de toepasbaarheid van het meetinstrument de Emergency Department Work Index (EDWIN) onderzocht als

maatstaf om de bezettingsgraad en fluctuaties in de bezetting op een SEH in Nederland te evalueren om vervolgens meer inzicht te verkrijgen in de drukte op een SEH. Verder onderzochten we het discriminerend vermogen (gevoeligheid) van de EDWIN bij het detecteren van SEH crowding, vergeleken met die van de bezettingsgraad (patiënten op de SEH ten opzichte van het aantal bedden) en de SEH verblijfsduur. Wat betreft de inhoud waren er enkele aanpassingen nodig om de EDWIN toepasbaar te maken voor de SEH in Nederland.[13-16] Dit resulteerde in de gewijzigde EDWIN (mEDWIN). Vanwege deze wijzigingen en het feit dat we ervan uit gingen dat de vooraf gedefinieerde afkapwaarden van de EDWIN niet van toepassing waren op onze SEH[13], moesten we ook de drempel van SEH crowding wijzigen om deze toepasbaar te maken voor de Nederlandse spoedzorg. In onze studies, varieerden de mEDWIN en het percentage SEH crowding aanzienlijk per dag, met een hogere mEDWIN en meer SEH crowding op reguliere werkdagen vergeleken met weekenden. Daarnaast was er een piek in mEDWIN score en SEH crowding tussen 13:00 en 18:00 uur. De mEDWIN bleek op basis van zijn onderscheidend vermogen een betere maat om SEH crowding aan te tonen, dan enkel naar de bezettingsgraad te kijken.

Samenvattend hebben we bewijs gevonden dat het gebruik van mEDWIN ondersteunt als instrument om de bezettingsgraad en de drukte op de SEH te volgen. Bij de interpretatie van deze resultaten is het van belang rekening te houden met de retrospectieve, observationele en single-center opzet van de studie. Toekomstig prospectief onderzoek is nodig, waarbij ook het toevoegen van de perceptie van patiënten en artsen ten aanzien van SEH crowding waardevol kan zijn.

Weekendeffect

Eerdere studies toonden een verband aan tussen de kwaliteit van de zorg op de SEH tijdens weekenden en nadelige uitkomsten, ook wel het 'weekendeffect' wordt genoemd.[17,18] In **hoofdstuk vier** onderzochten we het effect van ziekenhuisopname na een SEH-bezoek in het weekend op de uitkomst van oudere interne geneeskunde patiënten door de sterftecijfers (ziekenhuissterfte, 2-daagse en 30-dagen mortaliteit) te vergelijken met ziekenhuisopname op werkdagen. Onze retrospectieve studie toonde een weekendeffect bij oudere opgenomen patiënten, met hogere tweedaagse sterftecijfers en hogere ziekenhuissterfte, hoewel beiden niet statisch significant verschilden van de mortaliteit van de ouderen die reguliere werkdagen waren opgenomen. Na correctie voor belangrijke verstorende factoren, zoals comorbiditeit en urgentieniveau (die beiden hoger waren tijdens de weekenden), verdween het 'weekendeffect' verder.

Een mogelijke verklaring voor het ontbreken van een duidelijk (en statistisch significant) weekendeffect is het verschil in patiëntenpopulatie met eerdere studies, aangezien deze vaak gericht waren op een specifieke acute aandoening, zoals myocardinfarct of traumatisch hersenletsel, waarbij onmiddellijke beoordeling en behandeling essentieel is.[17-19] Deze groepen worden niet primair door een internist opgevangen en zijn derhalve niet geïncludeerd in deze studie. Daarnaast kan ook het verschil in organisatie van gezondheidszorg een rol spelen, aangezien de meeste onderzoeken naar het weekendeffect zijn uitgevoerd in de Verenigde Staten, Canada en het Verenigd Koninkrijk waar de eerste lijn anders georganiseerd is dan in Nederland.[17,18,20-22]

Desalniettemin bieden onze bevindingen belangrijke inzichten. Aangezien we geen duidelijk weekendeffect vonden voor oudere gehospitaliseerde interne geneeskunde patiënten, kan men zich afvragen of het bestuderen van het weekendeffect zich moet richten op specifieke patiëntpopulaties of dat het zich moet richten op de mogelijk verminderde toegang tot noodzakelijke hulpmiddelen in het algemeen. Daarnaast is het de vraag of sterfte een geschikte uitkomstmaat is voor de oudere patiënt of dat toekomstig onderzoek zich zou moeten richten op uitkomstmaten meer geschikt voor de oudere bevolking, zoals functionele achteruitgang, opnameduur in het ziekenhuis, heropnames of kwaliteit van leven.[23] Tenslotte is het aannemelijk dat een verminderde toegang tot de gezondheidszorg niet alleen een SEH-probleem betreft, maar een probleem van de gehele acute keten is.

