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Reductions in hospital admissions and mortality rates observed after integrating emergency care: a natural experiment

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ABSTRACT

Objectives: Reducing emergency admissions is a priority for the NHS. A single hospital's emergency care system was reorganised with the principles of front-loaded investigations, integration of specialties, reduced duplication, earlier decision making by senior clinicians and a combined emergency assessment area. The authors relocated our Medical Assessment Unit into our emergency department in 2006. The authors evaluated changes in admissions and mortality before and after 2006, compared with other similar hospitals.

Design: Quasi-experimental before and after study using routinely collected data.

Setting and participants: 1 acute hospital in England, the intervention site, was compared with 23 other English hospitals between 2001 and 2009.

Outcome measures: Our outcome measures were hospital standardised mortality ratios (HSMRs) for non-elective admissions and standardised admission ratios (SARs).

Results: The authors observed a statistically and clinically significant decrease in HSMR and SAR. The intervention hospital had the lowest HSMR and SAR of all the hospitals in our sample. This was statistically significant, p=0.0149 and p=0.0002, respectively.

Conclusion: Integrating emergency care in one location is associated with a meaningful reduction in mortality and emergency admissions to hospital.

ARTICLE SUMMARY

Article focus

- We describe the improvements that occur when a medical admissions unit is closed and relocated into an emergency department. We compared a single unit to a family of similar hospitals. We used routine data analysed by the Dr Foster healthcare intelligence unit.

Key messages

- Reducing duplicate processes, centralising hospital emergency care in one area and streamlining non-elective admission pathways is associated with sustained reductions in non-elective admissions and mortality.
- The Standardised Admissions Ratio is an effective way to measure the performance of non-elective admissions.

Strengths and limitations of this study

- This study has compared performance against controls over a ten year period.
- The study uses retrospectively analysed administrative data.

INTRODUCTION

There have been large increases in the number of emergency department attendances and emergency admissions over the past 10 years, policy initiatives have largely been ineffective at reducing this.[1] Emergency admissions now cost the NHS £11 billon a year.[2 3] In addition, emergency admissions disrupt elective care.[1] Secondary emergency care systems have evolved rather than developed by any planned process. While it has always been recognised that a part of an acute hospital needs to accessible for unplanned emergencies, there is less consensus on the optimal organisation of unplanned emergency care. Emergency care systems vary widely across the world and even within countries and between hospitals in different countries. An emergency department can be seen as having an advanced triage role, identifying and treating ill and injured while discharging safely the well. An ideal, publicly funded, hospital emergency care system would save lives, reduce morbidity while minimising admissions to hospital. The degree of investigation and management before admission varies widely. Medical Admissions Units (MAUs), where general practitioners (GP) can refer patients directly to a general physician, are common throughout the UK. Surgical Admission Units, where general practitioners can refer patients directly to a surgeon are also common. Patients referred to these admission units usually bypass emergency

departments. These admission units also receive referrals from the hospital emergency department. In the UK, around 50% of all emergency admissions to hospital pass through the emergency department.

While this model of care is well understood by healthcare staff, it results in long delays for definitive treatment and fragmented care. Patient may undergo multiple assessments if they pass through an emergency department and are then subsequently admitted to an assessment unit. Many bed moves result, which compromises infection control and continuity of care. In 2004, we embarked on a service redesign of the emergency assessment and admission process. We mapped out admission pathways for patients who were admitted non-electively. We sought to remove wasteful steps and duplication. It was apparent that the process of admitting general medical patients (the majority of non–elective admissions) to our hospital was fragmented, inequitable, complex and had multiple, duplicated steps. We found that patients often passed through two assessment areas, had documentation on two separate medical records, had blood tests repeated and might be assessed by up to five different doctors.

We opened the Emergency Assessment Unit (EAU) in 2006. The two diagrams show the process for admitting or discharging the majority of emergency patients presenting to our hospital. This was broadly similar to admission process in most acute hospitals in the UK before 2006 and radically different afterwards. We redesigned the service, so that the majority of non-elective admissions attended the emergency department. In 2006, we closed our MAU and relocated the staff to the emergency department. We expanded the emergency department by about the number of beds that the MAU had had. We developed a combined clerking process that was supported by shared documentation, with the overall aim of reducing assessments (figures 1 and 2). The emergency department was supported by the development of the short stay medical and surgical wards, a clinical decisions unit and a children's observation unit. These wards aimed to look after patients for no more than 3 days. There was an increased access to emergency radiology. The proportion of non-elective admissions entering the hospital through the emergency department rose from about 50% to around 80%. Patients requiring admission from the outpatient department, referrals from other hospitals and obstetric patients continued to bypass the emergency department. We did not use an explicit theoretical or scientific framework to guide us, but our approach had elements of lean manufacturing techniques in that we performed value stream mapping of patient pathways.[4] Our approach differed from 'lean' in that there was a 'big bang launch', and there was less emphasis on continuous improvement in this program than a 'lean model'.

