

Abstract

Objective: Based on routine administrative data, patients admitted to hospitals over the weekend appear to have a higher risk of death compared to weekday admissions. Such data do not take the severity of sickness of a patient on admission into account. Our aim was to incorporate a standardised vital signs physiological based measure of sickness known as the National Early Warning Score (NEWS) to investigate if weekend admissions are: sicker as measured by their index NEWS; have an increased risk of death; and experience longer delays in the recording of their index NEWS.

Methods: Analysis of 47117 emergency adult medical admissions in four acute hospitals. Patient admissions were linked with electronic NEWS data where eNEWS recorded within 24 hours of admission. Weekend admissions were defined as occurring on/after midnight on Friday up to midnight on Sunday. We examined the association with in-hospital mortality using multilevel linear and logistic regression models.

Results: Emergency medical admissions at the weekend had higher index NEWS (weekend: 2.53 versus weekday: 2.30, $p < 0.001$) with a higher risk of death (weekend: 706/11332 6.23% versus weekday: 2039/35785 5.70%; Odds Ratio=1.10, 95%CI 1.01 to 1.20, $p = 0.04$) which was no longer seen after adjusting for the index NEWS (Odds Ratio=0.99, 95%CI 0.90 to 1.09, $p = 0.87$). The time to index NEWS was earlier (-0.45 hours, 95%CI -0.52 to -0.38, $p < 0.001$) for weekend admissions.

Conclusions: Emergency medical admissions at the weekend with electronic NEWS recorded within 24 hours are sicker, have earlier clinical assessments, and after adjusting for their illness severity do not appear to have a higher risk of death compared to weekday admissions. A larger definitive study to confirm these findings is needed.

Introduction

Patients admitted to hospitals over the weekend appear to have a higher risk of death than patients who are admitted on weekdays.^{1,2,3} This phenomenon, known as the 'weekend effect' has been observed in Canada,⁴ UK,^{5,6,7} USA⁸ and Australia,⁸ and both in planned and unplanned admissions. Two hypotheses¹ have been proposed based on there being fewer staff and services in hospitals over the weekend⁹. First, patients admitted at the weekend are sicker than their weekday counterparts. Second, the quality of care in hospitals over the weekend is worse due to lower staffing levels and less access to the support services.

Most studies of the 'weekend effect' have relied on analyses of routine administrative data.^{2,8} Although this yields large sample sizes, the clinical information is of variable quality, in particular providing little or no data on how sick patients are on admission. Recently, in England, NHS hospitals have been encouraged by the Royal College of Physicians (London), to standardise the assessment of severity when patients present to hospital as part of the process of care and recorded on a clinical observation chart.¹⁰ They recommend the use of an instrument based on seven variables, the National Early Warning Score(s) (NEWS): respiration rate, oxygen saturations, any supplemental oxygen, temperature, systolic blood pressure, heart rate and level of consciousness (Alert, Voice, Pain, Unresponsive). These are routinely collected by nursing staff, usually for all patients, and then repeated thereafter depending on local hospital protocols.¹⁰

The clinical rationale for NEWS is that early recognition of deterioration in the vital signs of a patient can provide opportunities for effective.¹¹ NEWS is known to be a good predictor of mortality in hospital though is not suitable for certain patient groups^{Error! Bookmark not defined.} such as those with end-stage renal failure, or patients with acute intracranial conditions, which are characterised by abnormal physiology, or may not be suitably calibrated, say in patients with chronic obstructive airways disease.¹² NEWS is now routinely available in most NHS hospitals, is integral to the clinical decision making process, is regularly updated and is clinically valid.

Our aims were to conduct an exploratory study to compare emergency medical admissions at the weekend with admissions on weekdays to determine if: weekend admissions have higher index NEWS; weekend admissions have a higher risk of death and if this risk is modified when the index NEWS is taken into account; and weekend admissions experience longer delays in the recording of their index NEWS.

Methods

Setting

The study was conducted in four acute hospitals in the Yorkshire & Humberside region of England: Diana, Princess of Wales Hospital; Scunthorpe General Hospital; Scarborough Hospital; and York Hospital. The hospitals have approximately 400, 400, 330 and 700 beds respectively and have been using electronic NEWS (eNEWS) scoring since at least 2013 as part of their in-house electronic patient record systems.

