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Mortality before and after reconfiguration of the Danish hospital-based emergency healthcare system: a nationwide interrupted time series analysis

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ABSTRACT

Objectives The study aimed to investigate how the 'natural experiment' of reconfiguring the emergency healthcare system in Denmark affected in-hospital and 30-day mortality on a national level. The reconfiguration included the centralisation of hospitals and the establishment of emergency departments with specialists present around the clock.

Design Hospital-based cohort study.

Setting All public hospitals in Denmark.

Participants Patients with an unplanned contact from 1 January 2007 until 31 December 2016.

Interventions Stepped-wedge reconfiguration of the Danish emergency healthcare system.

Main outcome measures We determined the adjusted ORs for in-hospital mortality and HRs for 30-day mortality using logistic and Cox regression analysis adjusted for sex, age, Charlson Comorbidity Index, income, education, mandatory referral and the changes in the out of hours system in the Capital Region. The main outcomes were stratified by the time of arrival. We performed subgroup analyses on selected diagnoses: myocardial infarction, stroke, pneumonia, aortic aneurysm, bowel perforation, hip fracture and major trauma.

Results We included 11 367 655 unplanned hospital contacts. The adjusted OR for overall in-hospital mortality after reconfiguration of the emergency healthcare system was 0.998 (95% CI 0.968 to 1.010; p=0.285), and the adjusted OR for 30-day mortality was 1.004 (95% CI 1.000 to 1.008; p=0.045)). Subgroup analyses showed some possible benefits of the reconfiguration such as a reduction in-hospital and 30-day mortality for myocardial infarction, stroke, aortic aneurysm and major trauma.

Conclusions The Danish emergency care reconfiguration programme was not associated with an improvement in overall in-hospital mortality trends and was associated with a slight slowing of prior improvements in 30-day mortality trends.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ There are conflicting results on short-term mortality after reconfiguration of emergency healthcare systems.
⇒ Research on the consequences of major emergency healthcare reforms is scarce.
⇒ Additional knowledge is imperative, as major healthcare reforms are massive investments in physical and human capital and entail complex organisational changes.

WHAT THIS STUDY ADDS

⇒ The Danish emergency healthcare reconfiguration from 2007 to 2016 had no change on in-hospital mortality but slightly increased 30-day mortality.
⇒ Subgroup analyses showed a decrease in in-hospital or 30-day mortality for myocardial infarction, stroke, aortic aneurysm and major trauma, all conditions that require urgent management.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE AND/OR POLICY

⇒ Reconfiguration of a nationwide emergency healthcare system is a complex and massive investment.
⇒ As such, all mechanisms can never be described; however, the results of this study do not support any association between mortality and reconfiguration.

INTRODUCTION

Over the past few decades, the number of emergency hospital visits has increased in several European countries, including Denmark.[1] The increasing number of emergency visits are partially due to an ageing population, with an increasing comorbidity burden, which also increases the complexity of clinical presentations.[2 3]

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These challenges put pressure on healthcare systems and negatively influence the quality of care.[4] To mitigate these challenges, healthcare system reconfiguration, where services are centralised to a small number of large facilities, has been proposed in several countries (eg, the UK, Ireland, Belgium and the Netherlands).[5–8]

Since 2007, the emergency healthcare system in Denmark has been reconfigured.[9] This includes fewer emergency hospitals through mergers, the closing of smaller hospitals and the centralisation of specialised treatment, including emergency and acute care into one unit with the relevant medical specialists present at all times. A consequence for many patients has been longer distances and travel time to emergency departments (EDs), especially in rural areas. In addition, mandatory referral to the ED from either a general practitioner (GP) or the emergency dispatch centre was instituted nationwide. These initiatives were a part of a major reform to the healthcare system by the National Health Authority which aimed to provide equal access to uniform high-quality treatment at all times and in every part of the country.[9] ThisDanish reform address issues relevant to many healthcare systems, specifically the uniform efficient delivery of high-quality emergency healthcare services. In Denmark, this includes centralising emergency care to fewer sites, a single entrance for all unplanned patients and the presence of specialist doctors 24/7.

Mortality is a key marker of care quality.[10] Increased short-term mortality in out-of-hours admissions is an internationally recognised phenomenon that may be caused by a lack of experienced healthcare professionals and a shortage of staff.[11–13] Several single-centre and multicentre studies have shown both reduced and increased short-term mortality after reconfiguration of emergency healthcare systems.[8 10 14–18] However, research on the nationwide consequences of major emergency healthcare reforms is scarce.[19] Additional knowledge is imperative, as major healthcare reforms are massive investments in physical and human capital and entail complex organisational changes. The quasi-experimental implementation of reconfiguration in Denmark provides a unique opportunity to evaluate the benefits, if any, of centralising emergency care. In this study, we aimed to investigate how the reconfiguration of the emergency healthcare system in Denmark has affected in-hospital and 30-day mortality at a national level. We exploited the natural variation in implementation across Denmark to rigorously test how the reconfiguration of emergency care affects mortality across selected diagnoses and times of arrival at the hospital.

METHODS
Setting
The Danish healthcare system is tax-funded and provides universal coverage and services free of charge at the point of delivery for all of Denmark's 5.8 million residents. However, some co-payment is required for prescription drugs. All residents are assigned a GP, who acts as the gatekeeper to secondary healthcare.[20] Private hospitals represent <3% of all hospital activity and do not treat emergency patients.[20]

The 2007 healthcare reform
A major healthcare reform was introduced in Denmark in 2007.[9] Five larger administrative units were created to serve as regional authorities. The regions are responsible for governing, managing and funding public hospitals and were responsible for implementing the reform. Hospitals were centralised, resulting in the closure of most small, rural hospitals; when the reform is fully implemented in 2025, the number of hospitals will have been reduced from 44 (in 2007) to 21 (in 2025).[9] Centralisation was gradually implemented in a stepped-wedge configuration beginning in June 2008.

As part of the reconfiguration, all undifferentiated unplanned patients, except for a few specified populations (eg, children, psychiatric complaints, women in labour, etc) should initially be seen in EDs.[21] Therefore, it was mandatory for specialists from internal medicine, orthopaedic surgery, general surgery, anaesthesiology and radiology to be available in the ED around the clock. However, by 2016, this reform had only been fully implemented in approximately half of the country's hospitals,[22] and it was not until 2017 that emergency medicine was recognised in Denmark as a primary medical specialty.

Although many countries allow patients open access to the ED, from 2011 to 2014 Denmark introduced a referral system. This required patients to either call their emergency dispatch centre for an ambulance or are referred by their GP. Therefore, all Danish EDs are now closed to non-referred patients.

All five regions provide out-of-hours primary care, with first-line telephone contact with either a specialised triage nurse (The Capital Region of Denmark) or a GP (the four remaining regions), who decides the next step for the patients.[20] Before 2014, all out-of-hours patients had a home-visit or were asked to visit an out-of-hours clinic staffed by GPs. Since January 2014, the Capital Region did not offer home visits, and all patients who are thought to need urgent care are triaged to hospital and treated as ED patients. The change in the Capital Region, from a system like the other regions to the new system, has led to a substantial increase in the number of unplanned emergency hospital contacts.[1]

Data sources and study cohort
The study cohort was based on data from national databases maintained by the Danish government. We included all unplanned non-psychiatric hospital contacts by adult patients (aged ≥18 years) with a public hospital in Denmark from 1 January 2007

to 31 December 2016 with 30-day follow-up. All planned inpatient admissions, planned outpatient visits, patients in labour (International Classification of Diseases 10th Revision: O00–O99), visits to psychiatric hospitals and patients registered as dead before their hospital contact were excluded.

All residents in Denmark have a unique personal identification number that allows cross-linkage of all registers. Data were extracted from the Danish National Patient Registry (DNPR).[23] The study population selected from DNPR was merged with income data (Income Statistics Register), education-level data (The Danish Education Register), country of origin, marital status, age and vital status (The Danish Civil Registration System).[24–26]

No visits were counted twice in the study cohort. Patients could have several unplanned visits and admissions during the study period, and they were all included in the study cohort. Transfer between departments or from the ED visit to admission was coded as separate visits/admissions in the DNPR. When an unplanned ED visit was converted to an unplanned inpatient admission, or the patient was transferred between departments within 3 hours, the visits/admissions were considered to represent the same hospital contact. Sensitivity analysis of the 3-hour rule has demonstrated that this assumption is valid.[1]

Outcomes

The primary outcome was in-hospital mortality, and the secondary outcome was 30-day mortality from the date of admission of the index contact (both in-hospital and out-of-hospital mortality). Patients were followed until death or the end of the study period, whichever came first. In-hospital mortality was defined as death that occurred during the hospital stay. Some patients had multiple unplanned hospital contacts during the study period, including admissions that overlapped the 30-day follow-up time; death was only assigned to the last unplanned hospital contact for these patients.

Study design

We used an interrupted time-series analysis in which contacts before the reconfiguration of the emergency healthcare system were compared with contacts that occurred after reconfiguration.[27] Each hospital had a unique time period divided into two periods, before and after the reconfiguration, creating a natural stepped-wedge configuration. The unique period for each hospital was based on information obtained during telephone interviews with department leaders and public reports. We stratified the unplanned contacts into 23 hospitals with EDs in Denmark at the end of the study period.[1] Three hospitals did not change during the study period; therefore, their timeline only consisted of one period, and these three hospitals acted as control hospitals throughout the study. Online supplemental figures 1 and 2 show the raw unadjusted in-hospital and 30-day mortality rates for the 23 hospitals. The main results are reported on a national level.