Previous small-scale evaluations identified that this model of care was associated with a reduction in admissions and hospital standardised mortality.[5 6] However, these studies were compromised by short follow-up times and an absence of meaningful controls. We aimed to evaluate whether our model of care was associated with reduced admissions and inpatient mortality, compared with other similar hospitals. Our outcome measures were hospital standardised mortality ratios (HSMRs) for non-elective admissions and standardised admission ratios (SARs). We anticipated, based on previous work, that our admissions ratios would be lower, but we aimed to evaluate against similar hospitals.

METHODS

Addenbrookes is a teaching hospital in Cambridge, England. The emergency department sees around 90 000 patients per annum. We compared this hospital's performance with a family of most similar hospitals trusts. These were mainly teaching hospitals trusts outside London. This family of hospitals are frequently compared for operational performance. These 15 acute trusts are identified in box 1, comprising 23 emergency departments.

We conducted a retrospective evaluation using Dr Foster's data. This is a healthcare intelligence unit that

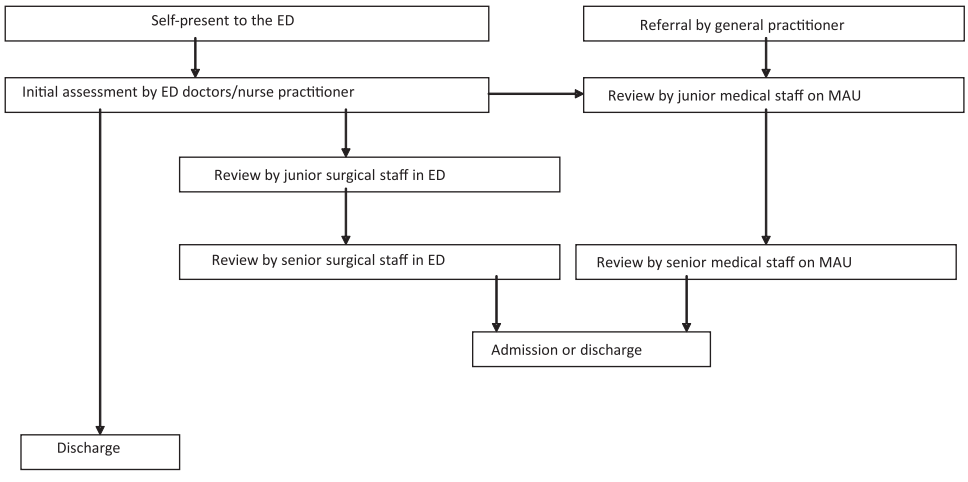

Figure 1 Traditional process for evaluating patients presenting for unscheduled care before 2006. ED, Emergency Department; MAU, Medical Admissions Unit.

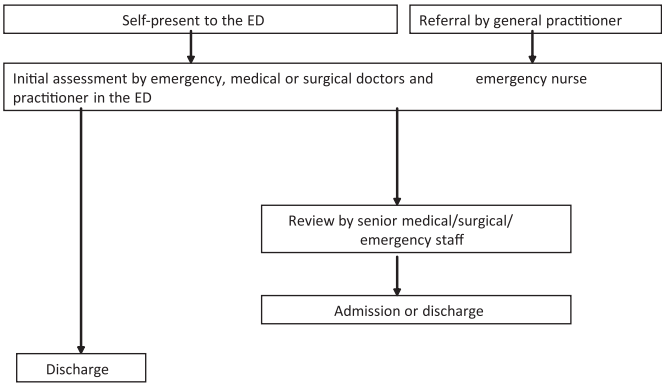

Figure 2 Streamlined process for evaluating patients presenting for unscheduled care from 2006.

analyses data from all the hospitals in the NHS. We evaluated HSMR for non-elective admissions over the years immediately before and after implementation of our integrated emergency care model in 2006. HSMR is a performance measure used widely throughout the NHS and has high face validity. HSMR is the ratio of the observed number of inhospital deaths during admissions with an HSMR diagnosis to the expected number of deaths, multiplied by 100. The expected number of deaths is actuarially based on a number of conditions with a predictable rate of death, including heart failure, strokes and fractured neck of femur. We ran the model with and without adjusting for socioeconomic deprivation. This made no practical difference to our results or conclusions, so we have reported the results without adjusting for socioeconomic deprivation. HSMR is reported throughout the NHS. HSMR is calculated for non-elective admissions regardless of whether they are admitted through an assessment unit or emergency department. We benchmarked our performance against the relevant financial year. We have previously developed a measure called the SAR with the Dr Foster unit.[7] The numerator is the number of non-elective admissions. The denominator was the total number of patients registered in GP practices that refer 80% or more of their patients to an included hospital. This was then compared with a national average to provide a ratio. We benchmarked our SAR against the relevant year. We analysed data from 2001 to 2009. We conducted the analysis in the summer of 2011, as this allowed enough time to ensure that all the hospitals had provided complete returns and that all long stay patients had been discharged.

