

**Variations in Mortality Across the Week Following Emergency Admission to Hospital.  
Linked Retrospective Observational Analyses of Hospital Episode Data in England,  
2004/5 to 2013/14**

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## SCIENTIFIC SUMMARY

### *Background*

There are long-standing concerns that patients admitted to hospital outside of normal working hours, when staffing levels are lower and some services are not available, suffer higher complication and mortality rates than patients admitted at times when the hospital is fully operational. This phenomenon has become known as the 'weekend effect', because the seminal studies in this area concentrated on weekend admissions. This phenomenon relates specifically to the time at which patients are admitted to hospital, and there is no similar variation in the time at which patients die.

Whilst the weekend effect has been described internationally, it is of particular concern to the National Health Service (NHS), which was founded on fundamental principles of equity. The current UK government's long-term vision is of an NHS that eliminates discrimination and reduces inequalities in care. If patients' outcomes are strongly dependent on the time that they are admitted to hospital, and if time of presentation is partly socially determined, this has implications for equity across the service. Extending the hours for which the NHS is fully operational has the potential to improve access and outcomes for patients. However, extending fully operational hours could also decrease efficiency by raising input costs and providing services that are relatively under-utilised.

Although the weekend effect is well described it is poorly understood. Previous studies have been limited by the availability, completeness and content of routine admissions data, which has restricted investigations to day of admission and prevented direct measurement of severity of illness. It is therefore not clear whether the weekend effect extends to other out-of-hours periods, or how far excess mortality for out-of-hours admissions reflects a different presenting population with higher severity of illness, and how much is explained by poorer availability and quality of services. It is also not known if service changes could bring out-of-hours mortality rates down to levels comparable to daytime and weekday rates, and what the cost implications of such changes would be. The NHS therefore faces difficult decisions in how it should respond to its responsibility to provide health care 24 hours a day, 7 days a week ('24/7').

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### *Research aims*

We aimed to assess: (i) the costs and benefits of introducing seven day services; (ii) whether mortality rates are elevated during all out-of-hours periods; (iii) whether selection of more severely ill patients for admission out-of-hours explains elevated mortality rates; and (iv) whether mortality rates out-of-hours are related to staffing levels.

To address these aims, we conducted five linked studies addressing the following research questions:

1. What are the potential costs and benefits of introducing seven day services?
2. Does the 'weekend effect' extend to nights? Does it persist over time?
3. Do higher mortality rates for patients admitted to hospital out-of-hours reflect a lower probability of admission?
4. Are higher mortality rates for out-of-hours admissions explained by greater severity of illness?
5. What is the relationship between staffing levels and out-of-hours mortality?

### *Methodological approach - data*

We conducted a linked series of retrospective analyses of Hospital Episode Data in England, using both national data (Studies 1, 3 and 4) and data from a single acute NHS Trust, Salford Royal NHS Foundation Trust – SRFT (Studies 2 and 5).

### *National analysis*

For Study 1 we obtained data on all emergency admissions to hospital in England from HES between 1st April 2010 and 31st March 2011 linked to data from the ONS on all-cause mortality within 30 days of admission. For studies 3 and 4 we used individual patient-level data on A&E attendances and emergency admissions from HES between 1st April 2013 and 31st March 2014. To control for deprivation, we attached the Index of Multiple Deprivation (IMD) 2010 score to the attendance and admission records using the patient's Lower-Layer Super Output Area (LSOA) of residence.

### *Salford Royal NHS Foundation Trust analysis*

For SRFT we extracted records for emergency patients admitted between April 2004 and March 2014. Extracted records contained the hour and minute of admission, allowing us to

categorise admissions over nighttime and weekends accurately. For Study 2, we estimated the association between patient outcomes and the precisely defined out-of-hour admissions. For Study 5, we focused on the patients admitted to the Acute Stroke Unit (ASU).