Both an unadjusted and a fully adjusted model were performed accounting for hospitals as clusters; the hospital status after the reconfiguration was used because of hospital mergers during the study period. The fully adjusted model accounted for seasonality, changes in visit patterns due to changes in the out-of-hours system in the Capital Region of Denmark and implementation of mandatory referral to the EDs. The model was also adjusted for sex, age, Charlson Comorbidity Index (CCI; low, 0; medium, 1–2 and high, >2),[28] ethnicity (Danish or non-Danish), education (low, medium or high education corresponding to the International Standard Classification of Education 1997 categories: 0–1, 2–3, 4–6) and income level (low, medium or high).

We used monthly time points for mortality and analysed a median of 53 time points (range 17–120) before reconfiguration and 67 time points (range 0–103) after reconfiguration (online supplemental figures 1 and 2). The impact model included a continuous-time variable (pretrend) throughout the study period and a continuous-time variable (slope change) from the reconfiguration date and onwards. The effect of reconfiguring the emergency healthcare system was estimated as the slope change between the two periods. The pretrend represents how the trend would have continued if the emergency healthcare system had not been reconfigured.

A pretrend with an OR or HR <1.00 represented a downward trend (decreasing mortality) (figure 1A,B), whereas a pretrend with an OR or HR >1.00 represented an upward trend (increasing mortality) (figure 1). A slope change with an OR or HR <1.00 represented a decrease in mortality, regardless of the direction of the pretrend. A slope change with an OR or HR >1.00 represented an increase in mortality, regardless of the direction of the pretrend. Therefore, a downward pretrend with an OR or HR for slope change >1.00 can still have an overall decrease in mortality (figure 1).

Subgroup analyses

We performed subgroup analyses in which the population was restricted to unplanned contacts with selected diagnoses (primary and secondary discharge diagnoses), including myocardial infarction, stroke, pneumonia, aortic aneurysm, bowel perforation, hip fracture and major trauma (see online supplemental table 1). Myocardial infarction, stroke, aortic aneurysm, bowel perforation and major trauma were chosen as specific diagnoses that require time-critical intervention. Hip fracture and pneumonia were less time-sensitive but frequent diagnoses. We expected that some of the diagnoses would benefit from the reconfiguration of the emergency healthcare system (myocardial infarction, stroke, aortic aneurysm,
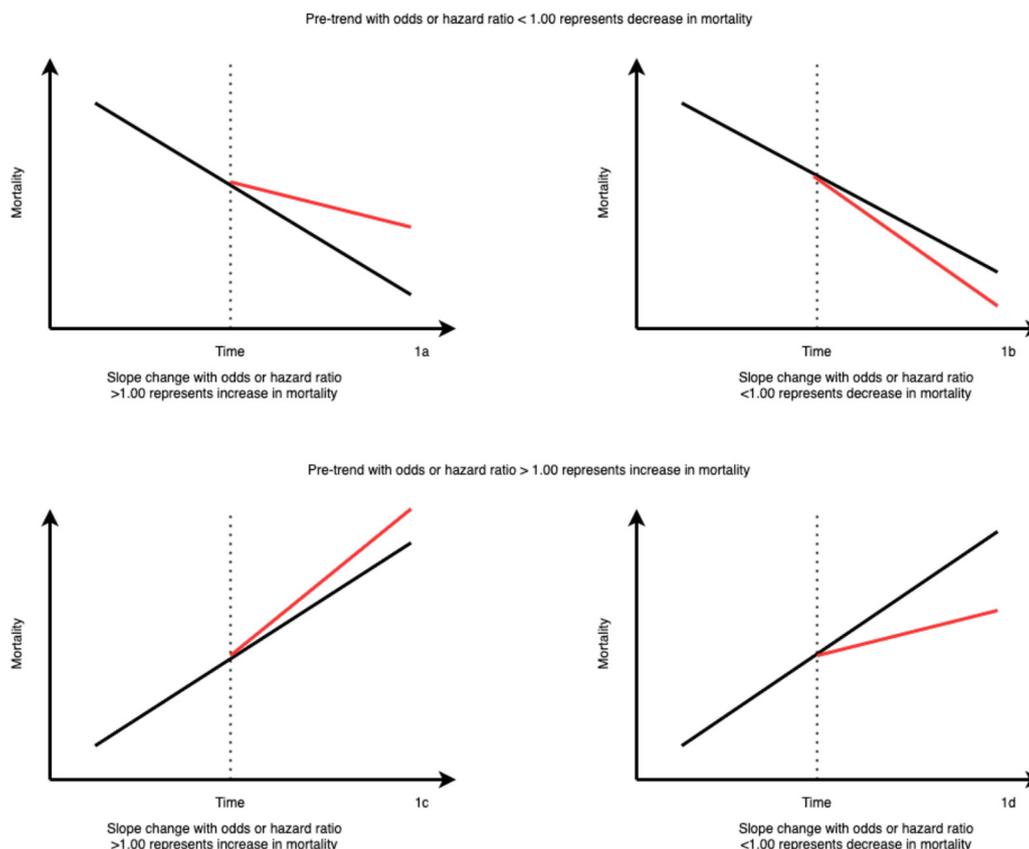
Pre-trend with odds or hazard ratio < 1.00 represents decrease in mortality

Figure 1 Different possible outcomes in interrupted time series. The dotted line represents the time of reconfiguration. The black line represents how the mortality trend was before the reconfiguration and would have continued if there was no reconfiguration of the emergency healthcare system. The red line represents the new trend after the reconfiguration of the emergency healthcare system. Slope change is the difference between the black and red lines.

bowel perforation and major trauma), whereas others would be expected to stay stable (pneumonia and hip fracture). These diagnoses are presented with the same outcomes and stratifications as the primary analyses.

When possible, the subgroup analyses were adjusted for the same variables as the main cohort. As some subgroup analyses had too few cases for the adjusted variables, the variables were removed one by one until analysis was possible. The predefined order for removing variables was ethnicity, education level, income level, CCI, age and sex.

Stratification

The analyses were stratified according to time of day for index contacts (categorised into three periods: daytime (07:00–14:59 hours), evening (15:00–22:59 hours) and night (23:00–06:59 hours)). Contacts were also defined as 'weekend' if between Friday 15:00 hours and Monday 06:59 hours, or 'weekday' if between Monday 07:00 hours and Friday 14:59 hours. These categories were chosen to investigate whether patients always received a uniform and high-quality care based on the standard shifts in Danish healthcare. Before reconfiguration, specialists were on call from home during the evening and night.

Statistical analysis

Baseline characteristics for unplanned contacts are presented as the means and SDs or medians and IQR for continuous variables and as frequency and percentage for categorical variables. The Wilcoxon rank-sum test was used to compare continuous variables, and Pearson's χ^2 test was used to compare categorical variables. In-hospital mortality was analysed by logistic regression and 30-day mortality as parametric time-to-event analyses with Weibull distribution. Patients with more than one contact within 30 days only accounted for risk time until the next contact in the time-to-event analyses. Data management and analyses were carried out in Stata V.15 (StataCorp, College Station, Texas, USA). A significance level of 5% was applied.

Patient and public involvement

This research was performed without patient involvement. Patients were not invited to comment on the study design and were not consulted to develop patient-relevant outcomes or interpret the results. Patients were not invited to contribute to the writing or editing of this document for readability or accuracy.

Table 1 Baseline characteristics of unplanned contacts before and after the reconfiguration of the emergency healthcare system

		No. of unplanned contacts	No. of unplanned contacts before	No. of unplanned contacts after	P value
Number of observations		11 367 655	4 704 362	6 663 293	<0.001
Median age, years (IQR)		53.0 (34.0, 71.0)	51.0 (33.0, 69.0)	54.0 (36.0, 72.0)	<0.001
Gender	Female	5 555 302 (48.9%)	2 272 986 (48.3%)	3 282 316 (49.3%)	<0.001
	Male	5 812 353 (51.1%)	2 431 376 (51.7%)	3 380 977 (50.7%)	
Of Danish origin	No	1 121 897 (9.9%)	497 126 (10.6%)	624 771 (9.4%)	<0.001
	Yes	10 209 875 (89.8%)	4 190 703 (89.1%)	6 019 172 (90.3%)	
	Missing	35 883 (0.3%)	16 533 (0.4%)	19 350 (0.3%)	
Married	No	6 576 038 (57.8%)	2 752 203 (58.5%)	3 823 835 (57.4%)	<0.001
	Yes	4 755 734 (41.8%)	1 935 626 (41.1%)	2 820 108 (42.3%)	
	Missing	35 883 (0.3%)	16 533 (0.4%)	19 350 (0.3%)	
Income €1000*, median (IQR)		28.5 (20.9, 43.4)	28.3 (19.8, 43.4)	28.6 (20.0, 43.4)	<0.001
Education†	Low	43 733 (0.4%)	22 127 (0.5%)	21 606 (0.3%)	<0.001
	Medium	8 594 723 (75.6%)	3 573 159 (76.0%)	5 021 564 (75.4%)	
	High	2 089 849 (18.4%)	797 951 (17.0%)	1 291 898 (19.4%)	
	Missing	639 350 (5.6%)	311 125 (6.6%)	328 225 (4.9%)	
Comorbidity‡	Low	6 790 806 (59.7%)	2 854 602 (60.7%)	3 936 204 (59.1%)	<0.001
	Medium	3 026 481 (26.6%)	1 230 790 (26.2%)	1 795 691 (26.9%)	
	High	1 550 368 (13.6%)	618 970 (13.2%)	931 398 (14.0%)	

*Includes salary, retirement benefits, welfare payments, remuneration and company profits. The income is price indexed (2015) and converted into Euros at a rate of €0.1344 per Danish krone.
†Highest completed education: basic school=low; vocational or upper secondary education=medium; greater than upper secondary education and vocational training education=high.
‡Charlson Comorbidity Index: Index score 0=low, Index score 1–2=moderate, Index score >2=high.