We contacted emergency medicine consultants working in all the other hospitals to establish whether their non-elective admissions to medicine or surgery were admitted through their emergency departments.

We used the method described by Palmer[8] to perform hypothesis testing on the rank performance of our hospital from 2006 onwards. A statistical analysis specifically designed for post hoc assessment of routinely collected data was applied to assess the plausibility of chance for accounting for observed differences in hospital care emergency care system performance measures after the policy change was implemented. In this natural experimental setting, two key rates were separately analysed to assess performance. We did not seek ethical approval as this was a service evaluation using routinely collected anonymous data.

Box 1 Family of similar hospitals

Cambridge University Hospitals NHS Foundation Trust
Central Manchester University Hospitals NHS Foundation Trust
Derby Hospitals NHS Foundation Trust
Lancashire Teaching Hospitals NHS Foundation Trust
Leeds Teaching Hospitals NHS Trust
Nottingham University Hospitals NHS Trust
Oxford Radcliffe Hospitals NHS Trust
Royal Liverpool and Broadgreen University Hospitals NHS Trust
Salford Royal NHS Foundation Trust
Sheffield Teaching Hospitals NHS Foundation Trust
Southampton University Hospitals NHS Trust
The Newcastle Upon Tyne Hospitals NHS Foundation Trust
University Hospital Birmingham NHS Foundation Trust
University Hospital of South Manchester NHS Foundation Trust
University Hospitals Bristol NHS Foundation Trust
University Hospitals of Leicester NHS Trust

RESULTS

We received complete data from all the hospital trusts that we contacted for information about the organisation of their emergency care services. The Dr Foster unit provided us with complete data sets on all the acute hospital trusts that we had identified as most similar to us. No hospital other than Addenbrookes routinely received GP-referred medical patients in their emergency department during the study period. Three emergency departments, in addition to Addenbrookes, routinely received GP-referred surgical admissions.

The SAR decreased suddenly in 2006 when the EAU opened and was the lowest of all the hospitals in the sample in 2006, 2007, 2008 and 2009 (table 2). The probability one prespecified hospital out of 16 performs consistently best across all 4 years is highly statistically significant, with p=0.0002 (figure 3).

There was a steady decrease in our HSMR, compared with controls during the study period (table 1). This decrease began in 2003. This was maintained and was the lowest of all the hospitals in the study in 2007, 2008 and 2009. The probability that the intervention hospital performed best out of 16 hospital trusts 3 out of 4 years is statistically significant, p=0.0149 (figure 4). We adjusted both SAR and HSMR for deprivation but found that the effect of this was minor and did not change our conclusions. The three hospitals that directed GP-referred surgical patients to the emergency department

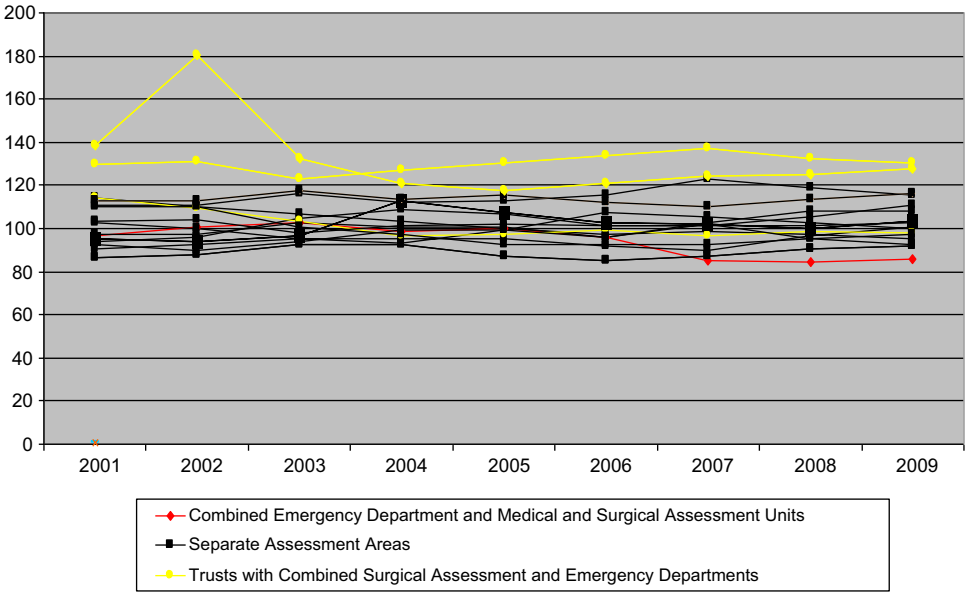

Figure 3 Standardised admissions ratio: Emergency Assessment Unit model versus similar hospitals.

had similar performance to the other hospitals that had Surgical Admission Units.