Sample and data

We considered all adult (age \geq 16 years) emergency medical admissions, discharged during 2014. For each admission, we obtained a pseudonymised patient identifier, patient's age, sex (male/female), discharge status (alive/dead), admission and discharge date and time, and eNEWS. We excluded records where eNEWS was missing or recorded outside ± 24 hours of the admission time because such scores are less likely to reflect the presenting sickness profile of acutely ill patients.

Patients' eNEWS ranged from 0 (lowest severity of illness) to 18 (the maximum value is 20). Weekend admissions were defined as occurring on/after midnight on Friday up to midnight on Sunday, and the index eNEWS was defined as the first score recorded within ± 24 hours of the admission time. We did not consider children and elective admissions because such analyses are likely to be underpowered because of the low mortality in these subgroups, and NEWS is not recommended for children.¹⁰

Statistical analyses

We used multilevel linear and logistic regression models according to whether the response variable was continuous or binary with hospital as a random intercept term which allows for clustering of patients within hospitals. We commenced with models with a single binary weekend (yes/no) covariate to estimate the crude (unadjusted) risk of death for weekday admissions versus weekend admissions. We then added additional covariates (index eNEWS, age, sex and calendar month) on the basis of their clinical justification (not statistical criteria) to produce adjusted estimates of the 'weekend effect'. For the logistic regression models, we report the effect sizes in terms of Odds Ratios (OR). Statistical significance was set at $p < 0.05$. Our results focus on size of the 'weekend effect' reported from model coefficients with 95% Confidence Intervals (95%CI).

The first set of models was used to determine the crude and adjusted ORs of in-hospital death following emergency medical admission to hospital over the weekend versus the weekday admissions. We used a series of multilevel logistic regression models, with died in hospital (yes/no) as the response variable. The preliminary model was a crude (unadjusted) model with weekend as the only covariate. A subsequent model included index eNEWS as an additional continuous covariate. The final model included age (years), sex, admission month and index eNEWS as additional covariates.

A second set of multilevel linear regression models was used to investigate the extent to which admissions over the weekend were sicker than those over the weekdays. We used the index (on-admission) eNEWS as the response variable with age, sex, died, admission month and weekend as covariates in a linear regression model.

A third set of multilevel linear regression models was used to investigate the extent to which emergency medical admissions over the weekend had delayed the index eNEWS recorded. The time interval (hours) from admission date-time to date-time of the index eNEWS was calculated. A negative value was legitimate because the index eNEWS can occur (for example in the Accident & Emergency department) before formal admission to hospital. The time to index eNEWS (hours) was the response variable with age, sex, died and weekend as covariates in a linear regression model.

All analyses were carried out using R (for pre-processing and graphics)¹³ and STATA (for statistical modelling).¹⁴

Results

Cohort description

There were 48774 emergency admissions across the four hospitals during the period. We excluded 1005 (2.1%) of admissions because they did not have any eNEWS recorded and a further 652 (1.3%) admissions because the index eNEWS was not recorded within ± 24 hours of the admission time. Emergency admissions with no eNEWS had a 18.1% (182/1005) mortality and those where the index eNEWS was not recorded within ± 24 hours of admission had a 8.3% (54/652) mortality. The proportion of admissions with missing eNEWS was lower at weekends (1.6%) than on weekdays (2.2%). The crude mortality for admissions with missing eNEWS at weekends was 27.5% compared with 15.0% on weekdays. After excluding those with no eNEWS data, we analysed 47117 emergency admissions with a mortality of 5.8% (2745). The deaths in the excluded subgroups accounted for 7.9% (236/2981) of all deaths.

Figure 1 shows the relationship between index eNEWS and in-hospital mortality on weekends versus weekdays in emergency medical admissions, which shows that mortality increases with higher index eNEWS.

Table 1 shows the profile of the emergency medical admissions comparing weekday and weekend admissions. Weekend admissions were older (0.77 years older, $p < 0.001$), had higher index eNEWS (0.23 points higher; 0.41 points higher for deceased patients) and had their index eNEWS recorded more promptly (0.49 hours earlier) than weekday admissions.