RESULTS

Our study included 11 367 655 emergency patient contacts, 4 704 362 before and 6 663 293 after the reconfiguration of the emergency healthcare system. The median age of patients, proportion of females, median income and proportion with a high education increased slightly, whereas the proportion with Danish ethnicity, married contacts and contacts with a low comorbidity score decreased slightly (table 1). As one would expect given the very large sample sizes, all precomparisons to postcomparisons are statistically significant but the two cohorts were in fact very similar.

Before reconfiguration, the raw unadjusted monthly in-hospital and 30-day mortality rates at individual hospitals ranged from 1.1% to 6.6% and 1.6% to 7.6%, respectively, and after reconfiguration from 0.6% to 4.5% and 1.2% to 5.5%, respectively. The three hospitals without reconfiguration had raw unadjusted monthly in-hospital and 30-day mortality rates ranging from 0.4% to 4.8% and 0.8% to 5.7%, respectively (online supplemental figures 1 and 2).

We observed a significant annual decrease in the adjusted in-hospital mortality (pretrend) of 5.5% before reconfiguration (table 2). Reconfiguration was not associated with a significant change in the annual adjusted in-hospital mortality (adjusted slope change). The results for time periods (table 2) were like the overall findings, with an annual significant decrease (4.8%–5.8%) in the adjusted in-hospital mortality

before reconfiguration (adjusted pretrend) and no effect of the reconfiguration on in-hospital mortality (adjusted slope change).

The overall annual decrease in adjusted 30-day mortality before reconfiguration was 3.5% (adjusted pretrend), and reconfiguration was associated with an 0.4% per year slowing in the rate of decrease (adjusted slope change) (table 3). Regardless of the time of week or day, adjusted 30-day mortality significantly decreased by 3.0%–3.6% per year before reconfiguration (adjusted pretrend). The adjusted 30-day mortality rate did not change after reconfiguration when stratifying for weekdays and weekends (adjusted slope change). When stratifying by the time of day, we found reconfiguration was associated with a significant improvement in the mortality trend for patients presenting at night-time by 1.5% per year. After reconfiguration, the adjusted 30-day mortality trend for patients presenting in the evening was unchanged, but the improvement trend slowed for patients presenting during the daytime by 0.8% annually.

Before reconfiguration, adjusted in-hospital mortality had been significantly decreasing over time for myocardial infarction, stroke, pneumonia, bowel perforation and hip fracture (table 4 and online supplemental tables 2-15). None of these diagnoses experienced changes to in-hospital mortality trends after reconfiguration. However, the annual adjusted in-hospital mortality trend

Table 2 ORs for in-hospital mortality for the pretrend and slope change related to the reconfiguration of the emergency healthcare system

	Unadjusted analyses				Adjusted analyses*			
	No. of unplanned contacts	OR	95% CI	P value	No. of unplanned contacts	OR	95% CI	P value
Overall	11 367 655				10 178 821			
Pretrend		0.96	0.928 to 0.993	0.018		0.945	0.932 to 0.958	<0.001
Slope change		1	0.951 to 1.051	0.997		0.989	0.968 to 1.01	0.285
Weekday versus weekend								
Weekday	7 650 177				7 207 136			
Pretrend		0.962	0.935 to 0.989	0.007		0.944	0.931 to 0.957	<0.001
Slope change		1.003	0.96 to 1.046	0.908		0.992	0.971 to 1.013	0.44
Weekend	3 717 478				3 510 680			
Pretrend		0.957	0.916 to 1.001	0.054		0.947	0.929 to 0.963	<0.001
Slope change		0.995	0.934 to 1.061	0.888		0.982	0.959 to 1.005	0.127
Time of admission								
07:00–15:00 hours	5 630 231				5 314 487			
Pretrend		0.959	0.931 to 0.987	0.005		0.942	0.929 to 0.956	<0.001
Slope change		1.006	0.961 to 1.053	0.804		0.995	0.974 to 1.017	0.669
15:003–23:00 hours	4 416 266				4 163 647			
Pretrend		0.958	0.918 to 0.998	0.042		0.947	0.93 to 0.964	<0.001
Slope change		0.995	0.939 to 1.054	0.865		0.985	0.959 to 1.011	0.242
23:00–07:00 hours	1 321 158				1 239 667			
Pretrend		0.974	0.936 to 1.014	0.205		0.952	0.933 to 0.972	<0.001
Slope change		0.994	0.938 to 1.052	0.827		0.973	0.945 to 1.003	0.077

Adjusted analyses were performed on a complete case basis.
*Adjusted for seasonality, the changes in the out-of-hours system in the Capital Region, the implementation of a referral system to emergency departments, sex, age, Charlson Comorbidity Index, ethnicity, education and income level.

for aortic aneurysm and major trauma improved significantly after reconfiguration.

The adjusted 30-day mortality trend improved significantly after reconfiguration for contacts with myocardial infarction, stroke and aortic aneurysm (adjusted slope change). No impact on these trends was observed for pneumonia and bowel perforation.

DISCUSSION
Principal findings
This nationwide interrupted time series study showed that reconfiguration of the Danish emergency healthcare system was not associated with a change to in-hospital mortality trends, but it was associated with a slight slowing of the prior improvement in 30-day mortality rates.

The goal of the healthcare reform by the Danish National Health Authority was to provide equal access to uniform, high-quality treatment in every part of the country at any time of day.[9] This included centralisation, hospital mergers and closures, specialists present around the clock, mandatory referral before access to the ED and longer travel times. In this study, we have investigated these as one intervention and have not considered its multiple components' specific contributions and possible interactions. In addition, the 23 hospitals included in this study had different baselines before the reform, and some hospitals and their patients experienced more changes than others. Furthermore, hospitals have implemented reforms according to different local configurations, which were not explicitly defined by the government.[29]

We expected mortality to decrease for rare but dangerous and time-critical diagnoses (eg, myocardial infarction, aortic aneurysm and bowel perforation) and to remain unchanged for the more frequent and less time-dependent diagnoses (pneumonia and hip fracture). Our results confirm some of these assumptions, as there was a decreased in-hospital mortality rate for aortic aneurysm and major trauma and a decreased 30-day mortality rate for aortic aneurysm, stroke and myocardial infarction.

Comparison with other studies
Evidence from nationwide reconfigurations of an emergency healthcare system is limited. A national study from the Ireland showed a decrease in case fatality ratios for serious emergency conditions from 2002 to 2014, with a slowed rate from 2007 and onwards that coincided with a period of economic contraction.[17] The authors found geographical differences in case fatality ratios.

Table 3 HRs for 30-day mortality for the pretrend and slope change related to the reconfiguration of the emergency healthcare system

	Unadjusted analyses				Adjusted analyses*			
	No. of unplanned contacts	HR	95% CI	P value	No. of unplanned contacts	HR	95% CI	P value
Overall	11 367 655				10 717 837			
Pretrend		0.977	0.975 to 0.98	<0.001		0.965	0.962 to 0.968	<0.001
Slope change		1.01	1.006 to 1.013	<0.001		1.004	1 to 1.008	0.045
Weekday versus weekend								
Weekday	7 650 177				7 207 143			
Pretrend		0.98	0.977 to 0.983	<0.001		0.966	0.962 to 0.97	<0.001
Slope change		1.009	1.005 to 1.013	<0.001		1.004	0.999 to 1.009	0.105
Weekend	3 717 478				3 510 694			
Pretrend		0.972	0.968 to 0.977	<0.001		0.964	0.959 to 0.97	<0.001
Slope change		1.012	1.006 to 1.018	<0.001		1.002	0.995 to 1.009	0.545
Time of admission								
07:00–15:00 hours	5 630 231				5 314 511			
Pretrend		0.977	0.974 to 0.981	<0.001		0.965	0.961 to 0.97	<0.001
Slope change		1.012	1.007 to 1.017	<0.001		1.008	1.002 to 1.013	0.006
15:00–23:00 hours	4 416 266				4 163 653			
Pretrend		0.974	0.97 to 0.978	<0.001		0.966	0.961 to 0.971	<0.001
Slope change		1.009	1.004 to 1.015	0.001		1.001	0.994 to 1.007	0.803
23:00–07:00 hours	1 321 158				1 239 673			
Pretrend		0.991	0.983 to 0.998	0.009		0.97	0.961 to 0.979	<0.001
Slope change		0.995	0.985 to 1.004	0.284		0.985	0.975 to 0.996	0.007

Adjusted analyses were performed on a complete case basis.
*Adjusted for seasonality, the changes in the out-of-hours system in the Capital Region, the implementation of a referral system to emergency departments, sex, age, Charlson Comorbidity Index, ethnicity, education and income level.
CCI, Charlson Comorbidity Index.

