Original Article

Evaluating dynamic patterns in mortality before and after reconfiguration of the Danish emergency healthcare system

M Fløjstrup, A Kollerup, SB Bogh, M Bech, D Henriksen, SP Johnsen & M Brabrand

Abstract

Background: This study explored changes in short-term mortality during a national reconfiguration of emergency care starting in 2007.

Methods: Unplanned hospital contacts at emergency departments across Denmark from 2007 to 2016. The reconfiguration was a natural experiment, resulting in individual timelines for each hospital. The outcome was in-hospital and 30-day mortality.

Results: Individual patient-level data included 9,745,603 unplanned hospital contacts from 2007 to 2016 at 20 hospitals with emergency departments. We observed a sharp downwards shift in in-hospital mortality and 30-day mortality in three hospitals in relation to the reconfiguration.

Conclusion: This nationwide study identified three hospitals where the reconfiguration was closely associated with reduced in-hospital and 30-day mortality. In contrast, no major effects were identified for the remaining hospitals.

Keywords

Health care reform, reconfiguration, emergency care, mortality

Key points

- Few hospitals experienced an immediate reduction in in-hospital and 30-day mortality after reconfigurations.
- Some hospitals had a reduction in in-hospital and 30-day mortality years after reconfiguration, which could indicate that changes in a reconfiguration take time to implement.
- As reconfiguration is a complex and massive investment, we can never describe all mechanisms.

Introduction

Danish emergency healthcare has been reconfigured over the past few decades, just as in the United States and other European countries.[1-5] Evaluating a national health care reform is complex, as reconfiguration often involves many mechanisms, such as centralisation, newer equipment, and better-educated healthcare staff. At the same time, it also has downsides, such as increased travel time for patients and potential crowding problems.

The primary aim of the Danish reform was to secure all emergency patients equal access to uniform and high-quality care at all times of day and in every part of the country.[6] The reconfiguration plans to reduce the number of hospitals with emergency departments through centralisation and closing of hospitals.[7] Furthermore, hospitals with emergency departments (ED) will have a single entrance for all unplanned patients. Mandatory referral to the ED and the presence of specialists in the ED are also part of the reconfiguration.

Prior evaluation of healthcare reforms, show conflicting results, with no change in mortality while others show some evidence for increased mortality after a reconfiguration.[3,4,8] A recent study from our research group finds the reconfiguration of the Danish emergency healthcare system has not change the national in-hospital mortality, but the national 30-day mortality rate is slowed down by the reconfiguration.[9] We evaluate the dynamic mortality patterns of patients with unplanned hospital contacts before and after the national reconfiguration of the emergency healthcare system in Denmark. The present study explores the pattern in in-hospital and 30-day mortality at the hospitals with EDs around the time of the reconfiguration.

Methods

Study design and setting

This cohort study was based on the Danish nationwide registries. We analysed data from all unplanned hospital contacts by adults (age ≥18 years) at Danish public hospitals from 1 January 2007 to 31 December 2016 with 30-day follow-up.[10]

Marianne Fløjstrup
MD, PhD[1,2]

Anna Kollerup
MSc, PhD[3]

Søren B. Bogh
MSc, PhD[4,5]

Mickael Bech
MSc, PhD[3]

Daniel Henriksen
MD, Phd[6]

Søren P. Johnsen
MD, PhD[7]

Mikkel Brabrand
MD, PhD[1,2,8]

[1] Department of Emergency Medicine, Hospital of South West Jutland, Esbjerg, Denmark
[2] Department of Regional Health Research, University of Southern Denmark, Esbjerg, Denmark
[3] VIVE - The Danish Center for Social Science Research, Copenhagen, Denmark
[4] Open Patient Exploratory Network (OPEN), University of Southern Denmark and Odense University Hospital, Odense, Denmark
[5] Department of Clinical Research, University of Southern Denmark, Odense, Denmark
[6] Department of Clinical Pharmacology, Odense University Hospital, Odense, Denmark
[7] Danish Centre for Clinical Health Services Research, Aalborg Universitet, Aalborg, Denmark
[8] Department of Emergency Medicine, Odense University Hospital, Odense, Denmark