DISCUSSION

We have found that the combining an MAU in the emergency department has been associated with a beneficial and sustained decrease in HSMR and SAR. We found that the HSMR started decreasing 2 years before the EAU opened. We found that GP-referred surgical admission units being co-located in emergency departments had little effect on HSMR or the numbers of admissions. This is not surprising as the numbers of non-elective surgical admissions and subsequent deaths are considerably lower than in patients admitted under general medical specialties.

We propose that this model of integrated emergency care allows an emergency department to fulfil its primary role of an advanced triage facility better, in that admissions are minimised safely and mortality declines. We speculate that there several reasons for reduced non-elective admissions. Many GP-referred low acuity conditions, such as suspected venous thromboembolism were attending an MAU and were counted as an admission. These patients are now rarely admitted. We think that this benefits these low acuity patients as they are usually discharged within 4 h. We also think that this benefits the health economy, as these patients are treated more cheaply. Access to advanced imaging, such as ultrasound and CT, improved as part of this model and this allows earlier discharge.

There are some important limitations to our work. The data were routinely collected and subject to significant variability. HSMR only presents data about patients who have been admitted to hospital, not those attending

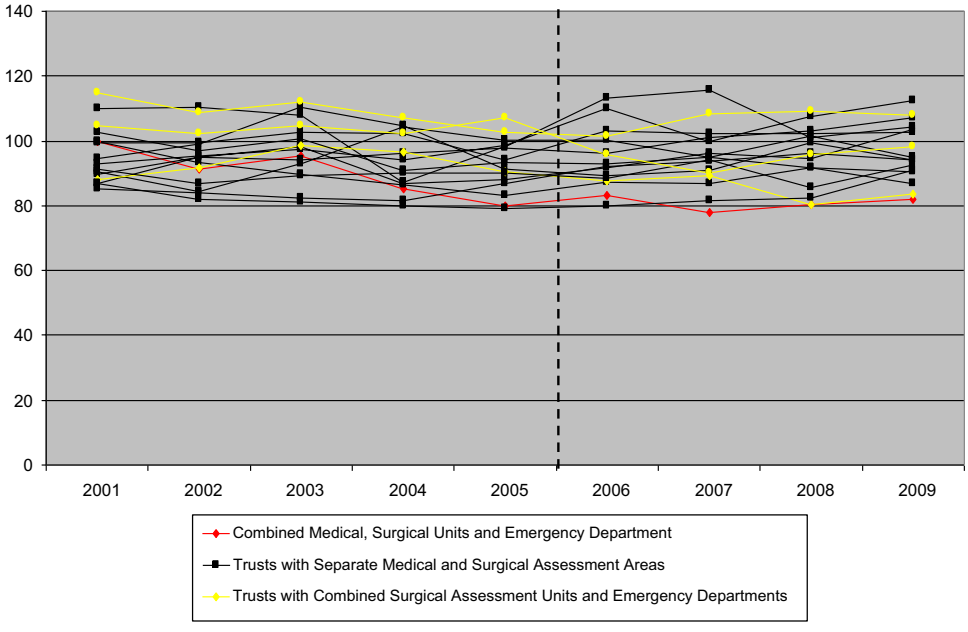

Figure 4 HSMR for non-elective admissions: Emergency Assessment Unit model compared to other similar hospitals.