#### *Methodological approach - analysis*

##### *National analysis*

For Study 1, we estimated the loss in patient health associated with the weekend effect for emergency admissions to all hospitals in England between 1st April 2010 and 31st March 2011. We calculated the number of quality-adjusted life years (QALYs) that could potentially be gained if the weekend effect were to be eradicated and these excess deaths were averted and calculated the maximum amount that the NHS should be prepared to spend on averting these deaths.

For Study 3, we separated patients by their route of admission to hospital: i) patients who access emergency services through A&E; and ii) patients admitted directly to hospital in an emergency. We estimated the risk-adjusted probability of dying within 30 days for the entire population of patients and for the subset selected for admission.

For Study 4, we used records for admitted patients with matching A&E records. We estimated how risk of mortality varied by time of arrival at A&E and by mode of arrival. We used logistic regression models to analyse differences in the probability of death within 30 days of admission across the 14 twelve-hour time of arrival periods and whether mortality was associated with the mode of arrival at A&E.

##### *Salford Royal NHS Foundation Trust analysis*

For Study 2, our primary outcome variable was mortality within 30 days of admission that occurred both in and out of hospital. We defined out-of-hour admissions as those admitted at weekends and public holidays, and compared their outcomes with admissions on weekdays. We fit probit models to estimate the extent to which the probability of death was associated with our exposure variable after controlling for observed patient characteristics.

For Study 5, we restricted our sample patients to those admitted to the Acute Stroke Unit (ASU) at SRFT as emergencies between January 2009 and July 2014. We broke down a

week into 14 periods, and compared the admission volume and the speed of initial treatment across these periods. We estimated a core model for the excess risk of death associated with out-of-hour periods of the week after adjusting for other risk factors of mortality.

### *Findings*

The key findings for each of the studies were:

#### Study 1: Costs and benefits of seven day services

- The estimated cost of implementing 7-day services nationally is £1.1 - 1.4 billion per year. This exceeds the maximum amount that NICE would recommend the NHS should spend on eradicating the observed weekend effect (£0.6 - 0.7 billion per year).
- There is as yet no evidence that: i) 7-day working can and will reduce the weekend effect; ii) that lower weekend mortality rates can be achieved without increasing weekday death rates; iii) that re-organising services to be fully operational over 7 days would be cost-effective.

#### Study 2: Persistence of the weekend effect and nighttime effects

- Mortality rates are elevated for patients admitted at night, and the highest risk of death is for patients admitted at night on weekends.
- In a case study hospital, the size of weekend and nighttime effects varied substantially over time. The effects were present in most years, but were not always statistically significant.

#### Study 3: Admission thresholds at weekends

- There is a higher threshold for emergency admission at weekends. Fewer patients are admitted, and on average they are likely to be sicker than patients admitted on weekdays.
- Higher mortality rates at weekends are found only amongst the subset of patients who are admitted to hospital.

#### Study 4: Severity of illness at weekends

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- Compared with weekday admissions, a higher proportion of patients admitted to hospital at night and on weekends arrive by ambulance.
- After accounting for arrival by ambulance, mortality rates are not elevated for patients admitted at nights and at weekends, with the exception of Sunday daytime.
- Elevated mortality rates for patients admitted at weekends and at night are likely to reflect higher average severity of illness.

#### Study 5: The impact of staffing levels

- After adjusting for the staffing level of nurses, weekend and nighttime effects for patients admitted with stroke to a case study hospital were substantially reduced.
- Having higher numbers of nurses on site immediately following admission is associated with increased patient survival in the first week, but not over longer periods. This effect is stronger for qualified nurses.

#### *Study limitations*

The studies are dependent on the accuracy and completeness of data recording by health care professionals and coders. If accuracy of recording is related to time of patient admission, then this will have biased our results.

We applied standard risk adjustment models in Studies 2-5. Some variables could be influenced by availability of diagnostic services, involvement of senior clinician in decision making, and other markers of clinical quality. There is therefore a risk that we over-adjusted, including what are effectively proxies for quality of care in our models.

For Studies 1, 2 and 5, reduced capacity out-of-hours might have led to the selection of a sicker patient population, and this might have explained the increased risk of mortality for out-of-hours of admissions. Results from Studies 3 and 4 suggest that this is likely to be the case, and that reported increased mortality out-of-hours is confounded by unmeasured severity of illness.