Corresponding author
Marianne Fløjstrup
Finsensgade 30,
Department of Emergency Medicine, Hospital of South West Jutland, Esbjerg, Denmark.
Email: Marianne.Flojstrup@rsyd.dk

The universal coverage of hospital services is free of charge for all residents because healthcare in Denmark is tax funded. Only prescription drugs, dental care, and some primary care providers require some co-payment.[11] The public hospitals are administered by five regions in Denmark. All residents are assigned a general practitioner (GP) who acts as a gatekeeper to secondary healthcare.[10] GPs offer out-of-hours primary medical services with first-line telephone contacts, and then referral to either home visits or centralised off-hours clinics staffed by GPs.[7] However, in 2014, the Capital Region changed their off-hours system to a system with first-line telephone contact with a nurse and then referral to the EDs.[7] This led to an expected increase in unplanned hospital contacts in the Capital Region of Denmark.[12]

In 2007, the Danish Health Authority issued plans for reform with a reconfiguration of emergency healthcare in Denmark. The goal of the reconfiguration was to increase the quality of care through centralised emergency healthcare to fewer hospitals with EDs across Denmark, 24-hour specialist coverage in the EDs, and improved access to diagnostic equipment.[6] All unplanned patients should initially be seen in the EDs, with only a few exceptions: children, psychiatric complaints, and women giving birth. Before 2007 more than 40 hospitals admitted unplanned patients across different wards at the hospitals.[6] The reform has been implemented in a stepwise process beginning in June 2008 and is expected to be completed in 2025, when the last newly built hospital will be completed. As the reform is not yet fully implemented, the study period in this paper is 2007 to 2016. In 2016 at the end of the study period, the number of hospitals with EDs was 23 in Denmark. Three hospitals had not been reconfigured at the end of the study period, therefore the data from these hospitals have not been included in the study. This reduction in hospitals that received unplanned patients led to an increase in the distance to the nearest hospital with an ED for many patients.[13] The reform demanded 24-hour specialist coverage from the following specialities: internal medicine, orthopaedic surgery, abdominal surgery, anaesthesiology, diagnostic radiology, and clinical biochemistry in the ED (a speciality in emergency medicine was first implemented in Denmark in 2017). However, by 2016, the 24-hour specialist coverage had only been fully implemented in approximately half of the hospitals. [14] From 2011 to 2014, a mandatory referral was implemented. This required that patients either called the emergency dispatch centre for an ambulance or were referred by their GP; before this time, access to EDs was on a walk-in basis. The implementation of mandatory referral led to a 9.4% national reduction in the number of unplanned hospital contacts.[15] Patients, who did not have a referral to the ED, were incited in the ED to contact their GP or the GP out-of-hours service. In collaboration with the regions, each hospital was responsible for implementing the reconfiguration, which could be compared to a step-wedge natural experiment. To the individual patient, the timing of the change was exogenous to their need for acute care.

Data sources

We extracted data from the Danish National Patient Registry and the Danish Civil Registration System.[10,16] These registries contain complete data on all hospital contacts and time of death for all citizens.[17] As patients could have several unplanned visits and admissions to the hospitals during the study period, we defined unplanned hospital contacts which included all unplanned visits and admissions to hospitals. Transfer between departments or from an 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 in our analyses. Sensitivity analysis of the 3-hour rule has demonstrated that this assumption is valid.[12] We also extracted data on socioeconomic status (income and education) and demographic data from Statistics Denmark.[18] All residents in Denmark have a unique personal identification number that allows cross-linkage of all registers. We excluded all women giving birth (International Classification of Diseases and Related Health Problems, tenth revision [ICD-10] codes O00-O99) because these are registered as unplanned in Denmark, but birth is most often expected.