Table 1 Hospital standardised mortality ratios for non-elective admissions

Acute trust	2001	2002	2003	2004	2005	2006	2007	2008	2009
Cambridge University Hospitals NHS Foundation Trust	99.9 (94.5–105.5)	91.3 (86.3–96.4)	95.4 (90.6–100.4)	85.3 (80.9–90.0)	79.9 (75.6–84.5)	83.4 (78.8–88.2)	77.9 (73.7–82.4)	80.5 (76.1–85.0)	81.9 (77.5–86.6)
B	109.9 (102.3–117.9)	110.5 (103.5–117.9)	108.1 (101.3–115.3)	87.2 (81.0–93.7)	98.3 (92.0–104.9)	113.3 (106.1–120.8)	115.6 (108.1–12.36)	101.1 (94.6–10.80)	104.2 (97.2–111.5)
C	92.8 (88.6–97.2)	95.5 (91.3–99.7)	97.3 (93.1–101.7)	94.1 (89.8–98.6)	98.4 (94.1–102.9)	110.1 (105.3–115.0)	99.7 (95.3–104.4)	107.6 (103.0–112.3)	112.4 (107.4–117.7)
D	90.4 (86.0–95.1)	84.3 (80.5–88.3)	93.0 (88.0–98.1)	104.1 (98.5–110.0)	100.1 (95.2–105.1)	100.3 (95.4–105.4)	95.1 (90.4–100.0)	101.6 (96.8–106.6)	94.8 (90.0–99.9)
E	99.7 (96.2–103.3)	93.1 (89.8–96.6)	89.5 (86.3–92.9)	86.5 (83.2–89.9)	83.2 (79.8–86.6)	87.1 (83.6–90.8)	87.0 (83.6–90.6)	91.8 (88.2–95.5)	90.7 (87.0–94.5)
F	89.8 (86.6–93.2)	95.0 (91.7–98.4)	98.1 (94.8–101.5)	86.9 (83.8–90.1)	88.0 (84.9–91.3)	91.8 (88.5–95.2)	96.0 (92.6–99.6)	94.8 (91.4–98.2)	103.4 (99.7–107.3)
G	87.0 (83.1–91.0)	94.8 (90.8–99.1)	94.2 (90.4–98.2)	96.3 (92.4–100.3)	97.9 (94.0–102.0)	96.2 (92.1–100.4)	101.2 (96.9–105.6)	103.1 (98.8–107.5)	107.2 (102.6–111.8)
H	94.4 (89.6–99.3)	99.2 (94.2–104.4)	110.5 (105.0–116.2)	104.6 (99.3–110.2)	91.1 (86.2–96.3)	89.4 (84.5–94.6)	90.7 (85.6–96.0)	99.2 (93.8–104.8)	94.0 (88.6–99.7)
I	88.1 (82.8–93.5)	91.5 (86.4–96.9)	98.5 (92.8–104.4)	96.8 (90.9–102.9)	90.3 (84.9–95.9)	87.7 (82.5–93.1)	89.4 (84.1–94.9)	80.2 (75.4–85.2)	83.5 (78.4–88.8)
J	91.4 (87.9–95.0)	86.8 (83.5–90.2)	89.3 (86.0–92.6)	90.3 (86.9–93.7)	89.9 (86.5–93.4)	88.5 (85.1–92.1)	94.2 (90.6–97.9)	85.5 (82.2–88.8)	92.7 (89.1–96.4)
K	99.2 (94.6–104.0)	99.3 (94.7–103.9)	102.8 (98.2–107.5)	102.3 (97.8–107.0)	94.0 (89.6–98.5)	103.3 (98.4–108.4)	102.3 (97.5–107.3)	102.1 (97.4–107.1)	102.5 (97.7–107.6)
L	87.0 (83.3–90.9)	82.0 (78.4–85.7)	81.2 (77.7–84.8)	80.1 (76.6–83.7)	79.0 (75.5–82.7)	79.9 (76.3–83.7)	81.6 (77.8–85.5)	82.3 (78.4–86.2)	90.7 (86.4–95.2)
M	115.0 (109.6–120.6)	108.7 (103.6–114.0)	112.0 (106.8–117.4)	107.1 (102.1–112.3)	102.7 (97.8–107.8)	101.4 (96.4–106.6)	108.2 (103.0–113.6)	109.0 (103.7–114.6)	107.9 (102.4–113.7)
N	85.1 (79.9–90.5)	84.1 (78.9–89.4)	82.5 (77.7–87.5)	81.6 (76.7–86.8)	86.9 (81.8–92.3)	92.2 (86.7–98.0)	93.8 (88.3–99.7)	96.4 (90.7–102.2)	94.2 (88.7–99.9)
O	102.6 (96.5–109.0)	97.1 (91.2–103.3)	100.7 (94.8–106.9)	90.7 (85.3–96.4)	93.4 (87.8–99.2)	93.1 (87.4–99.0)	95.1 (89.4–101.1)	91.9 (86.4–97.5)	86.9 (81.7–92.4)
P	104.9 (101.2–108.7)	102.2 (98.7–105.8)	104.8 (101.3–108.3)	102.2 (98.7–105.7)	107.0 (103.4–110.6)	95.7 (92.9–98.6)	90.2 (86.9–93.6)	95.6 (92.2–99.1)	98.1 (94.5–101.9)