This study also addressed the complexity of evaluating a reconfiguration. Some mechanisms, such as improved healthcare staffing, may improve the outcome, whereas delay in care is more likely to affect the outcome negatively. This study confirms the complexity of evaluating the Danish reform, as it introduced several mechanisms (eg, centralisation, senior decision-makers present out of hours and longer travel distance) simultaneously and each of these on its own has been shown to affect mortality.[9] Although we have not tested the single mechanisms involved in the reform, as this was beyond the scope of this paper, some mechanisms may have improved outcomes, whereas other mechanisms may have induced an increase in mortality.

A further study from England showed decreased 60-day mortality rates year 1 and 2 years after the centralisation of EDs.[18] In contrast, a multicentre study found no evidence of an association between changes in emergency care and population mortality.[8]

Prior research has shown that care outside of normal business hours has the best potential for improvement.[13] When stratifying our results for day and time of arrival, we found no difference in in-hospital mortality. However, reconfiguration did improve the overall 30-day mortality at night.

Our findings on in-hospital mortality are in line with another Danish study that found no change in in-hospital mortality after introducing consultants to the ED.[30]

We found decreased in-hospital and 30-day mortality at night and on weekends for myocardial infarction, stroke, aortic aneurysm and major trauma, which are all time-sensitive diagnoses. Similarly, high-risk, time-sensitive diagnoses (aortic aneurysm) are best handled by experienced staff, whereas other diagnoses (pneumonia and hip fracture) do not seem to benefit from higher volumes.[31] We were unable to show that in-hospital mortality from myocardial infarction improved with reconfiguration. A recent, large study from Sweden showed increased mortality in the first year after centralisation and improved survival in the following years.[32] We think that the primary reason for our findings is that all Danish patients with suspected myocardial infarction have been received at four hospitals since 2003 and the reconfiguration of the emergency healthcare system did not affect this.[33]

A mandatory referral has been shown to reduce the number of unplanned patients by 9.4%, mostly among the young and those without comorbidity.[34] The national mortality did not change during the period

Table 4 ORs and HRs for subgroups for the pretrend and slope change related to reconfiguration of the emergency healthcare system

	Unadjusted analyses				Adjusted analyses*			
	No. of patient contacts	OR/HR	95% CI	P value	No. of patient contacts	OR/HR	95% CI	P value
Myocardial infarction								
In-hospital mortality	114164				104580			
Pretrend		0.927	0.902 to 0.953	<0.001		0.934	0.914 to 0.956	<0.001
Slope change		1.006	0.951 to 1.064	0.84		0.973	0.943 to 1.005	0.093
30-day mortality	114164				105008			
Pretrend		0.945	0.934 to 0.957	<0.001		0.951*	0.937 to 0.966	<0.001
Slope change		0.996	0.979 to 1.014	0.685		0.979*	0.96 to 0.998	0.031
Stroke								
In-hospital mortality	218237				207362			
Pretrend		0.953	0.932 to 0.975	<0.001		0.954	0.931 to 0.978	<0.001
Slope change		0.994	0.968 to 1.02	0.634		0.982	0.955 to 1.01	0.214
30-day mortality	218237				201366			
Pretrend		0.982	0.973 to 0.992	<0.001		0.978*	0.966 to 0.99	<0.001
Slope change		0.984	0.972 to 0.997	0		0.978*	0.965 to 0.992	0.003
Pneumonia								
In-hospital mortality	446154				404398			
Pretrend		0.925	0.903 to 0.948	<0.001		0.934	0.912 to 0.956	<0.001
Slope change		1.013	0.979 to 1.047	0		1.005	0.974 to 1.037	0.749
30-day mortality	446154				404408			
Pretrend		0.958	0.952 to 0.964	<0.001		0.966*	0.959 to 0.974	<0.001
Slope change		1.001	0.993 to 1.009	1		0.997*	0.988 to 1.006	0.526
Aortic aneurysm								
In-hospital mortality	4049				3768			
Pretrend		1.025	0.991 to 1.059	0.15		0.986	0.942 to 1.032	0.537
Slope change		0.938	0.89 to 0.99	0.019		0.919	0.874 to 0.967	0.001
30-day mortality	4049				3811			
Pretrend		1.024	0.999 to 1.049	0.064		0.995*	0.963 to 1.027	0.743
Slope change		0.962	0.93 to 0.995	0.026		0.947*	0.916 to 0.98	0.002
Bowel perforation								
In-hospital mortality	13194				11954			
Pretrend		0.912	0.893 to 0.932	<0.001		0.934	0.9 to 0.97	<0.001
Slope change		0.986	0.948 to 1.025	0.473		0.973	0.94 to 1.006	0.11
30-day mortality	13194				13173			
Pretrend		0.939	0.917 to 0.962	<0.001		0.958†	0.933 to 0.985	0.002
Slope change		0.976	0.945 to 1.008	0.136		0.975†	0.949 to 1.003	0.077

Continued

Table 4 Continued

	Unadjusted analyses				Adjusted analyses*			
	No. of patient contacts	OR/HR	95% CI	P value	No. of patient contacts	OR/HR	95% CI	P value
Hip fracture In-hospital mortality	107 959				90 145			
Pretrend		0.967	0.938 to 0.997	0.033		0.955	0.926 to 0.984	0.003
Slope change		1.001	0.952 to 1.052	0.972		1	0.961 to 1.04	0.995
30-day mortality	107 959				90 556			
Pretrend		0.999	0.985 to 1.013	0.88		1.003*	0.982 to 1.024	0.779
Slope change		0.987	0.969 to 1.006	0.172		0.984*	0.962 to 1.005	0.139
Major trauma In-hospital mortality	43 841				41 377			
Pretrend		1.09	0.981 to 1.21	0.108		1.096	0.959 to 1.252	0.177
Slope change		0.86	0.752 to 0.983	0.027		0.818	0.721 to 0.928	0.002
30-day mortality	43 841				41 378			
Pretrend		1.045	1.008 to 1.083	0.019		1.001*	0.959 to 1.044	0.966
Slope change		0.924	0.875 to 0.976	0.004		0.955*	0.897 to 1.018	0.164

Adjusted analyses were performed on a complete case basis.
*Adjusted for seasonality, the changes in the out-of-hours system in the Capital Region, the implementation of a referral system to emergency departments, sex, age, CCI, ethnicity, education and income level.
†Adjusted for seasonality, the changes in the out-of-hours system in the Capital Region, the implementation of a referral system to emergency departments, sex, age, CCI and income level.
CCI, Charlson Comorbidity Index.

of the stepped-wedge implantation of mandatory referral.[34]

Centralisation increased the distance to the hospitals for many patients,[35] but the Danish Healthcare reform included an improved prehospital system.[9] A recent review of travel time and distance to EDs showed no evidence of an association between increased distance and mortality for the general population.[36]

Strengths and limitations of the study

We tried to address many of the mechanisms in the reconfiguration of emergency healthcare that might affect mortality, but there were still several mechanisms that were unaddressed. Severity of illness, staffing, organisation of the ED and the fact that some patients could have stayed at home because of longer travel distance were some of the known mechanisms that can affect mortality, and unknown residual confounders were a part of the reconfiguration. Although the study design took unknown confounders that were stable over time into account evaluating a healthcare reconfiguration is still complex and many known and unknown things affect mortality.[37]

We tried to set a fixed implementation date for each hospital, but this was somewhat arbitrary, as reconfiguration of a hospital does not happen overnight. In addition, through our design, we were unable to identify the effect of each of the individual changes made as part of the reconfiguration. When evaluating longitudinal effects, interrupted time series is a strong quasi-experimental design,[38] but our model does not fully account for a non-linear or an accelerated trend. We used stepped-wedge inclusion, adjusted for known interventions, and included control hospitals.[27]

We are unaware of any changes in registration practice occurring during the study period. Data may have been missing from some of the registers, particularly information on education level as the registers only cover 85%–90% of education data for immigrants. The adjusted analyses were made on complete cases. We only studied national trends, which may not reflect those of individual hospitals.

We have chosen to stratify our results in time periods that reflect the Danish healthcare professionals' working hours, although these are not completely identical to international working hours.

The strengths of the study are the nationwide design, the use of linked personal data from high-quality Danish registers,[39] and the inclusion of all emergency hospital contacts. Another strength is the subgroup analyses of specific diagnoses, as these subgroups are more homogenous than the main cohort.

Policy implications and future directions

Reconfiguration of a nationwide emergency healthcare system is a complex and massive investment. As such, we can never describe and attest to all mechanisms. Our results should be interpreted with caution, and additional studies are needed to clarify whether the severity of illness in unplanned patients has changed. In addition, studies on the effect of increased travel time are needed. Mortality is one of the last things to be affected by systemic change. We previously investigated the length of stay in the same study cohort and found no changes after the reconfiguration.[40] Our findings suggest that reconfiguration in Denmark was not associated with a change to in-hospital mortality trends, and was actually associated with a slowing of preconfiguration improvements in 30-day mortality trends. This may be because of poor implementation, as 10 years after the reform, three hospitals have still not been reconfigured. Geographical and hospital differences may also affect the results. Further research is needed at the geographical level.

