Paediatric outcomes and timing of admission

Louise Ramsden, 1 Martin Patrick McColgan, 2 Thomas Rosser, 3,4 Anne Greenough, 2,3,4,5 Simon J Clark1,2

ABSTRACT
Studies of adult patients have demonstrated that weekend admissions compared with weekday admissions had a significantly higher hospital mortality rate. We have reviewed the literature to determine if the timing of admission, for example, weekend or weekday, influenced mortality and morbidity in children. Seventeen studies reported the effect of timing of admission on mortality, and only four studies demonstrated an increase in those admitted at the weekend. Meta-analysis of the results of 15 of the studies demonstrated there was no significant weekend effect. There was, however, considerable heterogeneity in the studies. There were two large UK studies: one reported an increased mortality only for planned weekend admissions likely explained by planned admissions for complex conditions and the other showed no significant weekend effect. Two studies, one of which was large (n=2913), reported more surgical complications in infants undergoing weekend oesophageal atresia and tracheo-oesophageal repair. Medication errors have also been reported to be more common at weekends. Five studies reported the effect of length of stay, meta-analysis demonstrated a significantly increased length of stay following a weekend admission, the mean difference was approximately 1 day. Those data, however, should be interpreted with the caveat that there was no adjustment in all of the studies for differences in disease severity. We conclude that weekend admission overall does not increase mortality but may be associated with a longer length of stay and, in certain conditions, with greater morbidity.

INTRODUCTION
In 2001, it was reported that weekend admissions when compared with weekday admissions of 3789917 adults and children admitted through an emergency department to an acute care hospital in Canada had a significantly higher inhospital mortality rate if they had a ruptured abdominal aortic aneurysm, acute epiglottis or pulmonary embolism. The differences persisted for all diagnoses after adjustment for age, sex and coexisting disorders. A subsequent retrospective analysis of deaths of all 14217640 admissions to the English National Health Service during the financial year 2009/2010 demonstrated that 30-day mortality was increased in those admitted on weekend, although the likelihood of death occurring was less on a weekend than on a midweek day. More recently, an analysis of deaths of 503938 unselected emergency admissions to four UK hospitals was undertaken. Deaths within 30 days of admission occurred in 18313 (4.7%) patients admitted on a weekday and 6070 (5.1%) patients admitted on a weekend (P<0.001). Adjustment for routine haematology and biochemistry tests substantially reduced the excess mortality associated with emergency admissions at weekends and public holidays. No hospital workload measure was independently associated with mortality. Adjustment for patient level factors was not available in the study, but it was postulated that such an adjustment might have further reduced the residual excess mortality, as this was clustered around midday at weekends.

The infant mortality rate in England and Wales is 3.6 per 1000 live births and the child mortality rate is 1 per 1000, both are much lower than the adult mortality rate. Nevertheless, it is important to assess whether there is a weekend effect on mortality and other adverse outcomes in paediatric populations. We, therefore, have reviewed the literature to identify if there were significant differences according to admission at the weekend or weekdays regarding mortality, procedure complications, length and cost of hospital stay, medication errors and unplanned readmission rates. These are important questions to address as the results may have implications for redirection of health services resources to reduce adverse outcomes.

Mortality
Seventeen studies have reported the effect of timing of admission on mortality. Only four of the studies demonstrated an increased mortality in those at the weekend. One study showed among 234192 admissions to paediatric intensive care unit (PICU) in the USA, despite off hours admissions having higher acuity, after adjustment such admissions had a significantly lower odds of mortality (OR 0.91, 95% CI 0.86 to 0.95). Similarly, examination of 4456 emergency admissions to a PICU in an Australian hospital demonstrated that the risk-adjusted mortality was lower in after-hours (OR 0.712, 95% CI 0.518 to 0.980). Inhours were 08:00–18:00 on Monday–Friday and 08:00 to 12:00 on Saturday and Sunday, while after-hours were all other times. Meta-analysis was undertaken of the results of 15 of the studies (see online supplement for information regarding the analysis). This demonstrated a significant increased risk of mortality at the weekend (typical relative risk (RR) 1.37 (95% CI 1.07 to 1.76)) (figure 1), but the effect was no longer significant once adjusted data were analysed (figure 2). Importantly, however, different adjustments were used in the various studies, and there was considerable heterogeneity between the studies (table 1). This included the comparator time periods during the week, for