Table 2 Standardised admissions ratios

Acute trust	2001	2002	2003	2004	2005	2006	2007	2008	2009
Cambridge University Hospitals NHS Foundation Trust	85.9 (85.0–86.8)	90.8 (89.9–91.7)	96.7 (95.8–97.7)	97.5 (96.6–98.4)	102.4 (101.5–103.4)	102.2 (101.3–103.2)	87.9 (87.0–88.8)	88.2 (87.3–89.1)	90.2 (89.3–91.1)
B	110.7 (109.6–111.8)	111.5 (110.4–112.6)	120.4 (119.2–121.5)	146.7 (145.5–148.0)	148.1 (146.8–149.4)	149.2 (147.9–150.5)	144.1 (142.8–145.4)	139.8 (138.5–141.1)	144.9 (143.6–146.2)
C	101.7 (100.8–102.7)	104.0 (103.0–105.0)	102.6 (101.7–103.6)	111.0 (110.1–112.0)	116.3 (115.3–117.3)	121.3 (120.3–122.4)	117.6 (116.6–118.6)	123.3 (122.3–124.3)	130.4 (129.4–131.4)
D	133.6 (132.5–134.8)	176.5 (175.1–177.9)	136.2 (135.0–137.4)	130.3 (129.1–131.4)	130.9 (129.7–132.1)	140.6 (139.4–141.9)	140.3 (139.0–141.5)	142.0 (140.8–143.3)	146.3 (145.1–147.6)
E	102.0 (101.3–102.8)	104.1 (103.3–104.8)	114.8 (114.0–115.5)	118.1 (117.3–118.9)	122.6 (121.8–123.4)	123.1 (122.3–123.9)	128.2 (127.3–129.0)	135.0 (134.1–135.8)	135.3 (134.5–136.2)
F	113.0 (112.3–113.8)	115.0 (114.2–115.8)	109.8 (109.1–110.6)	111.3 (110.5–112.0)	110.2 (109.5–111.0)	115.7 (114.9–116.5)	112.8 (112.0–113.5)	116.1 (115.3–116.8)	119.6 (118.8–120.3)
G	82.0 (81.3–82.7)	80.6 (80.0–81.3)	88.1 (87.3–88.8)	98.0 (97.2–98.7)	101.7 (100.9–102.5)	103.2 (102.4–104.0)	105.9 (105.1–106.7)	100.2 (99.4–100.9)	98.4 (97.6–99.1)
H	129.1 (127.9–130.3)	131.6 (130.3–132.8)	145.2 (143.9–146.5)	146.4 (145.1–147.7)	153.8 (152.4–155.1)	165.0 (163.6–166.3)	170.5 (169.1–171.9)	165.5 (164.2–166.9)	161.8 (160.5–163.1)
I	138.5 (137.0–140.1)	141.9 (140.3–143.4)	139.9 (138.3–141.4)	151.3 (149.7–152.9)	161.4 (159.7–163.1)	174.1 (172.4–175.8)	174.2 (172.5–175.9)	169.5 (167.8–171.2)	167.5 (165.9–169.2)
J	122.7 (121.8–123.6)	120.2 (119.3–121.1)	122.7 (121.7–123.6)	124.1 (123.2–125.0)	125.3 (124.4–126.3)	127.7 (126.8–128.6)	125.1 (124.2–126.1)	124.0 (123.0–124.9)	122.1 (121.2–123.0)
K	96.6 (95.6–97.5)	95.3 (94.4–96.3)	95.5 (94.6–96.4)	98.2 (97.3–99.1)	108.5 (107.5–109.5)	122.9 (121.9–123.9)	117.2 (116.2–118.2)	115.3 (114.4–116.3)	113.8 (112.8–114.8)
L	125.5 (124.3–126.8)	121.9 (120.7–123.2)	121.0 (119.8–122.3)	118.8 (117.6–120.0)	124.5 (123.3–125.7)	133.2 (131.9–134.4)	126.1 (124.9–127.3)	129.3 (128.0–130.5)	128.6 (127.4–129.8)
M	97.2 (96.1–98.2)	100.0 (98.9–101.0)	110.5 (109.4–111.7)	115.7 (114.5–116.8)	113.5 (112.4–114.7)	117.0 (115.9–118.2)	115.5 (114.4–116.7)	120.7 (119.5–121.9)	122.4 (121.2–123.6)
N	89.3 (88.1–90.6)	92.4 (91.2–93.7)	100.1 (98.8–101.4)	104.2 (102.9–105.5)	108.7 (107.4–110.1)	110.1 (108.8–111.5)	104.4 (103.1–105.7)	113.4 (112.1–114.8)	118.7 (117.4–120.1)
O	91.4 (90.3–92.5)	94.7 (93.6–95.8)	108.7 (107.5–109.9)	118.3 (117.1–119.6)	120.9 (119.7–122.2)	120.7 (119.5–121.9)	117.3 (116.1–118.5)	117.9 (116.7–119.1)	119.8 (118.6–121.0)
P	112.3 (111.6–113.0)	114.3 (113.5–115.0)	124.7 (123.9–125.4)	125.8 (125.1–126.6)	133.7 (132.9–134.4)	136.8 (136.1–137.6)	129.3 (128.6–130.1)	134.0 (133.2–134.7)	138.6 (137.8–139.3)