CONCLUSION

An evaluation of the Danish emergency healthcare reconfiguration from 2007 to 2016 found it was associated with no change to in-hospital mortality trends and a slight slowing of 30-day mortality trends. Subgroup analyses showed an improvement in in-hospital or 30-day mortality trends for myocardial infarction, stroke, aortic aneurysm and major trauma.

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Supplementary information

Supplementary Figure 1
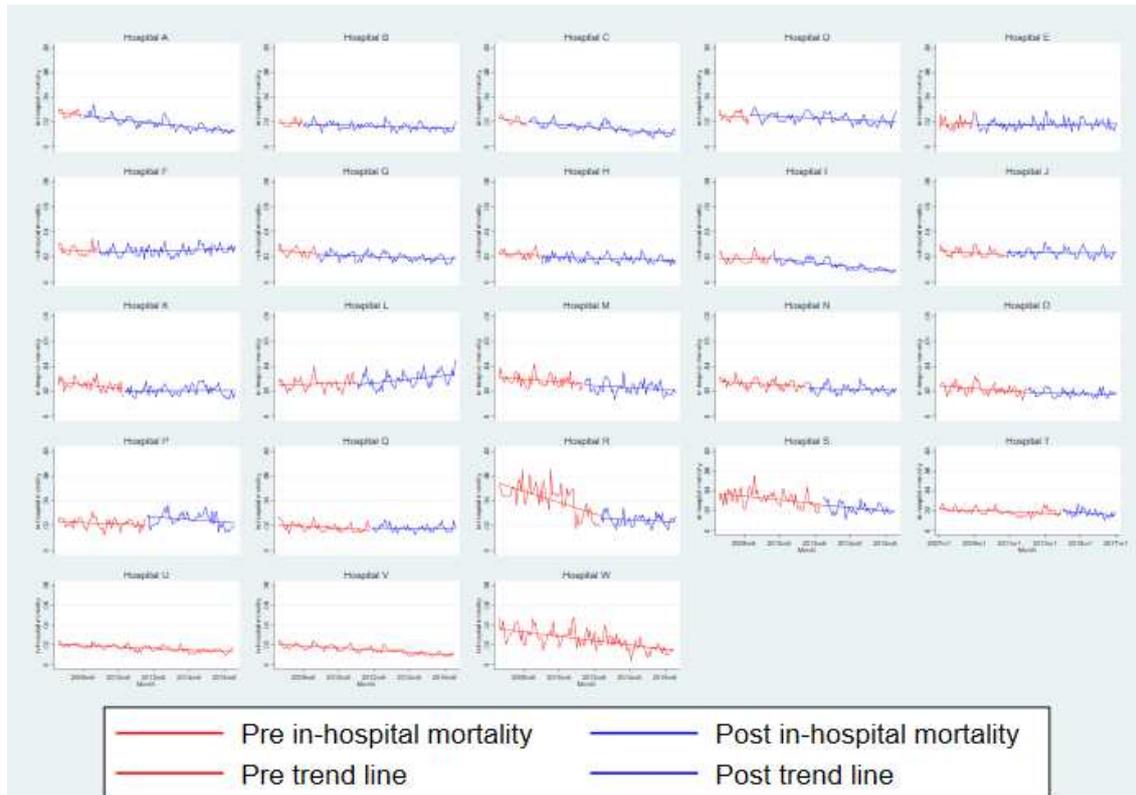
Raw unadjusted monthly in-hospital mortality rate at the 23 hospitals in Denmark from 2007-2016. Hospital U, V, and X have not reconfigured and therefore only consist of an before period. Red line represents the in-hospital mortality rate before the reconfiguration. Blue line represents the in-hospital mortality rate after the reconfiguration.

Supplementary Figure 2
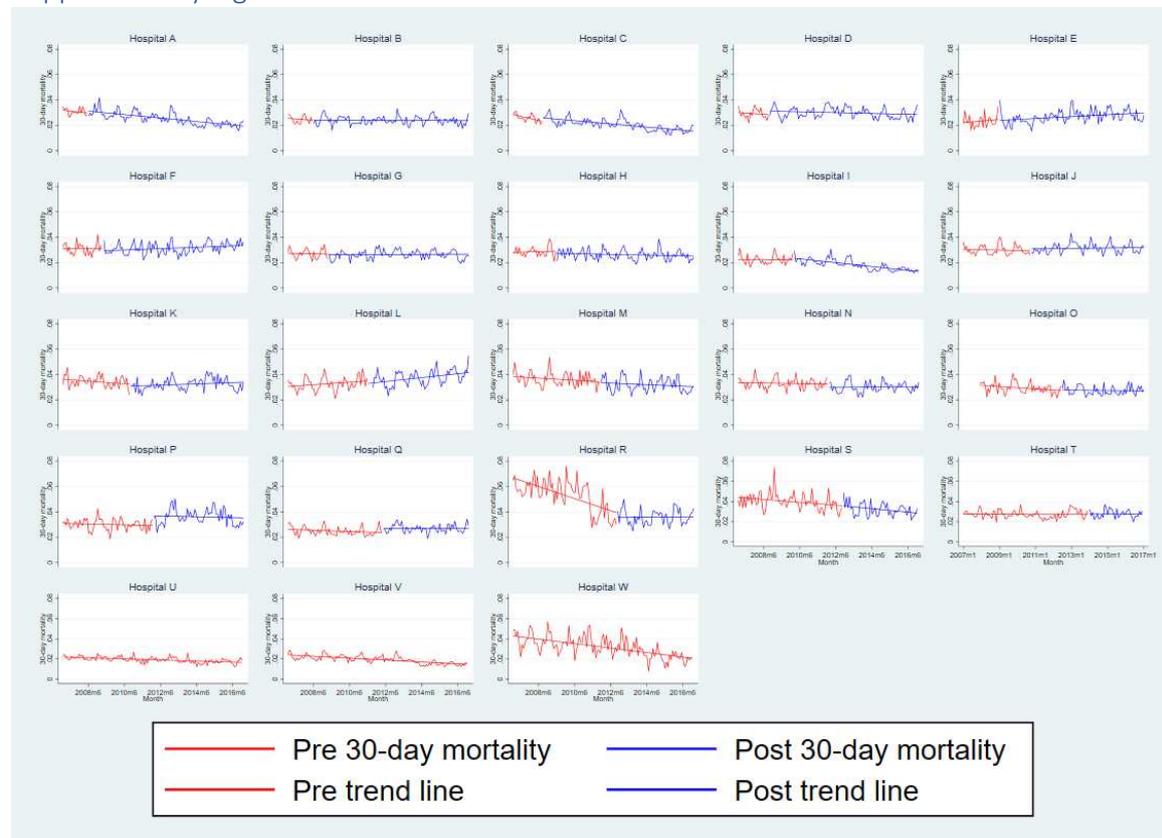
Raw unadjusted monthly 30-day mortality rate at the 23 hospitals in Denmark from 2007-2016. Hospital U, V, and X have not reconfigured and therefore only consist of an before period. Red line represents the 30-day mortality rate before the reconfiguration. Blue line represents the 30-day mortality rate after the reconfiguration.

Supplementary Table 1 ICD-10 codes for subgroups

Subgroups diagnoses	ICD-10 codes
Myocardial infarction	I21* I23* I24*
Stroke	I61 I63 I64 G645 I60.0-.7
Pneumonia	J12* J13* J14* J15* J16* J17* J18*
Aortic aneurism	I713 I715 I718
Bowel perforation	K251* K252* K255* K261* K262* K265* K271 K272 K275 K276 K281* K282* K284* K285* K286* K570 K570B K570C K572 K572B K572C K574 K574A K578 K631 K631A K822 K832
Hip fracture	S72*
Major trauma	T01-T07

Supplementary Table 2. Odds ratios for in-hospital mortality for myocardial infarction for the pre-trend and slope change related to the reconfiguration of the emergency healthcare system. Adjusted analyses were performed on a complete case basis.

		Unadjusted analyses			Adjusted analyses[a]			
	No. of unplanned contacts	Odds ratio	95% CI	P-value	No. of unplanned contacts	Odds ratio	95% CI	P-value
Overall	114,164				104,580			
Pre-trend		0.927	0.902 0.953	<0.001		0.934	0.914 0.956	<0.001
Slope change		1.006	0.951 1.064	0.840		0.973	0.943 1.005	0.093
Weekday vs. weekend								
Weekday	76,422				69,980			
Pre-trend		0.924	0.895 0.953	<0.001		0.926	0.904 0.947	<0.001
Slope change		1.005	0.949 1.064	0.863		0.974	0.943 1.006	0.115
Weekend	37,742				34,443			
Pre-trend		0.933	0.908 0.959	<0.001		0.951	0.919 0.984	0.004
Slope change		1.008	0.951 1.068	0.796		0.972	0.937 1.009	0.137
Time of admission								
7 am to 3 pm	53,870				49,005			
Pre-trend		0.922	0.887 0.958	<0.001		0.932	0.907 0.958	<0.001
Slope change		1.004	0.937 1.077	0.902		0.972	0.939 1.007	0.121
3 pm-11 pm	37,396				34,091			
Pre-trend		0.924	0.901 0.949	<0.001		0.930	0.905 0.956	<0.001
Slope change		1.012	0.963 1.063	0.644		0.979	0.947 1.012	0.209
11 pm-7 am	22,898				20,905			
Pre-trend		0.944	0.919 0.970	<0.001		0.948	0.902 0.995	0.032
Slope change		0.999	0.948 1.052	0.962		0.965	0.914 1.020	0.207

[a] Adjusted for seasonality, the changes in the out of hours system in the Capital Region, the implementation of a referral system to EDs, sex, age, CCI, ethnicity, education, and income level.