example, the length of the weekend varied from 19:00 on Friday to 07:00 on Monday compared with Saturday 12:00 to Sunday 24:00. Others compared out of hours with regular hours, which were 07:00–19:00 on weekdays; another definition of out of hours was nights, weekends and public holidays. This may have influenced the results as, for example, in one study of 20 547 PICU admissions, although there was no weekend effect on mortality, there was an excess of mortality in children admitted during the evening compared with during daytime hours.6 This was not confirmed in another study, but it was much smaller (n=210).7

Of those that showed a significant adverse weekend effect, one assessed 19 386 children aged 1–18 years of age in the USA who were admitted with ischaemic or haemorrhagic stroke.5 A limitation of the study was that it relied on the correct coding of the diagnoses in the database.5 Another examined the outcome of 12 893 children older than or equal to 90 days admitted to a rural hospital in Kenya. Although deaths within 4 hours and 4–48 hours of admission were significantly higher at the weekend, deaths beyond 48 hours were not.9 A further study examined 439 457 patients less than 18 years of age who required surgery on the same day of admission. After adjusting for confounding variables at the weekend, the OR for the risk of death was 1.63 (95% CI 1.21 to 2.2).12 Two large studies reported UK findings. In one,17 a nationwide paediatric intensive care audit was undertaken of 86 000 admissions. Nearly half (47.1%) of the admissions were out of hours and 79.2% of those were emergency admissions. The risk adjusted mortality for planned admissions was OR 1.99 (1.67 to 2.37), but there was no significant risk for emergency admissions (OR 0.93, 95% CI 0.86 to 1.01). The overall raised mortality for out of hours admissions was suggested by the authors to be accounted for by planned admissions following complex operations.17 In the other large UK-based study, 19 729 patients were included with 12 697 being under 15 years of age. The case-related fatality rates following admission for meningococcal disease were reported.11 No significant differences were reported between weekend and weekday admissions and, after undertaking sensitivity analyses and analysing multivariate models, the lack of a weekend effect remained.
### Table 1: Studies assessing paediatric outcomes and timing of admission

<table>
<thead>
<tr>
<th>Study group</th>
<th>Study type</th>
<th>Outcome</th>
<th>Exposure</th>
<th>Key result</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adil et al</td>
<td>Retrospective cohort</td>
<td>Mortality</td>
<td>Weekend or weekday admission</td>
<td>Ischaemic stroke Children admitted at weekends had a higher rate of discharge to nursing facilities (vs home) (OR 1.5 (95% CI 1.1 to 1.9), P=0.006). Haemorrhagic stroke</td>
<td>Limited by reliance on correct coding of diagnoses within NIS database and under reporting of comorbidities. Adjustment was made for age, sex and confounding factors significant (P&lt;0.05) in univariate analysis.</td>
</tr>
<tr>
<td>Goldacre et al</td>
<td>Retrospective cohort</td>
<td>Mortality</td>
<td>Daytime (08:00–17:00) or evening (17:00–08:00)</td>
<td>No significant difference in mortality rates between weekend and weekday admission regarding severity of illness.</td>
<td>Used PRISM scoring as method for adjusting for illness severity.</td>
</tr>
<tr>
<td>Attenello et al</td>
<td>Retrospective cohort</td>
<td>Mortality</td>
<td>Weekend or weekday admission</td>
<td>Weekend admission was not associated with increased mortality (P=0.46)</td>
<td>Multivariate analysis to account for confounding factors that included time to shunt insertion.</td>
</tr>
<tr>
<td>Desai et al</td>
<td>Retrospective cohort</td>
<td>Mortality</td>
<td>Daytime (08:00–17:00) or evening (17:00–08:00)</td>
<td>No significant differences in complications between groups.</td>
<td>Accounted for baseline health status using anaesthetic scoring system (ASA).</td>
</tr>
<tr>
<td>Goldstein et al</td>
<td>Retrospective cohort</td>
<td>Mortality</td>
<td>Daytime (08:00–17:00) or evening (17:00–08:00)</td>
<td>Combined morbidity and mortality at nights and weekends</td>
<td>Looked at level of ICD9 codes associated with each patient as a way of assessing comorbidities. Adjusted for age, gender, race, insurance status, comorbid diagnoses, geographical region, type of hospital, admission type and surgical procedure.</td>
</tr>
<tr>
<td>Gonzalez et al</td>
<td>Retrospective cohort</td>
<td>Mortality</td>
<td>Daytime (08:00–17:00) or evening (17:00–08:00)</td>
<td>The overall complication rate was lower in off-hours group (45.7% versus 61.9% P=0.034)</td>
<td>The most common indication for ECMO were congenital diaphragmatic hernia (CDH) and persistent pulmonary haemorrhage (23%).</td>
</tr>
</tbody>
</table>