Measurements

To study the dynamic patterns in mortality before and after the reconfiguration we were inspired by the event study design. This design is a difference-in-difference design and are often used in economics and political design, but has also been used to evaluate closure of hospitals.[19,20] We split each of the 20 hospital's unique observation periods into a period before and after the reconfiguration. The hospitals' periods were based on telephone interviews with department leaders and public reports, as there was no objectively determined date for the reconfiguration at each hospital. We chose to use half-yearly time points in the analyses. We followed the different hospitals for a range of 2 to 14 half-years before and 0 to 17 half-years after reconfiguration. To analyse the mortality patterns around the reconfiguration, we indexed all half-years relative to the half-year before the reconfiguration (half

year -1) and analysed the dynamic patterns around the reconfiguration for each hospital. We were interested in sharp shifts around the reconfiguration event because that would indicate that the reconfiguration had influenced the mortality rate. If there were no shifts from non-significant in the half-year period before the reconfiguration, i.e., period -1, to significant in the half-year periods around the reconfiguration, i.e., half year 0 or 1, then the reconfiguration appeared not to have been critically important to the mortality rate in the specific hospital.

Outcomes

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

Analysis

Baseline characteristics for the unplanned hospital contacts were presented as medians and interquartile ranges (IQRs) for continuous variables and as frequency and percentage for categorical variables. The half-yearly in-hospital mortality rates were analysed by linear regression, whereas 30-day mortality was analysed by 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. Changes in in-hospital mortality were reported as changes in percentage points, whereas changes in 30-day mortality were reported as hazard ratios. Data management and analyses were carried out in Stata 16 (Stata Corp LP, College Station, TX), and a significance level of 5% was applied.

Ethics

In compliance with Danish law, registry studies are exempted from the need to obtain approval from an ethics committee.[17] The study was approved by the Danish Data Protection Agency (file no. 17/18411).

Results

Our analyses included 9,745,603 unplanned hospital contacts by 3,100,995 individuals from 1 January 2007 to 31 December 2016, and 196,675 individuals (2.0% contact level) died in-hospital and 266,938 (2.7% contact level) died within 30 days after discharge. For most hospitals, the median age and proportion of unplanned hospital contacts with high comorbidity and high education increased after the reconfiguration (Table 1). However, the proportion of unplanned hospital contacts of Danish origin decreased at most hospitals after the reconfiguration (Supplementary Table 1).

In-hospital mortality

As mortality rates, in general, decreased over time, we observed a downward trend in mortality in most hospitals. Three hospitals (hospitals I, K, and N) had a sharp shift at the time of reconfiguration, resulting in reduced in-hospital mortality: -0.3 (95% CI -0.5; -0.2), -0.5 (95% CI -0.8; -0.2), and -0.3 (95% CI -0.5; -0.1) percentage points in half-year 0 or 1 after the reconfiguration (Figure 1). Hospital N increased to a non-significant level over time. In addition, four hospitals (hospitals D, L, M, and P) had a sharp shift with decreased in-hospital mortality, which was not concerning the reconfiguration but happened several half-years after the reconfiguration. Hospital J had a sharp shift with increased in-hospital mortality several half-years after the reconfiguration.

30-day mortality

The same three hospitals (hospitals I, K, and N) with reduced in-hospital mortality also had reduced 30-day mortality based on a sharp shift around the time of reconfiguration (Table 2). Among these three hospitals, we observed hazard ratios of 0.8 (95% CI 0.7; 0.9), 0.8 (95% CI 0.7; 0.9), and 0.9 (95% CI 0.8; 0.9), respectively. For the remaining hospitals, we did not observe any changes in 30-day mortality concerning the reconfiguration.

Discussion

Our national study on the dynamic pattern in mortality before and after reconfiguration of emergency healthcare showed no uniform effect on in-hospital and 30-day mortality. Three hospitals immediately decreased in-hospital mortality and 30-day mortality after the reconfiguration. However, one of the hospitals increased over time, for unknown reasons. Many hospitals had a decrease in in-hospital mortality over time, but this was not related to the reconfiguration. Four hospitals had a delayed sharp shift in in-hospital mortality from non-significant to significant. It is not possible from our data to conclude whether this is due to a delayed effect of the reconfiguration or if something else happened at this time at the four hospitals.