Triage

Het Manchester Triage Systeem (MTS), een triagesysteem met vijf niveaus, wordt in Nederland vaak gebruikt om de urgentie van beoordeling en behandeling op de SEH te bepalen.[24] In **hoofdstuk vijf** werd het voorspellend vermogen van de MTS bij oudere patiënten voor het zorggebruik op de SEH (diagnostiek, medicatie, procedures en consulten), de SEH verblijfsduur, ziekenhuisopname en ziekenhuissterfte geëvalueerd. In onze SEH-populatie waren het zorggebruik op de SEH, het aantal ziekenhuisopnames en de ziekenhuissterfte hoger bij oudere patiënten dan bij jongere volwassen patiënten, ongeacht de triagecategorie. Het voorspellend vermogen van de MTS voor ziekenhuissterfte was minder goed bij oudere patiënten dan bij jongere volwassen patiënten. Daarnaast was de MTS nauwkeuriger in het voorspellen van ziekenhuisopname en ziekenhuissterfte bij oudere chirurgische patiënten dan bij oudere beschouwende patiënten.

Aangezien niet alleen de snelheid van het starten van de behandeling wordt bepaald door de triagecategorie, maar ook de efficiëntie van het eventuele zorggebruik op de

SEH hierop is gebaseerd, hebben deze bevindingen belangrijke gevolgen voor de praktijk. Oudere patiënten hebben een groter risico op ondertriage en een verkeerde diagnose dan jongere patiënten, door de vaak atypische ziektepresentatie van acute aandoeningen en aanwezigheid van multimorbiditeit, met als mogelijk gevolg suboptimale behandeling en ongewenste uitkomsten.[3,4,25,26] Optimalisatie van triage van oudere patiënten op de SEH, bijvoorbeeld door incorporatie van cognitieve of functionele status of klinische intuïtie, is noodzakelijk om nadelige uitkomsten te voorkomen en doorstroom op de SEH te verbeteren.

Patiënt-gerelateerde factoren die de spoedzorg beïnvloeden

Naast organisatorische factoren zijn er verschillende patiënt-gerelateerde factoren, zoals multimorbiditeit, polyfarmacie en een atypische ziektepresentatie, die van invloed zijn op de spoedeisende zorg voor oudere patiënten. Hyponatriëmie werd als voorbeeld genomen ter evaluatie van patiënt-gerelateerde factoren. Hyponatriëmie is een veelvoorkomend medisch probleem bij oudere patiënten op de SEH dat uitgebreide diagnostiek vergt en mogelijk ernstige gevolgen kan hebben met name bij kwetsbare oudere patiënten.[27]

Hyponatriëmie

Oudere patiënten zijn vatbaar voor het ontwikkelen van hyponatriëmie vanwege de aanwezigheid van multimorbiditeit met als gevolg polyfarmacie en leeftijd-gerelateerde fysiologische veranderingen.[28-30] In **hoofdstuk zes** werd de prevalentie, presentatie, behandeling en uitkomst van oudere patiënten die zich op de SEH presenteerden met klinisch relevante hyponatriëmie, gedefinieerd als een serumnatriumspiegel <130 mmol/l, onderzocht. De oudere patiënten in onze retrospectieve studie bleken zich vaak met niet-specifieke klachten te presenteren, zoals malaise, verwardheid of vallen. Er werd slechts in een minderheid van de patiënten systematisch diagnostiek verricht naar de oorzaak van de hyponatriëmie. Met betrekking tot de uitkomsten, bleken oudere patiënten met hyponatriëmie niet alleen een langere opnameduur (8 versus 6 dagen) te hebben vergeleken met ouderen zonder hyponatriëmie, ook hadden ze een hogere mortaliteit na 3 maanden. Na correctie voor leeftijd en comorbiditeit was enkel matige hyponatriëmie (125-129 mmol/L) geassocieerd met een verhoogd risico op overlijden.