### Additional Notes
- **Arias et al (2018)**: Children admitted at weekends had a higher rate of discharge to nursing facilities (vs home) (OR 1.5 (95% CI 1.1 to 1.9), P=0.006). Haemorrhagic stroke mortality was higher in children admitted at weekends (OR 1.4 (95% CI 1.1 to 1.9), P=0.04). LOS and charges were also higher in both groups in children admitted at the weekend.
- **Goldacre et al (2017)**: Used PRISM scoring as method for adjusting for illness severity.
- **Attenello et al (2019)**: Used PIM2 scoring as a way of adjusting for illness severity.
- **Desai et al (2019)**: Created their own prognostic indicator score and used this to adjust for illness severity.
- **Goldstein et al (2019)**: Adjusted for sex, age, year of admission, IMD score and day of the week of admission.
- **Gonzalez et al (2019)**: Looked at level of ICD9 codes associated with each patient as a way of assessing comorbidities. Adjusted for age, gender, race, insurance status, comorbid diagnoses, geographical region, type of hospital, admission type and surgical procedure.
### Table 1 Continued

<table>
<thead>
<tr>
<th>Study group</th>
<th>Study type</th>
<th>Outcome</th>
<th>Exposure</th>
<th>Key result</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goodman et al</td>
<td>Retrospective cohort</td>
<td>Mortality during primary admission</td>
<td>Weekend or weekday admission</td>
<td>Weekend mortality rate (OR 1.0 (95% CI 0.8 to 1.6))</td>
<td>If admitted at weekend: admission duration: 1.4 days longer (95% CI 0.7 to 2.1), time to chemotherapy initiation: 0.36 day longer (95% CI 0.3 to 0.5) and risk of respiratory failure: OR 1.5 (95% CI 1.2 to 1.7)</td>
</tr>
<tr>
<td>Hixon et al</td>
<td>Prospective cohort</td>
<td>Mortality prior to discharge from hospital</td>
<td>Weekend or weekday admission or discharge during the day</td>
<td>Following adjustment for confounding variables, there was no significant difference in death rate at weekends or in the evenings: weekend: P=0.146 evening: P=0.711</td>
<td>Used PRISM3 to assess for illness severity.</td>
</tr>
<tr>
<td>McGry et al</td>
<td>Retrospective cohort</td>
<td>Mortality during PICU admission</td>
<td>Inhours (07:00–18:59 Monday–Friday) or off-hours (19:00–07:00 Saturday/Sunday anytime)</td>
<td>Weekend death (OR 1.01 (95% CI 0.94 to 1.09), P=0.79) Night death (OR 0.86 (95% CI 0.81 to 0.92), P=0.0001) Risk of death between hours 06:00 and 11:00 OR 1.27 (95% CI 1.26 to 1.39), P=0.0001</td>
<td>Used PRISM scoring as a way of assessing severity of illness. Data adjusted for confounders including illness severity. No evidence of increased out of hours mortality.</td>
</tr>
<tr>
<td>McShane et al</td>
<td>Retrospective cohort</td>
<td>Mortality before discharge from PICU</td>
<td>Out-of-hours (nights, weekends and public holidays) or in-hours admission</td>
<td>47.1% of admissions were out of hours, with 79.2% being emergency admissions. Risk-adjusted mortality for planned admissions was higher in out-of-hours (OR 1.99 (95% CI 1.67 to 2.37), P&lt;0.0001) but not for emergency admissions (OR 0.93 (95% CI 0.86 to 1.01), P=0.07)</td>
<td>Adjustment PIM, year of admission, sex ethnicity, age group and diagnostic group</td>
</tr>
<tr>
<td>Numa et al</td>
<td>Prospective cohort</td>
<td>PICU mortality</td>