The national reconfiguration aimed for equal access to uniform and high-quality care at all times and in every part of the country for all emergency patients.[6] Studies from UK and Ireland have shown

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

	Number of observations	Age, median (IQR)	Males	Charlson comorbidity index[b]		
				Low	Medium	High
Hospital A						
Before	86,666	56 (37, 73)	43,009 (49.6%)	48,926 (56.5%)	25,417 (29.3%)	12,323 (14.2%)
After	928,709	56 (38, 73)	452,739 (48.7%)	530,936 (57.2%)	262,644 (28.3%)	135,129 (14.6%)
Hospital B						
Before	95,978	48 (32, 67)	51,930 (54.1%)	63,109 (65.8%)	22,396 (23.3%)	10,473 (10.9%)
After	528,630	51 (33, 69)	279,795 (52.9%)	332,181 (62.8%)	129,837 (24.6%)	66,612 (12.6%)
Hospital C						
Before	117,385	55 (36, 70)	58,738 (50%)	72,523 (61.8%)	32,019 (27.3%)	12843 (10.9%)
After	720,754	54 (37, 71)	349,859 (48.5%)	452,092 (62.7%)	186,064 (25.8%)	82,598 (11.5%)
Hospital D						
Before	87,866	50 (33, 68)	46,230 (52.6%)	55,772 (63.5%)	21,887 (24.9%)	10,207 (11.6%)
After	479,832	53 (35, 70)	243,444 (50.7%)	282,539 (58.9%)	130,843 (27.3%)	66,450 (13.8%)
Hospital E						
Before	34,809	46 (31, 66)	19,449 (55.9%)	23,720 (68.1%)	7,823 (22.5%)	3,266 (9.4%)
After	223,054	53 (35, 71)	115,886 (52.0%)	137,290 (61.6%)	57,027 (25.6%)	28,737 (12.9%)
Hospital F						
Before	61,350	54 (36, 70)	32,379 (52.8%)	35,972 (58.6%)	17,044 (27.8%)	8,334 (13.6%)
After	242,096	56 (38, 72)	124,178 (51.3%)	138,091 (57.0%)	66,914 (27.6%)	37,091 (15.3%)
Hospital G						
Before	104,892	52 (35, 68)	56,021 (53.4%)	66,390 (63.3%)	25,890 (24.7%)	12,612 (12%)
After	446,644	55 (37, 71)	234,942 (52.6%)	261,433 (58.5%)	120,772 (27.0%)	64,439 (14.4%)
Hospital H						
Before	80,832	51 (33, 70)	44,003 (54.4%)	48,853 (60.4%)	21,452 (26.5%)	10,527 (13%)
After	328,981	53 (33, 71)	173,269 (52.7%)	198,139 (60.2%)	85,862 (26.1%)	44,980 (13.7%)
Hospital I						
Before	221,020	46 (30, 68)	113,283 (51.3%)	142,325 (64.4%)	53,368 (24.1%)	25,327 (11.5%)
After	634,681	47 (29, 68)	315,172 (49.7%)	401,102 (63.2%)	156,790 (24.7%)	76,789 (12.1%)
Hospital J						
Before	226,565	53 (35, 71)	119,503 (52.7%)	138,941 (61.3%)	60,235 (26.6%)	27,389 (12.1%)
After	391,461	56 (37, 72)	199,949 (51.1%)	225,886 (57.7%)	110,406 (28.2%)	55,169 (14.1%)

opposing effects of reconfiguration at the hospital level on mortality.[3,4,21,22] Some studies found that the hospitals benefit from a reconfiguration, with reduced mortality, whereas others observed no effect of reconfiguration. A study from the US found increased mortality after closing and centralisation of emergency patients for those patients who were affected by a closure.[8] We speculate that there are several reasons for the differences among hospitals. Firstly, the patient population varies across the hospitals. Secondly, we found that the unplanned hospital contacts became older during the study period, with increased prevalence of chronic illness, leading to more complex clinical presentation in the EDs. This is in line with other European countries.[23,24] We adjusted for these factors in our analyses, but there are several other factors, which may influence mortality, such as the number of specialists present, organisation of the ED, and equipment. However, we were not able to adjust to these factors. We are convinced that individual components of the entire reorganisation (e.g., centralising emergency healthcare, specialists present at night and weekends, early review by a specialist, better equipment) have lowered mortality, whereas other unknown components potentially could have induced an increase in mortality. Another reason for the different changes in mortality among hospitals is that the hospitals, in collaboration with the regions, were responsible for implementing the reconfiguration, leading to many different ways of organising care.[25] The three hospitals, that had an immediate effect of the reconfiguration, are to