Risk of in-hospital death

The crude (unadjusted) pooled odds ratio (OR) following weekend admission (Table 2) was 10% higher than weekday admissions. Adjustment for index eNEWS reduced the OR such that there was no longer an increased risk for weekend admissions (OR=0.99). Further adjustment by age, sex and admission month reduced the OR to 0.97.

Severity of index eNEWS

Emergency medical admissions over the weekend had higher adjusted (Table 2) index eNEWS than weekday admissions in all hospitals. The adjusted effect size was 0.22 points higher which equates to a standardised difference of 0.09 ($0.22/2.43$, where 2.43 is the standard deviation).

Time to recording of index eNEWS

Emergency medical admissions at the weekend had their index eNEWS recorded more promptly than weekday admissions (Table 2). The adjusted effect size was 0.45 hours earlier.

Discussion

Main findings

Patients admitted as medical emergencies over the weekend are sicker than those who are admitted on weekdays and are not at increased risk of in-hospital mortality once that level of sickness using their index eNEWS recorded within ± 24 hours of admission is taken into account. The index eNEWS was recorded about 30 minutes sooner at the weekend compared with on weekdays. This is surprising given the lower staffing levels on weekends and important because the principal concern around the 'weekend effect' is the extent to which it results in clinically avoidable deaths (and a principal cause of clinically avoidable deaths is poor clinical monitoring).

Our findings are based on the analysis of eNEWS which is a predictor of hospital mortality and is a key component of interventions to detect patient deterioration. Previous studies have shown that failure to respond to deterioration due to poor monitoring and inadequate responses are an important cause of avoidable deaths **Error! Bookmark not defined.**

Our study involves emergency medical admissions in four hospitals (teaching/non-teaching, smaller/larger, coastal/city, deprived/affluent, with local escalation policies for NEWS) with electronic NEWS which simultaneously enables us to consider the severity of illness on admission, albeit with limited evidence of reliability and validity,¹¹ as well as the monitoring of vital signs of patients. Our indicator of sickness, eNEWS, is derived from six vital signs routinely collected as part of the process of care which provides some insight into the quality of monitoring vital signs because eNEWS is date-time stamped. Nonetheless our study does not report on the other aspects of the quality of care, which have been found to vary over weekends¹ and other problems (eg diagnostic errors, inadequate drug or management) seen with clinically avoidable deaths **Error! Bookmark not defined.** Indeed, the index eNEWS may also be confounded by care in the emergency department, such that suboptimal initial care at weekends may lead to a higher index eNEWS. Thus, causality could be reversed – poor initial care at weekends leads to higher index eNEWS at weekends. Whilst this is possible, it is unlikely because we found that the time to index eNEWS is earlier on the weekends versus the weekdays.

A key challenge with the use of routine data is to determine its quality and reliability. Whilst there is published evidence to show electronic NEWS is superior to pen and paper NEWS^{16,17} the integrity of the data in routine settings is more difficult to determine. However, unlike administrative data, NEWS is integral to the process of care and clinical decision making. This provides a higher degree of assurance because eNEWS is continually exposed to human and electronic validation¹⁸ and is also supported by regular internal audits in our hospitals. We are not able to determine the subsequent clinical response to NEWS and how this differed at weekends versus weekdays.

Limitations of the study

There were four limitations to this study. First, our study is based on only four hospitals, so the extent to which these exploratory findings are generalisable to other hospitals is unclear. Second, we excluded 3.4% of emergency medical admissions that did not have eNEWS recorded at all or within ± 24 hours of admission. These admissions experienced a mortality of 7.9% of deaths. This will have included patients in which eNEWS is not recommended, such as those requiring immediate resuscitation, direct admission to intensive care, patients with end-stage renal failure or with acute intracranial conditions.¹¹ Indeed, the higher mortality (18.1% and 8.3% vs 5.8%) seen in the excluded

subgroups does suggest that they are at higher risk. Third, our study was not sufficiently powered to find an adjusted ‘weekend effect’ as the results do not exclude an odds ratio of 1.1 for an increased mortality at weekends. And fourth, we considered in-hospital mortality which is confounded by the length of stay, whereas 30-day mortality would overcome this, and likewise we did not consider patients who died on arrival to hospital before being admitted.