<td>Inhours (08:00–18:00 Monday–Friday) or off-hours (08:00–12:00 Saturday–Sunday) or after-hours (all other times)</td>
<td>Following adjustment for illness severity. After-hours risk of death (OR 0.712 (95% CI 0.518 to 0.980), P=0.037) Shorter median length of stay for after-hours versus in-hours admissions.</td>
<td>Used paediatric index of mortality (PIM) scoring to adjust for illness severity.</td>
</tr>
<tr>
<td>Nwosu et al</td>
<td>Retrospective cohort</td>
<td>Mortality</td>
<td>Weekend or weekday</td>
<td>Weekend deaths less in SCBU (ratio 0.88), paediatric ward (ratio 0.88) and children’s ED (ratio 0.87). The labour ward had significantly higher weekend to weekday death rates of 1.72:1.</td>
<td>Ages ranged from a few hours to 94 years</td>
</tr>
<tr>
<td>Pettes et al</td>
<td>Prospective cohort</td>
<td>PICU mortality</td>
<td>Office hours (08:00–18:00 Monday–Friday) or off-hours (18:00–08:00 Monday–Friday and all weekends and bank holidays)</td>
<td>66% patients admitted during of-hours. Adjusting for severity of illness, there was no significant effect of off-hours admission on mortality. Risk-adjusted mortality for planned admissions was higher in out-of-hours (OR 1.99 (95% CI 1.67 to 2.37), P&lt;0.0001) but not for emergency admissions (OR 0.93 (95% CI 0.86 to 1.01), P=0.07)</td>
<td>Used PIM1 and PRISM2 scoring systems to adjust for severity of illness.</td>
</tr>
<tr>
<td>Sayant et al</td>
<td>Retrospective cohort</td>
<td>Hospital mortality</td>
<td>Weekends or weekday procedure</td>
<td>Weekend versus weekday surgical procedure had no significant effect on mortality or resource utilisation (P=0.05). Surgical complication rates were higher in those undergoing a weekend procedure (OR 2.2 (95% CI 1.01 to 4.8), P=0.048).</td>
<td>Additional adjustment for morbidity and risk factors.</td>
</tr>
<tr>
<td>Auger et al</td>
<td>Retrospective cohort</td>
<td>Unplanned readmission within 30 days of discharge</td>
<td>Weekends or weekday procedure for admission or discharge</td>
<td>Weekend readmission had significantly higher odds of unplanned readmission (OR=1.09 (95% CI 1.004 to 1.18), P&lt;0.05). Being discharged on the weekend was not associated with unplanned readmission (OR=0.97 (95% CI 0.931 to 1.033)).</td>
<td>ICD9 codes used to identify children with chronic complex conditions.</td>
</tr>
<tr>
<td>Yeung et al</td>
<td>Retrospective cohort</td>
<td>Morbidity</td>
<td>Inhours (08:00–15:30 Monday–Friday) or after-hours (remaining time period including weekends and bank holidays)</td>
<td>Significant increase in oesophageal leaks in after-hours group (P=0.014). Postoperative ventilation time significantly longer in after-hours group (16.1 days vs 9.3 days), P=0.001. No significant difference in mortality.</td>
<td>Small sample size.</td>
</tr>
<tr>
<td>Miller et al</td>
<td>Retrospective cohort</td>
<td>Medication dispensing errors (pharmacy and nursing)</td>
<td>Day or night or weekday (Monday 07:00–Friday 18:59) or weekend</td>
<td>Weekday day nursing shift 1.17 errors/1000 doses versus weekend 2.55 errors/1000 doses (P&lt;0.0004) or versus night 2.12 errors/1000 doses dispensed (P=0.005). No significant association between time and severity of the error.</td>
<td>Administration errors were most common.</td>
</tr>
</tbody>
</table>
Complication rates