Hospital K						
Before	135,974	57 (38, 73)	71,106 (52.3%)	77,322 (56.9%)	37,320 (27.4%)	21,332 (15.7%)
After	269,031	59 (40, 74)	136,340 (50.7%)	146,880 (54.6%)	74,105 (27.5%)	48,046 (17.9%)
Hospital L						
Before	116,833	55 (38, 71)	62,194 (53.2%)	70,585 (60.4%)	31,680 (27.1%)	14,568 (12.5%)
After	167,314	58 (89, 73)	86,354 (51.6%)	94,119 (56.3%)	47,651 (28.5%)	25,544 (15.3%)
Hospital M						
Before	129,535	57 (38, 74)	66,593 (51.4%)	73,712 (56.9%)	37,065 (28.6%)	18,758 (14.5%)
After	148,018	60 (41, 75)	75,410 (50.9%)	80,502 (54.4%)	45,082 (30.5%)	22,434 (15.2%)
Hospital N						
Before	269,374	52 (33, 70)	142,796 (53%)	154,823 (57.5%)	75,637 (28.1%)	38,914 (14.4%)
After	306,330	54 (34, 71)	157,960 (51.6%)	171,330 (55.9%)	88,870 (29.0%)	46,130 (15.1%)
Hospital O						
Before	219,991	53 (34, 71)	116,936 (53.2%)	137,829 (62.7%)	54,268 (24.7%)	27,894 (12.7%)
After	226,343	56 (36, 73)	117,994 (52.1%)	136,875 (60.5%)	59,588 (26.3%)	29,880 (13.2%)
Hospital P						
Before	174,355	52 (34, 70)	94,017 (53.9%)	110,372 (63.3%)	42,403 (24.3%)	21,580 (12.4%)
After	151,344	59 (39, 74)	76,951 (50.8%)	86,851 (57.4%)	41,491 (27.4%)	23,002 (15.2%)
Hospital Q						
Before	336,031	49 (30, 66)	175,263 (52.2%)	205,030 (61%)	79,939 (23.8%)	51,062 (15.2%)
After	305,157	55 (34, 71)	159,982 (52.4%)	168,205 (55.1%)	83,772 (27.5%)	53,180 (17.4%)
Hospital R						
Before	86,025	63 (45, 77)	42,184 (49%)	39,735 (46.2%)	31,334 (36.4%)	14,956 (17.4%)
After	108760	60 (41, 76)	52,865 (48.6%)	60,973 (56.1%)	32,813 (30.2%)	14,974 (13.8%)
Hospital S						
Before	64,970	57 (38, 74)	34,619 (53.3%)	36,941 (56.9%)	19,237 (29.6%)	8,792 (13.5%)
After	59,311	59 (39, 74)	30,725 (51.8%)	35,109 (59.2%)	16,431 (27.7%)	7,771 (13.1%)
Hospital T						
Before	280,704	53 (34, 71)	146,027 (52%)	170,486 (60.7%)	71,876 (25.6%)	38,342 (13.7%)
After	147,998	58 (39, 74)	74,808 (50.5%)	82,856 (56.0%)	40,518 (27.4%)	24,624 (16.6%)

b Charlson Comorbidity Index: 0 = low, 1-2 = moderate, >2 = high

our personal experience the hospitals have changed their organisational setup the most around the time of reconfiguration. These three hospitals have implemented independent international recognisable EDs with specialists present at all times. Although we set a specific date as the cut-off for the reconfiguration of each hospital, which is somewhat arbitrary, the implementation of the reconfiguration happened gradually. Moreover, emergency medicine was first accepted as a medical speciality in 2017,[26] and the number of Danish emergency specialists is still limited. The Capital Region of Denmark changed their off-hours GP service in 2014, which resulted in all previous off-hours GP patients being seen in the EDs. Thus, less ill, and less comorbid patients were suddenly also seen in the EDs.[12]