Results in relation to other studies

The ‘weekend effect’ has been explored in over 100 studies¹ and in most cases this has been undertaken using administrative data. An exception is a single hospital study which also reported that patients are sicker on the weekend and that once illness severity using biochemical markers were included in the model, the ‘weekend effect’ disappeared.¹⁶ Likewise, a recent study found no difference in mortality following stroke when based on a clinical database¹⁷ whereas a previous study using administrative data reported a 26% higher death rate for weekend admissions.¹⁹ Another recent study found circumstantial evidence of a selection effect whereby the threshold used to admit at the weekends is higher than during the weekdays.²⁰ Our study also found that patients admitted at weekends are sicker.

Administrative data do not include the physiological variables used in the NEWS,²¹ likewise, the NEWS does not include the diagnoses and comorbidity labels reported in administrative data. Indeed, as some diagnostic subgroups (eg brain injury) are not appropriately assessed using the NEWS, we cannot extrapolate our findings to these subgroups. Nevertheless, O’Sullivan et al found that including comorbidity did not improve the accuracy of a laboratory data model to predict mortality in emergency admissions²² suggesting that the omission of comorbidity in our approach may not be a major limitation, although further work is warranted.

Furthermore, whilst previous studies which have examined the quality of care have found longer delays and higher error rates²³⁻²⁶ we found no evidence of delays in respect of monitoring patients using eNEWS.

Implications for clinicians or policymakers

The notion that there is a generic ‘weekend effect’ that applies to all hospitals may be overly simplistic. The ‘weekend effect’ is a complex phenomenon^{1,3} requiring further study to understand the underlying mechanisms and inform our efforts to improve safety for patients. Our results provide evidence against the ‘weekend effect’ and so do not support calls for changes in hospital working practices based on higher weekend mortality. However, if patients are indeed sicker at the

weekend, this may suggest the need for greater resources at the weekend, although we found that they have earlier, not later, clinical assessments under the current staffing model.

Implications for research

There is a need for a definitive study to investigate the 'weekend effect' using a physiological measure to adjust for illness severity to confirm that studies based on routine administrative data have exaggerated the 'weekend effect' because of inadequate risk adjustment. A recent study by Anselmi et al found that after adjusting for arrival to hospital by ambulance (used as a marker for illness severity) there was no increased risk of death following admission at night or any period of the weekend apart from Sunday daytime, suggesting that risk adjustment using inpatient administrative data does not adequately account for illness severity.²⁷

We also need to determine why emergency admissions are sicker at the weekend. The combined use of data sources, such as routine blood test results as well as administrative and staffing data²⁸ may allow analyses of specific disease groups using physiological data. Patients who do not get eNEWS also merit study as they are a group with higher mortality rates if they are admitted over the weekend as compared with weekdays. Finally, future studies could consider eNEWS over time along with other health outcomes such as length of stay, escalation to critical outreach and admission to intensive care.

References - **[Note to Authors: ensure references are correct]**

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Characteristic	Weekday	Weekend	p-value	Weekend Effect [†] (95%CI)
Number of admissions (%)	35785 (75.95)	11332 (24.05)	-	-
Sex (male) (%)	17387 (48.59)	5407 (47.71)	0.099	Odds Ratio 0.97 (0.93 to 1.00)
Mean Age (years) (SD)	67.57 (19.17)	68.32 (19.49)	<0.001	0.77 (0.36 to 1.18)
Mean Index eNEWS (SD)	2.30 (2.40)	2.53 (2.56)	<0.001	0.23 (0.18 to 0.28)
Mean time interval [‡] (hours) to index eNEWS (SD)	0.22 (3.79)	-0.26 (3.55)	<0.001	-0.49 (-0.57 to -0.42)
Mean Length of Stay (days) (SD)	7.54 (11.55)	7.34 (11.61)	0.117	-0.20 (-0.44 to 0.05)
Died (%)	2039 (5.70)	706 (6.23)	0.035	Odds Ratio 1.10 (1.01 to 1.20)
Mean Index eNEWS (SD) deceased patients	4.83 (3.48)	5.27 (3.53)	0.006	0.41 (0.12 to 0.71)

Table 1 Characteristics of weekend versus weekday emergency admissions

[†]P-values and estimates (95%CI) of effect are from a weekend term in a linear (for continuous variables) or logistic (for binary variables) regression model whereas a hospital term as a random effect. [‡]: negative time interval indicates that index eNEWS was recorded before the administrative date and time of admission.