A number of studies have assessed whether complications were increased at the weekend. The complications included increased unplanned readmission rates, increased complication rates, treatment delay and increased medication errors.

In a study of 53,383 children in the USA (newborns and children who died were excluded), weekend admission was associated with a significantly higher odds of an unplanned readmission in 30 days, but weekend discharge was not associated with a significantly higher unplanned readmission rate.

There appears to be a weekend effect regarding certain procedural complications. In a retrospective cohort of 580 patients less than 18 years of age undergoing 710 urgent or emergency neurosurgical procedures in a Texas Children’s Hospital, there was a significant excess of surgical complications at weekends and weekdays after-hours.

In a small study of 28 patients undergoing oesophageal atresia and trachea-oesophageal repair, there were significantly more oesophageal leaks in those admitted after-hours and this was associated with a longer postoperative length of ventilation (16.1 vs 9.3 days).

Those findings were confirmed in a larger cohort (n=861) of infants less than 8 days of age undergoing oesophageal atresia and trachea-oesophageal repair identified from the USA Kid’s Inpatient Database. A greater rate of surgical complications were reported in those undergoing a weekend procedure (OR 2.2, 95% CI 1.01 to 4.8).

In a study of 439,457 children less than 18 years of age in the USA who required surgery on the day of admission, there was an increase in procedural complications and receipt of blood transfusions despite similar intraoperative haemorrhage at the weekend. In contrast, the overall complication rate was lower out of hours in 176 children requiring extracorporeal membrane oxygenation in a tertiary centre.

Weekend admission was not associated with a significant excess of mortality among 12,043 children with newly diagnosed acute lymphocytic leukaemia or acute myeloid leukaemia, but the length of admission was on average 1.4 days longer and the time to start chemotherapy was 0.3 days later (both differences were statistically significantly).

In addition, children had an increased risk of respiratory failure if admitted at the weekend (OR 1.5, 95% CI 1.2 to 1.7). In a report of 140 medication errors occurring in a tertiary paediatric hospital, the rate of errors per 1000 doses were significantly higher on weekend compared with week days (2.25 vs 1.17, P=0.004).

Length of stay

Five studies have reported the effect of timing of admission on length of stay.

A number of studies reported an increased length of stay in those admitted at the weekend, but it is important to appreciate that this was not the case in all studies, and the populations assessed in the various studies were very heterogeneous. In 23,332 children aged less than 2 years admitted with a diagnosis of failure to thrive to USA hospitals, weekend admission was significantly correlated with increased length of stay. The average increase in the length of stay of 1.93 days and was associated with an increase in the cost of care.

Among 10,042 patients admitted to a ward in a children’s hospital in Poland that treated haematology-oncology, diabetic and nephrology patients, after controlling for clinical factors, weekend admission was associated with a longer duration of hospital stay by an average 1.86 days.