Limitations

The most important limitation of this study is that we cannot identify the effect of the individual changes that happened as part of the reconfiguration. Such as the dynamic closing of hospitals and centralisation, and that each hospital was responsible for its reconfiguration, leading to some heterogeneity in its timeline. In addition, we chose a specific date for the reconfiguration at each hospital, though we are aware that reconfiguration does not happen from one day to another at an emergency hospital but takes time. Another limitation is the period from 2007 to 2016, however, more recent data was not available. We chose to include all unplanned hospital contacts from a patient, not just the first or the last as this would have induced selection bias, because of the long study

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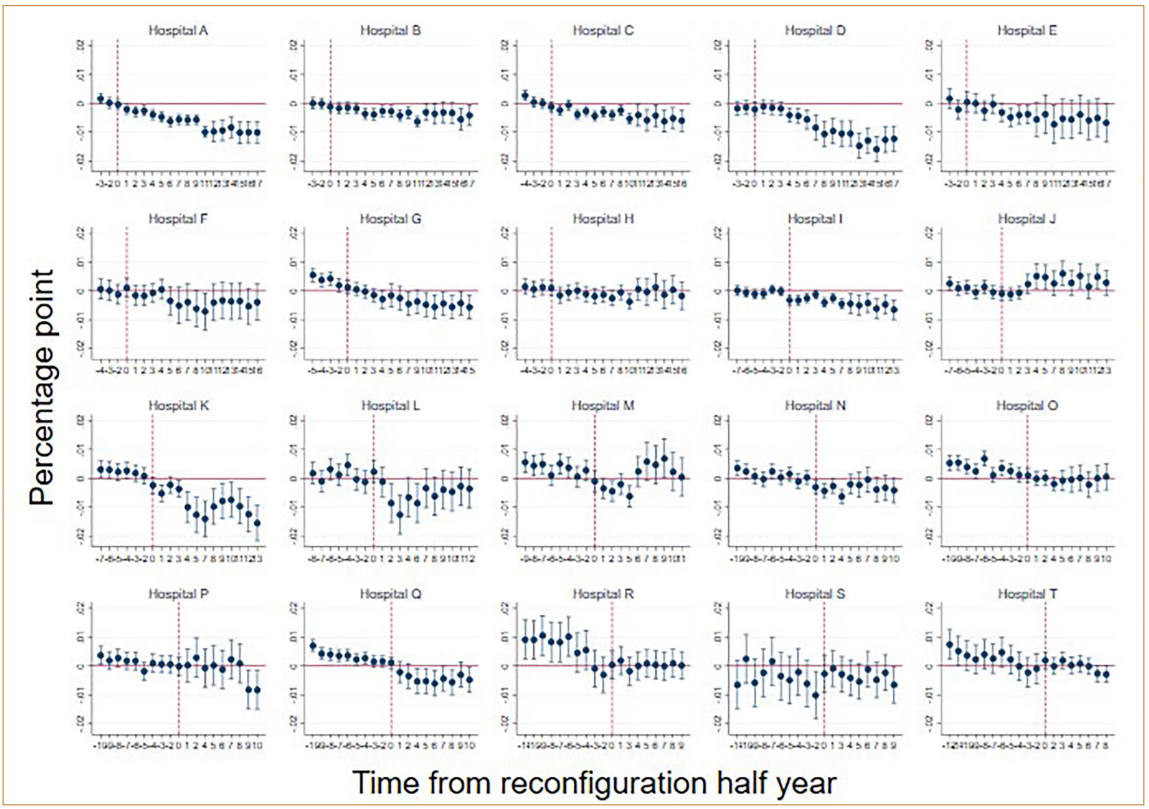

Figure 1. Contact-level in-hospital mortality. The horizontal line at time -1 represents the half-year in which the reconfiguration occurred. The blue dot represents the half yearly adjusted mortality rate. The blue error bars represent the 95% Confidence interval. The changes are in percentage points. The hospitals I, K and N showed an immediate significant reduction in mortality.