For Studies 1, 3 and 4 we were restricted by data availability to deaths that occur in hospital, and could not examine out of hospital deaths.

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Studies 2 and 5 were based on a single Trust, which is unlikely to be fully nationally representative in terms of patient population, local service provision, quality of clinical care, or accuracy of data recording. SRFT is a single site and the restricted volume of patients analyzed means that our analyses may lack sufficient power, particularly for the longitudinal analyses.

For Study 4, we utilized A&E records, which are less complete and accurate than inpatient records. However, we only used information on arrival time and mode of arrival from the A&E record, and no specific concerns about these variables have been raised. Nonetheless, arrival by ambulance is an imperfect proxy for severity of illness, and it is likely that there are further aspects of severity affecting the risk of mortality that remained unmeasured. In addition, if reduced availability of alternative transport results in less severely ill patients being more likely to use emergency ambulances out-of-hours, our results will be biased towards finding a reduction in out-of-hours mortality following adjustment for mode of arrival.

## *Conclusions and recommendations*

### *Overview*

We have found that the 'weekend effect' extends to nighttime periods, and it is therefore more appropriate to discuss an 'out-of-hours effect'. This effect was reduced for stroke patients in a large teaching hospital when more – and more experienced – nursing staff were present during the first hour of admission. Nationally, looking at all emergency admissions, we found that excess mortality out-of-hours was largely explained by a sicker population of patients being selected for admission. Higher than expected mortality remained only for admissions during Sunday daytime. We also found that the estimated cost of implementing 7-day services exceeds the maximum amount that NICE would recommend the NHS should spend on eradicating excess mortality at weekends.

### *Implications of the study*

The move towards 7-day services has begun with local implementation in Acute Trusts; hospitals are required to implement new clinical standards for 'seven day services', which include providing emergency admissions with a thorough clinical assessment by a suitable consultant within 14 hours of arrival and timely 24-hour access to consultant-directed

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interventions. These moves are being supported by other initiatives including longer nursing shifts, extended contracts for community pharmacies, and the opening of GP surgeries at evenings and weekends. The costs and benefits of these initiatives are largely unknown. Extending normal hours of operation could be cost-effective if it leads to improved access and better patient outcomes, particularly if these improvements benefit groups that are traditionally under-served and suffer worse health as a result.

However, improved patient outcomes are only likely to occur if higher mortality for out-of-hours admissions reflects restricted access to services or poorer quality of care. In this study, we have found that elevated mortality rates – considering all reasons for admission together – are largely explained by patient selection; fewer and sicker patients are admitted to hospitals out-of-hours, and these patients have a greater underlying risk of death. It is therefore unlikely that simply extending normal hours of operation will eliminate excess out-of-hours mortality. In addition, unless there is substantial investment in training and recruitment, increasing the level of clinician cover during the weekends will require a redistribution of the existing workforce, diverting cover away from weekdays. Diverting consultant cover away from weekdays towards weekends would be expected to affect the quality of services and outcomes for patients admitted during the week, and the introduction of seven day services might therefore narrow the gap between weekday and weekend mortality, but at the cost of higher weekday rates.

As with previous studies, we have focused on mortality related to the time of admission, as this is a critical period for patient care. Whilst we have found that mortality is not significantly increased for admissions during most out-of-hours periods once selection effects are accounted for, it is possible that risks are elevated for patients already in hospital who deteriorate or require a critical intervention during out-of-hours periods. It is also possible that outcomes other than mortality are worse for patients admitted out-of-hours.

In addressing variations in patient outcomes across the week, a more nuanced approach, extending services for key specialties over critical periods - rather than implementing whole-system changes - is likely to be the most cost-effective. Future research should aim to identify these candidate specialties and critical periods.

### *Future work*

Future research should aim to develop and use appropriate measures of severity of illness to facilitate meaningful analysis of variations in patient outcomes, and to identify candidate specialties and critical periods for which extending services is likely to be cost-effective.

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