Weekend Effect	Odds Ratio or Effect Size (95%CI)
Crude (unadjusted) Odds Ratio for death following weekend admission	1.10 (1.01 to 1.20) p=0.035
Odds Ratio for death following weekend admission adjusted for index eNEWS only	0.99 (0.90 to 1.09) p=0.867
Odds Ratio for death following weekend admission adjusted for age, sex, admission month and index eNEWS	0.97 (0.88 to 1.07) p=0.541
Effect Size for Index eNEWS for weekend admission adjusted for age, sex, and admission month	0.22 (0.17 to 0.27) P<0.001
Effect Size for Time (hours) to index eNEWS for weekend admission adjusted for age, sex, admission month and index eNEWS	-0.45 (-0.52 to -0.38) P<0.001

Table 2 Odds ratios or effect sizes (95%CI, p-values) for mortality comparing weekend versus weekday emergency admissions. Effect sizes are absolute differences.

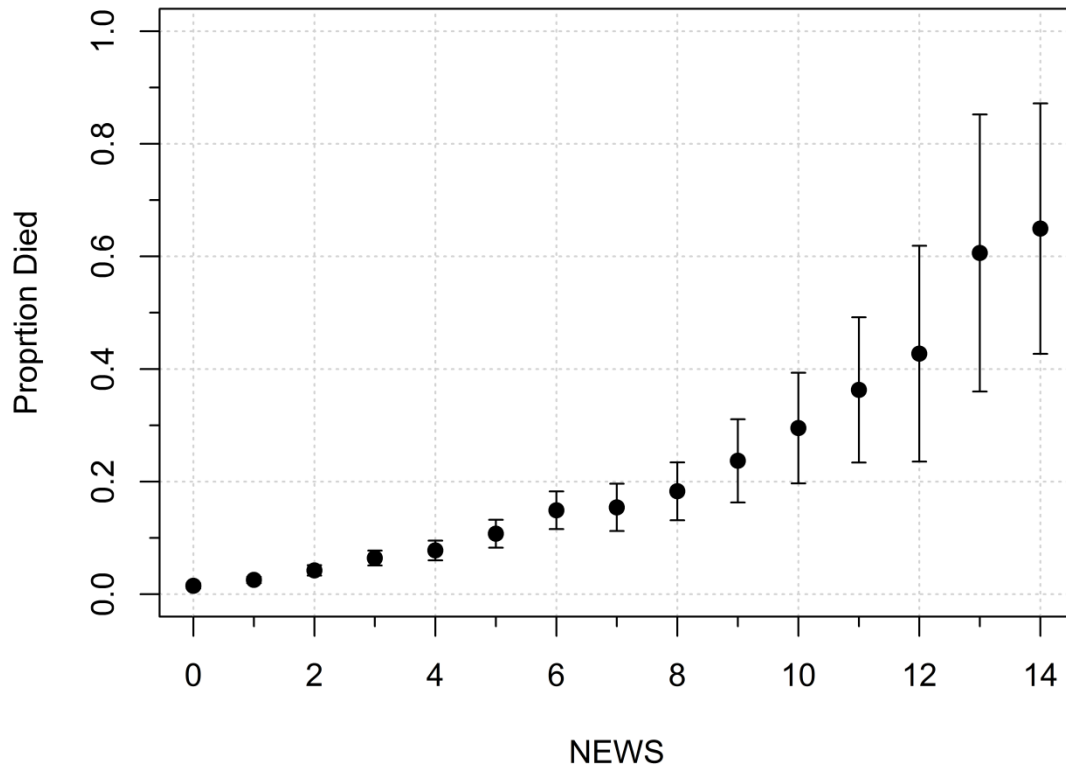


Figure 1: Observed in-hospital mortality versus index electronic NEWS. Vertical bars are exact 95% confidence intervals.

Note: for visualisation purposes, we capped eNEWS to 14.