the emergency department. It is possible that our decline in HSMR might be offset by more people dying in the emergency department or dying at home. We think that this is unlikely. HSMR is an imperfect measure to assess quality of care in hospitals.[9 10] However, the use of HSMR to identify comparative trends, as we have, is less controversial. Acute hospitals in the England are obliged to report these data for performance management and follow a standard reporting system.

It is possible that the changes we saw in SAR may be due to changes in the way primary care is organised locally. We think that this is unlikely; first, we are unaware of any major changes in the way that GPs refer patients to the hospital, second, there was a big decrease just after the EAU opened, consistent with a causal relationship. We cannot ascribe a causal relationship to the changes that we have seen with our study design, a natural experiment design only allows description of associations.

The measure of admissions, SARs, can be criticised in that we had to develop a new measure. However, other performance measures available are designed for emergency departments and not the whole emergency care pathway. This measure of admissions is superior to other measures, such as conversion rate, as it provides information about a whole acute care system performance, rather than an individual department.

The 4 h target was introduced during the study period. This is a performance measure that mandates that 95% of patients need to have left the emergency department within 4 h of arrival, with financial penalties for non-compliance. This could be a potential confounding variable; however, it was applied equally to all the study hospitals.

This work comes from a single centre and care should be taken in generalising the results to other hospitals; however, the principles of reduced fragmentation and duplication of care that we have described are intuitively plausible. We have described a complex intervention, and it is difficult to be sure what parts of the intervention have lead to a beneficial response. Our study design, a natural experiment, does not allow us to state that our model causes the reduced admissions and mortality. However, combining care from multiple specialty teams, front-loading investigations, improving access to investigations and reducing duplication reduces admissions and mortality is plausible and seems to have a temporal, specific and strong effect. We did not use an explicit theoretical framework or scientific method to develop our model of care. Our approach had elements of lean manufacturing principles, but we had to be pragmatic.

We did have not presented an economic analysis of these data, this an area of future work. However, this model of care provides benefits to the whole health economy.

There is little literature that we could find about system redesign to reduce emergency hospital admissions. Most interventions are condition or presentation specific, such as falls in the elderly or frequent attenders.[1 11 12] Other studies assess the effect of general practitioners working in, or close, to the emergency department or walk-in centres.[13–15] These have reported inconsistent or minor effects, at best. There is some evidence that early assessment by experienced doctors and nurses in an emergency department reduces emergency admissions.[16–18] There is a large literature that examines how to improve processes within an emergency department, but little of this measures patient-orientated outcomes.[19–24] Future work should attempt to validate these findings across different hospitals.

CONCLUSIONS

Combining emergency admissions within one place is associated with significant and beneficial reductions in mortality and admissions. This model of integrated emergency care may allow emergency departments to fulfil their advanced triage function better.

Contributors AAB and SMR initiated the project and developed the study protocol. VA and TJHB provided clinical and operational context, respectively, into the discussion. CP performed the statistical analysis. All authors contributed to the writing of the manuscript. AAB and SMR conceived the project. AAB and VA wrote the initial draft and analysed the results. TJHB contributed to the design and discussion. CP provided statistical analysis. All authors read and approved the final version of the paper.

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Competing interests None.

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Data sharing statement There are no relevant unpublished data.