Vanwege het frequent voorkomen van hyponatriëmie bij oudere patiënten en de associatie met slechte uitkomsten hebben de eerder genoemde bevindingen belangrijke klinische implicaties. Naast het verbeteren van het bewustzijn bij artsen ten

aanzien van de verhoogde gezondheidsrisico's die gerelateerd zijn aan hyponatriëmie bij deze kwetsbare populatie, een grondige evaluatie en adequate behandeling van hyponatriëmie bij oudere patiënten, is preventie van hyponatriëmie, rekening houdend met beïnvloedbare risicofactoren, zoals medicatiegebruik, belangrijk om nadelige uitkomsten te voorkomen.

Toekomstperspectief

Hoewel we van mening zijn dat dit proefschrift een waardevolle bijdrage levert en inzicht geeft in de huidige kennis over organisatorische en patiënt-gerelateerde factoren die een rol spelen in de zorg voor oudere patiënten op de SEH, is het essentieel om tot een lange termijn verbeteringsplan te komen voor spoedeisende zorg voor oudere patiënten.

Aanbevelingen zouden zich daarom onder meer moeten richten op: (I) pogingen om de organisatorische belasting door oudere patiënten met multimorbiditeit en complexe diagnostiek op de SEH te minimaliseren; (II) het besef van gezondheidszorg-medewerkers dat de huidige triagemethoden die op de SEH worden gebruikt de 'echte' ernst van de ziekte van oudere patiënten onderschatten en dat triagemethoden wellicht moeten worden geoptimaliseerd door gebruik te maken van klinische intuïtie en een inschatting te maken van cognitieve en functionele status; (III) het verbeteren van de infrastructuur van de acute zorg, bijvoorbeeld door het ontwikkelen van een zorgtraject voor ouderen met niet-specifiek klachten en (IV) het creëren van een robuuste onderzoeksinfrastructuur, inclusief de mogelijkheid om prospectief (real-time) data te verzamelen en om continu (nieuwe) zorgpaden te evalueren.

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Appendix

List of publications

List of publications

This thesis

Brouns SHA, Dortmans MKJ, Jonkers FS, Lambooij SLE, Kuijper A, Haak HR. Hyponatraemia in elderly emergency department patients: a marker of frailty. Neth J Med. 2014;72:311-317.

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Appendix

Dankwoord

Dankwoord

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Appendix

Curriculum vitae

Curriculum vitae

Steffie Brouns werd geboren op 28 oktober 1986 te Roermond. Na afronden van het VWO (gymnasium) aan Sint Ursula Scholengemeenschap te Horn in 2005, studeerde zij geneeskunde aan de Universiteit van Maastricht. In 2010 en 2011 volgde een afsluitende semiarts stage binnen de Interne Geneeskunde uitgevoerd in het Máxima Medisch Centrum. In 2011 behaalde zij haar artsexamen en startte zij onder begeleiding van prof. dr. H.R. Haak en dr. P.S. Stassen met het promotieonderzoek naar de kwaliteit en efficiëntie van spoedeisende zorg voor oudere patiënten, waarvan dit proefschrift het resultaat is. In deze periode werden taken als arts-onderzoeker gecombineerd met klinische werkzaamheden als escalatie-arts en arts-assistent op de afdeling Interne Geneeskunde in het Máxima Medisch Centrum. In december 2014 startte zij met de opleiding tot internist in het Máxima Medisch Centrum (opleider dr. A.G. Lieverse). Deze opleiding werd in 2019 voortgezet in het Maastricht Universitair Medisch Centrum+ met de differentiatie Ouderengeneeskunde onder begeleiding van prof. dr. C.D.A. Stehouwer, prof. dr. R.P. Koopmans (opleiders Interne Geneeskunde) en dr. E. Pijpers en dr. B.P.A. Spaetgens (opleiders differentiatie Ouderengeneeskunde). In 2021 heeft zij haar opleiding afgerond en sindsdien is zij werkzaam als internist ouderengeneeskunde in het Maastricht Universitair Medisch Centrum+.