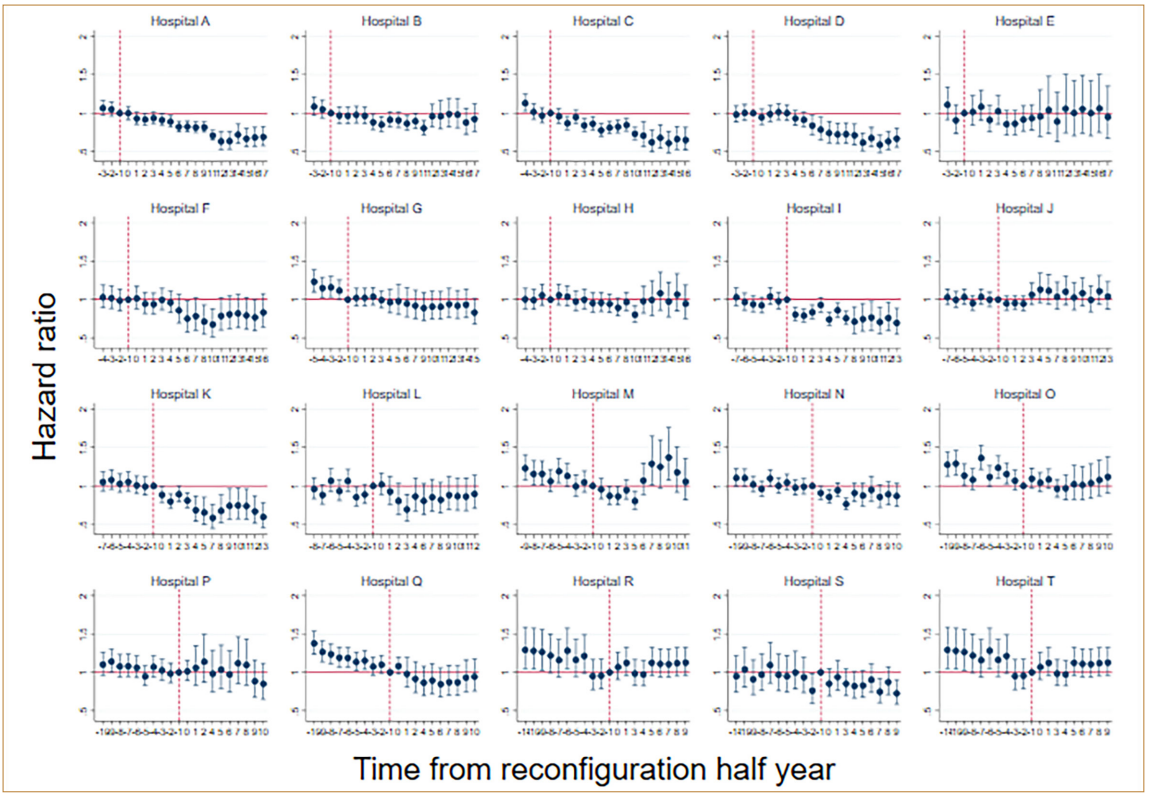

Figure 2. Contact-level 30-day mortality. The horizontal line at time -1 represents the half-year before the reconfiguration occurred. The blue dot represents the half yearly adjusted mortality rate. The blue error bars represent the 95% Confidence interval. The changes are in hazard ratios. The hospitals I, K and N showed an immediate significant reduction in mortality.

period. We are not aware of changes in registration practice during the study period, but this could be a possible limitation. Finally, our study design does not allow us to consider any underlying mortality trend at the individual hospitals. However, our results focus on sharp shifts from non-significant to significant changes in mortality.

Conclusion

In this study of the effect of a nationwide reconfiguration of emergency hospital care on mortality, we identified three hospitals with emergency departments where the reconfiguration appeared to have an immediate effect with reduced in-hospital and 30-day mortality. Another four hospitals had a delayed sharp shift with decreased in-hospital mortality after the reconfiguration, which could indicate that changes in a reconfiguration take time to implement. The remaining hospitals had no major effects.

Declaration of interest

The authors declare no competing interests.

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