Supplementary Table 3. Hazard ratios for 30-day mortality for myocardial infarction for the pre-trend and slope change related to the reconfiguration of the emergency healthcare system. Adjusted analyses were performed on a complete case basis.

		Unadjusted analyses			Adjusted analyses[a]			
	No. of unplanned contacts	Odds ratio	95% CI		P-value	No. of unplanned contacts	Odds ratio	95% CI	P-value
Overall	114,164					105,008			
Pre-trend		0.945	0.934	0.957	<0.001		0.951	0.937 0.966	<0.001
Slope change		0.996	0.979	1.014	0.685		0.979	0.960 0.998	0.031
Weekday vs. weekend									
Weekday	76,422					70,259			
Pre-trend		0.940	0.926	0.954	<0.001		0.940	0.922 0.958	<0.001
Slope change		1.001	0.979	1.023	0.924		0.988	0.965 1.011	0.308
Weekend	37,742					34,749			
Pre-trend		0.958	0.938	0.977	<0.001		0.970	0.946 0.995	0.020
Slope change		0.985	0.956	1.014	0.297		0.962	0.934 0.991	0.010
Time of admission									
7 am to 3 pm	53,870					49,541			
Pre-trend		0.935	0.919	0.952	<0.001		0.948	0.927 0.969	<0.001
Slope change		1.005	0.979	1.031	0.718		0.983	0.956 1.010	0.220
3 pm-11 pm	37,396					34,395			
Pre-trend		0.947	0.927	0.966	<0.001		0.947	0.923 0.972	<0.001
Slope change		0.993	0.964	1.023	0.634		0.978	0.949 1.008	0.149
11 pm-7 am	22,898					21,072			
Pre-trend		0.968	0.942	0.995	0.018		0.964	0.932 0.997	0.031
Slope change		0.979	0.943	1.017	0.280		0.968	0.932 1.005	0.089

[a] Adjusted for seasonality, the changes in the out of hours system in the Capital Region, the implementation of a referral system to EDs, sex, age, CCI, ethnicity, education, and income level.

Supplementary Table 4. Odds ratios for in-hospital mortality for stroke for the pre-trend and slope change related to the reconfiguration of the emergency healthcare system. Adjusted analyses were performed on a complete case basis.

| | No. of unplanned contacts | Unadjusted analyses | | | | Adjusted analyses[a] | | | | |
		Odds ratio	95% CI		P-value	No. of unplanned contacts	Odds ratio	95% CI		P-value
Overall	218,237					207,362				
Pre-trend		0.953	0.932	0.975	<0.001		0.954	0.931	0.978	<0.001
Slope change		0.994	0.968	1.020	0.634		0.982	0.955	1.010	0.214
Weekday vs. weekend										
Weekday	149,975					138,320				
Pre-trend		0.951	0.931	0.972	<0.001		0.951	0.928	0.975	<0.001
Slope change		1.000	0.974	1.027	0.983		0.991	0.963	1.019	0.520
Weekend	68,262					62,869				
Pre-trend		0.957	0.929	0.985	0.003		0.959	0.931	0.988	0.007
Slope change		0.980	0.950	1.011	0.206		0.966	0.933	0.999	0.046
Time of admission										
7 am to 3 pm	112,418					103,286				
Pre-trend		0.953	0.935	0.971	<0.001		0.952	0.926	0.978	<0.001
Slope change		1.004	0.981	1.028	0.712		0.993	0.971	1.016	0.556
3 pm-11 pm	83,808					77,112				
Pre-trend		0.951	0.916	0.988	0.009		0.952	0.921	0.985	0.004
Slope change		0.978	0.941	1.016	0.252		0.971	0.933	1.011	0.150
11 pm-7 am	22,011					20,207				
Pre-trend		0.965	0.936	0.994	0.020		0.976	0.934	1.019	0.266
Slope change		0.994	0.956	1.034	0.761		0.969	0.926	1.013	0.160

[a] Adjusted for seasonality, the changes in the out of hours system in the Capital Region, the implementation of a referral system to EDs, sex, age, CCI, ethnicity, education, and income level.

Supplementary Table 5. Hazard ratios for 30-day mortality for stroke for the pre-trend and slope change related to the reconfiguration of the emergency healthcare system. Adjusted analyses were performed on a complete case basis.

	No. of unplanned contacts	Unadjusted analyses				Adjusted analyses[a]				
		Odds ratio	95% CI		P-value	No. of unplanned contacts	Odds ratio	95% CI		P-value
Overall	218,237					201,366				
Pre-trend		0.982	0.973	0.992	<0.001		0.978[a]	0.966	0.990	<0.001
Slope change		0.984	0.972	0.997	0.016		0.978[a]	0.965	0.992	0.003
Weekday vs. weekend										
Weekday	149,975					149,975				
Pre-trend		0.981	0.970	0.993	<0.001		0.982[b]	0.969	0.995	0.006
Slope change		0.990	0.975	1.006	0.226		0.986[b]	0.970	1.002	0.083
Weekend	68,262					68,262				
Pre-trend		0.983	0.968	0.998	0.030		0.985[b]	0.967	1.003	0.100
Slope change		0.973	0.953	0.993	0.010		0.964[b]	0.944	0.985	0.001
Time of admission										
7 am to 3 pm	112,418					112,350				
Pre-trend		0.988	0.975	1.001	0.073		0.984[c]	0.969	0.998	0.029
Slope change		0.986	0.969	1.004	0.125		0.980[c]	0.963	0.998	0.030
3 pm-11 pm	83,808					83,754				
Pre-trend		0.974	0.960	0.988	<0.001		0.977[c]	0.961	0.994	0.009
Slope change		0.982	0.963	1.002	0.074		0.980[c]	0.960	1.000	0.046
11 pm-7 am	22,011					21,995				
Pre-trend		0.986	0.963	1.010	0.263		1.001[c]	0.972	1.030	0.966
Slope change		0.983	0.952	1.016	0.311		0.970[c]	0.938	1.003	0.073

[a] Adjusted for seasonality, the changes in the out of hours system in the Capital Region, the implementation of a referral system to EDs, sex, age, CCI, ethnicity, education, and income level.
[b] Adjusted for seasonality, the changes in the out of hours system in the Capital Region, the implementation of a referral system to EDs, sex, age, and CCI.
[c] Adjusted for seasonality, the changes in the out of hours system in the Capital Region the implementation of a referral system to EDs, sex, age, income level, and CCI.

Supplementary Table 6. Odds ratios for in-hospital mortality for pneumonia for the pre-trend and slope change related to the reconfiguration of the emergency healthcare system. Adjusted analyses were performed on a complete case basis.

	No. of unplanned contacts	Unadjusted analyses				No. of unplanned contacts	Adjusted analyses[a]			
		Odds ratio	95% CI		P-value		Odds ratio	95% CI		P-value
Overall	446,154					404,398				
Pre-trend		0.925	0.903	0.948	<0.001		0.934	0.912	0.956	<0.001
Slope change		1.013	0.979	1.047	0.457		1.005	0.974	1.037	0.749
Weekday vs. weekend										
Weekday	302,186					273,981				
Pre-trend		0.933	0.913	0.953	<0.001		0.932	0.910	0.955	<0.001
Slope change		1.013	0.983	1.044	0.402		1.006	0.974	1.040	0.712
Weekend	143,968					130,054				
Pre-trend		0.909	0.879	0.940	<0.001		0.937	0.914	0.960	<0.001
Slope change		1.012	0.967	1.060	0.606		1.002	0.973	1.033	0.870
Time of admission										
7 am to 3 pm	219,260					199,187				
Pre-trend		0.920	0.897	0.945	<0.001		0.924	0.898	0.952	<0.001
Slope change		1.019	0.982	1.058	0.310		1.014	0.978	1.052	0.438
3 pm-11 pm	169,390					152,375				
Pre-trend		0.919	0.890	0.949	<0.001		0.935	0.916	0.954	<0.001
Slope change		1.012	0.972	1.054	0.556		1.002	0.973	1.032	0.883
11 pm-7 am	57,504					51,194				
Pre-trend		0.962	0.940	0.985	0.001		0.965	0.935	0.996	0.027
Slope change		0.988	0.958	1.020	0.452		0.979	0.944	1.015	0.240

[a] Adjusted for seasonality, the changes in the out of hours system in the Capital Region, the implementation of a referral system to EDs, sex, age, CCI, ethnicity, education, and income level.

Supplementary Table 7. Hazard ratios for 30-day mortality for pneumonia for the pre-trend and slope change related to the reconfiguration of the emergency healthcare system. Adjusted analyses were performed on a complete case basis.