REFERENCES

1. Purdy S. *Avoiding Hospital Admissions. What Does the Research Evidence Say?* London, UK: Kings Fund, 2010.
2. Blunt I, Bardsley M, Dixon J. *Trends in Emergency Admissions in England 2004-2009: Is Greater Efficiency Breeding Inefficiency?* London, UK: Nuffield Trust, 2010.
3. Stephen G. Rising hospital admissions. *BMJ* 2010;340:636.
4. Holweg M. The genealogy of lean production. *J Oper Manag* 2007;25:420–37.
5. Boyle A, Fuld J, Ahmed V, *et al*. Does integrated emergency care reduce mortality and non-elective admissions? A retrospective analysis. *Emerg Med J* 2012;29:208–12.
6. Boyle AA, Robinson SM, Whitwell D, *et al*. Integrated hospital emergency care improves efficiency. *Emerg Med J* 2008;25:78–82.
7. Boyle A, Fuld J, Ahmed V, *et al*. Does integrated emergency care reduce mortality and non-elective admissions? A retrospective analysis. *Emerg Med J* 2012;29:208–12.
8. Palmer CR. Probability of recurrence of extreme data: an aid to decision-making. *Lancet* 1993;342:845–7.
9. Mohammed AM, Jonathan JD, Alan G, *et al*. Evidence of methodological bias in hospital standardised mortality ratios: retrospective database study of English hospitals. *BMJ* 2009;338:b780.
10. Alex B, Brian J, Paul A. Strengths and weaknesses of hospital standardised mortality ratios. *BMJ* 2011;342:c7116.
11. Snooks H, Cheung WY, Close J, *et al*. Support and Assessment for Fall Emergency Referrals (SAFER 1) trial protocol. Computerised on-scene decision support for emergency ambulance staff to assess and plan care for older people who have fallen: evaluation of costs and benefits using a pragmatic cluster randomised trial. *BMC Emerg Med* 2010;10:2.
12. Lynch RM, Greaves I. Regular attenders to the accident and emergency department. *J Accid Emerg Med* 2000;17:351–4.

13. Dale J, Lang H, Roberts JA, *et al*. Cost effectiveness of treating primary care patients in accident and emergency: a comparison between general practitioners, senior house officers, and registrars. *BMJ* 1996;312:1340–4.
14. Salisbury C, Hollinghurst S, Montgomery A, *et al*. The impact of co-located NHS walk-in centres on emergency departments. *Emerg Med J* 2007;24:265–9.
15. Jimenez S, de la RG, Miro O, *et al*. [Effect of the incorporation of a general practitioner on emergency department effectiveness] (In Spanish). *Med Clin (Barc)* 2005;125:132–7.
16. Gonnah R, Hegazi MO, Hmdy I, *et al*. Can a change in policy reduce emergency hospital admissions? Effect of admission avoidance team, guideline implementation and maximising the observation unit. *Emerg Med J* 2008;25:575–8.
17. Thornton V, Hazell W. Junior doctor strike model of care: reduced access block and predominant Fellow of the Australasian College for Emergency Medicine staffing improve emergency department performance. *Emerg Med Australas* 2008;20:425–30.
18. Sen A, Hill D, Menon D, *et al*. The impact of consultant delivered service in emergency medicine: the Wrexham Model. *Emerg Med J* 2012;29:366–71.
19. Dickson EW, Singh S, Cheung DS, *et al*. Application of lean manufacturing techniques in the Emergency Department. *J Emerg Med* 2009;37:177–82.
20. Holden RJ. Lean thinking in emergency departments: a critical review. *Ann Emerg Med* 2011;57:265–78.
21. Moskop JC, Sklar DP, Geiderman JM, *et al*. Emergency department crowding, part 2–barriers to reform and strategies to overcome them. *Ann Emerg Med* 2009;53:612–17.
22. Cooke MW, Wilson S, Pearson S. The effect of a separate stream for minor injuries on accident and emergency department waiting times. *Emerg Med J* 2002;19:28–30.
23. Castille K, Cooke M. One size does not fit all. View 2. *Emerg Med J* 2003;20:120–2.
24. Cooke MW, Higgins J, Kidd P. Use of emergency observation and assessment wards: a systematic literature review. *Emerg Med J* 2003;20:138–42.

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract X	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale X	2	Explain the scientific background and rationale for the investigation being reported
Objectives X	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design X	4	Present key elements of study design early in the paper
Setting X	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants X (However this is a longitudinal study, based on routine data, so this doesn't match well)	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables X (However, we have not reported confounding variables as analysis of these did not change our conclusions)	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement X	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias X	9	Describe any efforts to address potential sources of bias
Study size X	10	Explain how the study size was arrived at
Quantitative variables X	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods X (However, we have not reported confounding variables as analysis	12	(*a*) Describe all statistical methods, including those used to control for confounding

of these did not change our conclusions)	(*b*) Describe any methods used to examine subgroups and interactions
	(*c*) Explain how missing data were addressed
	(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy
	(*e*) Describe any sensitivity analyses

Continued on next page

Results		
Participants **X** (We have reported HSMRs and SARS instead as this is more meaningful)	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data This is not available	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data **X**	15*	*Cohort study*—Report numbers of outcome events or summary measures over time
		Case-control study—Report numbers in each exposure category, or summary measures of exposure
		Cross-sectional study—Report numbers of outcome events or summary measures
Main results **X**	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses (Not reported)	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations **X**	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation **X**	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability **X**	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding **X**	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.