In contrast, in 549 patients undergoing a planned Norwood procedure with a diagnosis of hypoplastic left heart syndrome or other single right ventricle anomalies in a children’s hospital in Chicago, after adjusting for known risk factors for poor outcomes, there was no significant effect on length of stay with a weekend admission.
stay, length of PICU stay, duration of ventilation or mortality. Moreover, another study of PICU patients demonstrated that among 4456 emergency PICU admissions of children less than 14 years of age, after using paediatric index of mortality (PIM) scoring to adjust for illness severity, the median length of stay was shorter after out of hours admission. Meta-analysis demonstrated an increased length of stay following weekend admission (RR 1.31, 95% CI 0.85 to 1.76); the mean difference was approximately 1 day (Figure 3). The results, however, should be interpreted with caution as adjustment could not be made in all studies for differing illness severity in patients admitted out of hours or at weekends.

**DISCUSSION**

We have not found a significant ‘weekend’ effect on paediatric mortality but an adverse effect on length of stay and greater complications in certain conditions. Our literature review emphasises the heterogeneity of the studies examining this topic. It was, however, possible to undertake a meta-analysis of the majority of studies on the impact on mortality of weekend admission that demonstrated no significant effect on mortality when adjusted results were used. It is important, however, to re-emphasise that different adjustments were used in the various studies.

The majority of studies have assessed the outcomes of children living and being treated outside the UK and, therefore, the results must be interpreted with the caveat that they may have been in the context of different healthcare provision. In one of the two large UK studies, no significant differences were reported between weekend and weekday admissions and in the other an increase in mortality was seen only in planned weekend admissions and not emergency weekend admissions. Those results highlight that it may be case mix that influences results with patients following complex surgery being more likely to be admitted to PICU at the weekend.

We have not reported whether deaths were more likely to occur at the weekend or on a weekday, as this was not available for the majority of studies. Importantly, the retrospective analysis of deaths of all 14,217,640 admissions to the English National Health Service demonstrated that the 30 day mortality was increased in those admitted on weekend days, but the likelihood of death occurring was less on a weekend day than on a mid-week day. It would be important to determine in UK paediatric populations the timing of deaths to identify if there are any excess deaths at the weekend as that might reflect inadequate ‘resource’ at that time.

None of the studies specifically looked at staffing levels, which could contribute to a ‘weekend effect’. Paediatric staffing is an area of concern, 89% of consultants responding to a Royal College of Paediatrics and Child Health (RCPCH) survey stated that they were very or moderately concerned about how the service would cope in the next 6 months. The Royal College of Nursing and the RCPCH have issued documents detailing standards of staffing and expectations of care for children admitted to hospital. An audit of the medical standards by RCPCH, years after their introduction, found that, although they were being met in the majority of cases, there were still improvements to be made to better achieve the standards out-of-hours. The weekend effect may be mitigated by paediatrics being a relatively senior-led specialty; 96.4% of units surveyed in ‘Consultant Delivered Care’ operated some form of consultant delivered care, including 90.3% of consultant-led handovers.

In conclusion, studies of adult patients had demonstrated a significantly higher in hospital mortality in those admitted at weekends. A recent study, however, suggested that adjustment for acuity reduced that risk. Our review of paediatric studies demonstrated no overall significant adjusted risk for mortality following weekend admissions. There was, however, an increase in complications following weekend procedures in certain conditions. In five studies, there was an increased length of stay following a weekend admission, but it was not possible to adjust in all for patient acuity. The increase in hospital stay and apparent excess in complications in certain conditions in infants and children admitted at the weekend needs further investigation. Those results would identify whether there is a need for redirection of health services resources to reduce adverse outcomes in infants and children.

**REFERENCES**


30 Royal College of Paediatrics and Child Health. Facing the future: standards for paediatric services. 5–11 Theobalds Road, London: Royal College of Paediatrics and Child Health, 2011.