	No. of unplanned contacts	Unadjusted analyses				Adjusted analyses[a]				
		Odds ratio	95% CI		P-value	No. of unplanned contacts	Odds ratio	95% CI		P-value
Overall	446,154					404,408				
Pre-trend		0.958	0.952	0.964	<0.001		0.966	0.959	0.974	<0.001
Slope change		1.001	0.993	1.009	0.856		0.997	0.988	1.006	0.526
Weekday vs. weekend										
Weekday	302,186					273,985				
Pre-trend		0.968	0.961	0.976	<0.001		0.968	0.959	0.978	<0.001
Slope change		0.995	0.985	1.005	0.346		0.993	0.982	1.004	0.190
Weekend	143,968					130,423				
Pre-trend		0.938	0.929	0.948	<0.001		0.962	0.949	0.975	<0.001
Slope change		1.012	0.999	1.026	0.074		1.006	0.991	1.021	0.433
Time of admission										
7 am to 3 pm	219,260					199,643				
Pre-trend		0.954	0.946	0.962	<0.001		0.956	0.946	0.967	<0.001
Slope change		1.005	0.994	1.017	0.389		1.005	0.992	1.018	0.440
3 pm-11 pm	169,390					152,823				
Pre-trend		0.952	0.943	0.961	<0.001		0.969	0.957	0.981	<0.001
Slope change		1.004	0.991	1.017	0.565		0.998	0.984	1.012	0.751
11 pm-7 am	57,504					51,942				
Pre-trend		0.987	0.973	1.002	0.098		0.985	0.966	1.004	0.122
Slope change		0.985	0.966	1.005	0.141		0.981	0.961	1.001	0.067

[a] Adjusted for seasonality, the changes in the out of hours system in the Capital Region, the implementation of a referral system to EDs, sex, age, CCI, ethnicity, education, and income level.

Supplementary Table 8. Odds ratios for in-hospital mortality for aortic aneurism for the pre-trend and slope change related to the reconfiguration of the emergency healthcare system. Adjusted analyses were performed on a complete case basis.

| | No. of unplanned contacts | Unadjusted analyses | | | Adjusted analyses[a] | | | |
		Odds ratio	95% CI		P-value	No. of unplanned contacts	Odds ratio	95% CI		P-value
Overall	4,049					3,768				
Pre-trend		1.024	0.999	1.049	0.064		0.986	0.942	1.032	0.537
Slope change		0.962	0.930	0.995	0.026		0.919	0.874	0.967	0.001
Weekday vs. weekend										
Weekday	2,680					2,472				
Pre-trend		1.020	0.991	1.050	0.181		0.968	0.920	1.020	0.222
Slope change		0.963	0.926	1.001	0.059		0.916	0.866	0.970	0.003
Weekend	1,369					1,266				
Pre-trend		1.035	0.996	1.076	0.081		1.024	0.945	1.108	0.566
Slope change		0.952	0.904	1.003	0.066		0.915	0.841	0.997	0.042
Time of admission										
7 am to 3 pm	1,656					1,535				
Pre-trend		1.006	0.969	1.045	0.758		0.969	0.909	1.032	0.324
Slope change		0.984	0.935	1.036	0.547		0.943	0.882	1.007	0.082
3 pm-11 pm	1,565					1,452				
Pre-trend		1.039	1.004	1.076	0.030		0.989	0.937	1.044	0.695
Slope change		0.935	0.894	0.978	0.004		0.881	0.832	0.934	<0.001
11 pm-7 am	828					728				
Pre-trend		1.043	0.993	1.096	0.096		1.014	0.899	1.142	0.825
Slope change		0.945	0.887	1.007	0.079		0.926	0.851	1.007	0.071

[a] Adjusted for seasonality, the changes in the out of hours system in the Capital Region, the implementation of a referral system to EDs, sex, age, CCI, ethnicity, education, and income level.

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Supplementary Table 9. Hazard ratios for 30-day mortality for aortic aneurism for the pre-trend and slope change related to the reconfiguration of the emergency healthcare system. Adjusted analyses were performed on a complete case basis.

		Unadjusted analyses				Adjusted analyses[a]			
	No. of unplanned contacts	Odds ratio	95% CI		P-value	No. of unplanned contacts	Odds ratio	95% CI		P-value
Overall	4,049					3,811				
Pre-trend		1.024	0.999	1.049	0.064		0.995[a]	0.963	1.027	0.743
Slope change		0.962	0.930	0.995	0.026		0.947[a]	0.916	0.980	0.002
Weekday vs. weekend										
Weekday	2,680					2,514				
Pre-trend		1.020	0.991	1.050	0.181		0.977[a]	0.939	1.016	0.239
Slope change		0.963	0.926	1.001	0.059		0.951[a]	0.916	0.988	0.010
Weekend	1,369					1,297				
Pre-trend		1.035	0.996	1.076	0.081		1.024[a]	0.971	1.081	0.382
Slope change		0.952	0.904	1.003	0.066		0.932[a]	0.881	0.986	0.015
Time of admission										
7 am to 3 pm	1,656					1,656				
Pre-trend		1.006	0.969	1.045	0.758		0.983[b]	0.937	1.030	0.472
Slope change		0.984	0.935	1.036	0.547		0.965[b]	0.916	1.016	0.175
3 pm-11 pm	1,565					1,565				
Pre-trend		1.039	1.004	1.076	0.030		1.038[b]	0.991	1.087	0.113
Slope change		0.935	0.894	0.978	0.004		0.932[b]	0.891	0.975	0.002
11 pm-7 am	828					828				
Pre-trend		1.043	0.993	1.096	0.096		1.044[b]	0.976	1.117	0.206
Slope change		0.945	0.887	1.007	0.079		0.933[b]	0.876	0.995	0.034

[a] Adjusted for seasonality, the changes in the out of hours system in the Capital Region, the implementation of a referral system to EDs, sex, age, CCI, ethnicity, education, and income level.
[b] Adjusted for seasonality, the changes in the out of hours system in the Capital Region, the implementation of a referral system to EDs and sex.

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Supplementary Table 10. Odds ratios for in-hospital mortality for bowl perforation for the pre-trend and slope change related to the reconfiguration of the emergency healthcare system

	No. of unplanned contacts	Unadjusted analyses				No. of unplanned contacts	Adjusted analyses[a]			
		Odds ratio	95% CI		P-value		Odds ratio	95% CI		P-value
Overall	13,194					11,954				
Pre-trend		0.912	0.893	0.932	<0.001		0.934	0.900	0.970	<0.001
Slope change		0.986	0.948	1.025	0.473		0.973	0.940	1.006	0.110
Weekday vs. weekend										
Weekday	9,088					8,180				
Pre-trend		0.906	0.879	0.933	<0.001		0.934	0.888	0.984	0.010
Slope change		0.990	0.954	1.028	0.608		0.976	0.939	1.014	0.216
Weekend	4,106					3,533				
Pre-trend		0.926	0.899	0.955	<0.001		0.944	0.905	0.984	0.006
Slope change		0.977	0.921	1.036	0.428		0.961	0.921	1.003	0.069
Time of admission										
7 am to 3 pm	6,284					5,584				
Pre-trend		0.891	0.863	0.919	<0.001		0.918	0.882	0.955	<0.001
Slope change		0.976	0.920	1.034	0.407		0.939	0.889	0.991	0.023
3 pm-11 pm	4,831					4,204				
Pre-trend		0.926	0.894	0.959	<0.001		0.949	0.888	1.015	0.125
Slope change		0.989	0.944	1.038	0.660		0.997	0.944	1.054	0.927
11 pm-7 am	2,079					1,755				
Pre-trend		0.941	0.907	0.976	0.001		0.947	0.874	1.025	0.177
Slope change		1.007	0.954	1.062	0.800		0.999	0.932	1.070	0.976

[a] Adjusted for seasonality, the changes in the out of hours system in the Capital Region, the implementation of a referral system to EDs, sex, age, CCI, ethnicity, education, and income level.

Supplementary Table 11. Hazard ratios for 30-day mortality for bowl perforation for the pre-trend and slope change related to the reconfiguration of the emergency healthcare system. Adjusted analyses were performed on a complete case basis.

	No. of unplanned contacts	Unadjusted analyses				No. of unplanned contacts	Adjusted analyses[a]			
		Odds ratio	95% CI		P-value		Odds ratio	95% CI		P-value
Overall	13,194					13,173				
Pre-trend		0.939	0.917	0.962	<0.001		0.958[a]	0.933	0.985	0.002
Slope change		0.976	0.945	1.008	0.136		0.975[a]	0.949	1.003	0.077
Weekday vs. weekend										
Weekday	9,088					9,088				
Pre-trend		0.930	0.904	0.957	<0.001		0.943[b]	0.911	0.975	<0.001
Slope change		0.982	0.946	1.020	0.352		0.989[b]	0.953	1.026	0.559
Weekend	4,106					4,106				
Pre-trend		0.952	0.904	0.991	0.017		0.962[b]	0.916	1.010	0.122
Slope change		0.982	0.921	1.024	0.276		0.973[b]	0.921	1.027	0.315
Time of admission										
7 am to 3 pm	6,284					6,284				
Pre-trend		0.922	0.889	0.957	<0.001		0.938[c]	0.899	0.979	0.004
Slope change		0.965	0.919	1.013	0.154		0.971[c]	0.923	1.021	0.247
3 pm-11 pm	4,831					4,831				
Pre-trend		0.943	0.911	0.976	0.001		0.946[c]	0.905	0.989	0.014
Slope change		0.984	0.942	1.028	0.462		0.984[c]	0.941	1.028	0.463
11 pm-7 am	2,079					2,079				
Pre-trend		0.962	0.915	1.012	0.131		0.979[c]	0.919	1.043	0.504
Slope change		1.009	0.949	1.074	0.768		1.015[c]	0.952	1.082	0.645

[a] Adjusted for seasonality, the changes in the out of hours system in the Capital Region, the implementation of a referral system to EDs, sex, age, CCI, ethnicity, education, and income level.
[b] Adjusted for seasonality, the changes in the out of hours system in the Capital Region, the implementation of a referral system to EDs, and sex.
[c] Adjusted for seasonality, the changes in the out of hours system in the Capital Region, and the implementation of a referral system to EDs.

Supplementary Table 12. Odds ratios for in-hospital mortality for hip fracture for the pre-trend and slope change related to the reconfiguration of the emergency healthcare system. Adjusted analyses were performed on a complete case basis.

		Unadjusted analyses				Adjusted analyses[a]			
	No. of unplanned contacts	Odds ratio	95% CI		P-value	No. of unplanned contacts	Odds ratio	95% CI		P-value
Overall	107,959					90,145				
Pre-trend		0.967	0.938	0.997	0.033		0.955[a]	0.926	0.984	0.003
Slope change		1.001	0.952	1.052	0.972		1.000[a]	0.961	1.040	0.995
Weekday vs. weekend										
Weekday	71,675					59,451				
Pre-trend		0.972	0.945	1.000	0.054		0.961[a]	0.930	0.992	0.014
Slope change		0.995	0.951	1.042	0.845		0.993[a]	0.956	1.032	0.721
Weekend	36,284					29,895				
Pre-trend		0.957	0.920	0.995	0.028		0.940[a]	0.903	0.978	0.002
Slope change		1.012	0.950	1.077	0.715		1.013[a]	0.962	1.067	0.624
Time of admission										
7 am to 3 pm	48,840					48,004				
Pre-trend		0.962	0.930	0.995	0.025		0.959[b]	0.934	0.985	0.002
Slope change		1.002	0.951	1.057	0.935		1.009[b]	0.968	1.051	0.683
3 pm-11 pm	43,847					43,130				
Pre-trend		0.966	0.930	1.002	0.064		0.965[b]	0.940	0.991	0.009
Slope change		1.009	0.950	1.072	0.776		1.006[b]	0.959	1.056	0.799
11 pm-7 am	15,272					14,839				
Pre-trend		0.983	0.950	1.017	0.326		0.965[b]	0.925	1.007	0.101
Slope change		0.979	0.944	1.016	0.270		0.969[b]	0.932	1.006	0.103

[a] Adjusted for seasonality, the changes in the out of hours system in the Capital Region, the implementation of a referral system to EDs, sex, age, CCI, ethnicity, education, and income level.
[b] Adjusted for seasonality, the changes in the out of hours system in the Capital Region, the implementation of a referral system to EDs, sex, age, CCI, and income level.

Supplementary Table 13. Hazard ratios for 30-day mortality for hip fracture for the pre-trend and slope change related to the reconfiguration of the emergency healthcare system. Adjusted analyses were performed on a complete case basis.

	No. of unplanned contacts	Odds ratio	95% CI		P-value	No. of unplanned contacts	Odds ratio	95% CI		P-value
		Unadjusted analyses				**Adjusted analyses[a]**				
Overall	107,959					90,556				
Pre-trend		0.999	0.985	1.013	0.880		1.003[a]	0.982	1.024	0.779
Slope change		0.987	0.969	1.006	0.172		0.984[a]	0.962	1.005	0.139
Weekday vs. weekend										
Weekday	71,675					60,140				
Pre-trend		0.995	0.978	1.012	0.553		0.997[a]	0.973	1.022	0.826
Slope change		0.990	0.969	1.012	0.368		0.987[a]	0.962	1.011	0.289
Weekend	36,284					30,416				
Pre-trend		1.004	0.981	1.027	0.733		1.009[a]	0.974	1.044	0.629
Slope change		0.986	0.957	1.016	0.372		0.986[a]	0.952	1.022	0.441
Time of admission										
7 am to 3 pm	48,840					48840				
Pre-trend		0.998	0.978	1.018	0.845		1.007[b]	0.983	1.032	0.565
Slope change		0.977	0.952	1.004	0.090		0.975[b]	0.948	1.003	0.082
3 pm-11 pm	43,847					43,847				
Pre-trend		0.998	0.979	1.018	0.842		1.006[b]	0.982	1.031	0.627
Slope change		1.005	0.981	1.029	0.711		1.007[b]	0.981	1.033	0.590
11 pm-7 am	15,272					15,272				
Pre-trend		0.995	0.967	1.023	0.706		0.994[b]	0.958	1.030	0.731
Slope change		0.992	0.958	1.026	0.629		0.878	0.766	1.007	0.062

[a] Adjusted for seasonality, the changes in the out of hours system in the Capital Region, the implementation of a referral system to EDs, sex, age, CCI, ethnicity, education, and income level.
[b] Adjusted for seasonality, the changes in the out of hours system in the Capital Region, the implementation of a referral system to EDs, and sex.

Supplementary Table 14. Odds ratios for in-hospital mortality for Major trauma for the pre-trend and slope change related to the reconfiguration of the emergency healthcare system. Adjusted analyses were performed on a complete case basis.

		Unadjusted analyses				Adjusted analyses[a]			
	No. of unplanned contacts	Odds ratio	95% CI		P-value	No. of unplanned contacts	Odds ratio	95% CI		P-value
Overall	43,841					41,377				
Pre-trend		1.090	0.981	1.210	0.108		1.096	0.959	1.252	0.177
Slope change		0.860	0.752	0.983	0.027		0.818	0.721	0.928	0.002
Weekday vs. weekend										
Weekday	26,815					25,354				
Pre-trend		1.081	0.972	1.202	0.150		1.092	0.944	1.264	0.234
Slope change		0.859	0.748	0.987	0.032		0.825	0.717	0.949	0.007
Weekend	17,026					15,639				
Pre-trend		1.105	0.993	1.229	0.066		1.101	0.973	1.246	0.128
Slope change		0.860	0.752	0.984	0.028		0.810	0.721	0.909	<0.001
Time of admission										
7 am to 3 pm	17,068					16,085				
Pre-trend		1.109	1.006	1.222	0.038		1.122	0.991	1.271	0.070
Slope change		0.838	0.726	0.968	0.016		0.799	0.705	0.906	<0.001
3 pm-11 pm	19,428					17,988				
Pre-trend		1.086	0.965	1.222	0.170		1.092	0.932	1.279	0.279
Slope change		0.854	0.746	0.977	0.022		0.801	0.690	0.929	0.003
11 pm-7 am	7,345					6,579				
Pre-trend		1.052	0.942	1.175	0.366		1.062	0.940	1.199	0.336
Slope change		0.931	0.817	1.060	0.280		0.878	0.766	1.007	0.062

[a] Adjusted for seasonality, the changes in the out of hours system in the Capital Region, the implementation of a referral system to EDs, sex, age, CCI, ethnicity, education, and income level.

Supplementary Table 15. Hazard ratios for 30-day mortality for Major trauma e for the pre-trend and slope change related to the reconfiguration of the emergency healthcare system. Adjusted analyses were performed on a complete case basis.

		Unadjusted analyses				Adjusted analyses[a]			
	No. of unplanned contacts	Odds ratio	95% CI		P-value	No. of unplanned contacts	Odds ratio	95% CI		P-value
Overall	43,841					41,378				
Pre-trend		1.045	1.008	1.083	0.017		1.001[a]	0.959	1.044	0.973
Slope change		0.924	0.875	0.976	0.004		0.955[a]	0.897	1.018	0.161
Weekday vs. weekend										
Weekday	26,815					26,815				
Pre-trend		1.049	1.003	1.098	0.037		1.008[b]	0.959	1.061	0.746
Slope change		0.910	0.850	0.974	0.006		0.947[b]	0.878	1.022	0.162
Weekend	17,026					17,026				
Pre-trend		1.051	0.992	1.114	0.094		1.003[b]	0.939	1.072	0.922
Slope change		0.930	0.853	1.014	0.099		0.931[b]	0.845	1.024	0.142
Time of admission										
7 am to 3 pm	17,068					17,008				
Pre-trend		1.074	1.018	1.134	0.010		1.028[c]	0.967	1.094	0.371
Slope change		0.887	0.818	0.961	0.004		0.931[c]	0.850	1.020	0.123
3 pm-11 pm	19,428					19,346				
Pre-trend		1.048	0.991	1.109	0.100		1.013[c]	0.951	1.080	0.681
Slope change		0.920	0.846	1.001	0.052		0.913[c]	0.831	1.004	0.060
11 pm-7 am	7,345					7,297				
Pre-trend		1.016	0.937	1.101	0.703		0.978[c]	0.889	1.077	0.656
Slope change		0.967	0.859	1.088	0.574		0.962[c]	0.842	1.100	0.570

[a] Adjusted for seasonality, the changes in the out of hours system in the Capital Region, the implementation of a referral system to EDs, sex, age, CCI, ethnicity, education, and income level.
[b] Adjusted for seasonality, the changes in the out of hours system in the Capital Region, the implementation of a referral system to EDs, sex, age, and CCI.
[c] Adjusted for seasonality, the changes in the out of hours system in the Capital Region, the implementation of a referral system to EDs, sex, age, income level, and CCI.