

Paediatric outcomes and timing of admission

Louise Ramsden,¹ Martin Patrick McColgan,² Thomas Rossor,^{3,4} Anne Greenough,^{2,3,4,5} Simon J Clark^{1,2}

► Additional material is published online only. To view please visit the journal online (<http://dx.doi.org/10.1136/archdischild-2017-314559>).

¹Neonatal Unit, Sheffield Teaching Foundation Hospitals Trust, Sheffield, UK

²Royal College of Paediatrics and Child Health, London, UK

³MRC-Asthma UK Centre in Allergic Mechanisms of Asthma, King's College London, London, UK

⁴Department of Women and Children's Health, School of Life Course Sciences, Faculty of Life Sciences and Medicine, King's College London, London, UK

⁵NIHR Biomedical Centre at Guy's and St Thomas NHS Foundation Trust and King's College London, London, UK

Correspondence to

Dr Simon J Clark;
Simon.Clark@sth.nhs.uk

Received 12 December 2017

Revised 12 February 2018

Accepted 14 February 2018

Published Online First

15 March 2018

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 trachea-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 3 789 917 adults and children admitted through an emergency department to an acute care hospital in Canada had a significantly higher in-hospital mortality rate if they had a ruptured abdominal aortic aneurysm, acute epiglottitis or pulmonary embolism.¹ The differences persisted for all diagnoses after adjustment for age, sex and coexisting disorders.¹ A subsequent retrospective analysis of deaths of all 14 217 640 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.² More recently, an analysis of deaths of 503 938 unselected emergency admissions to four UK hospitals was undertaken. Deaths within 30 days of admission occurred in 18 313 (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.³

The infant mortality rate in England and Wales is 3.6 per 1000 live births and the child mortality rate is 1 per 1000,⁴ 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.^{5–21} Only four of the studies^{5 9 12 17} demonstrated an increased mortality in those at the weekend. One study¹⁶ showed among 234 192 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). In-hours 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.¹⁸ 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



To cite: Ramsden L, McColgan MP, Rossor T, et al. *Arch Dis Child* 2018;**103**:611–617.

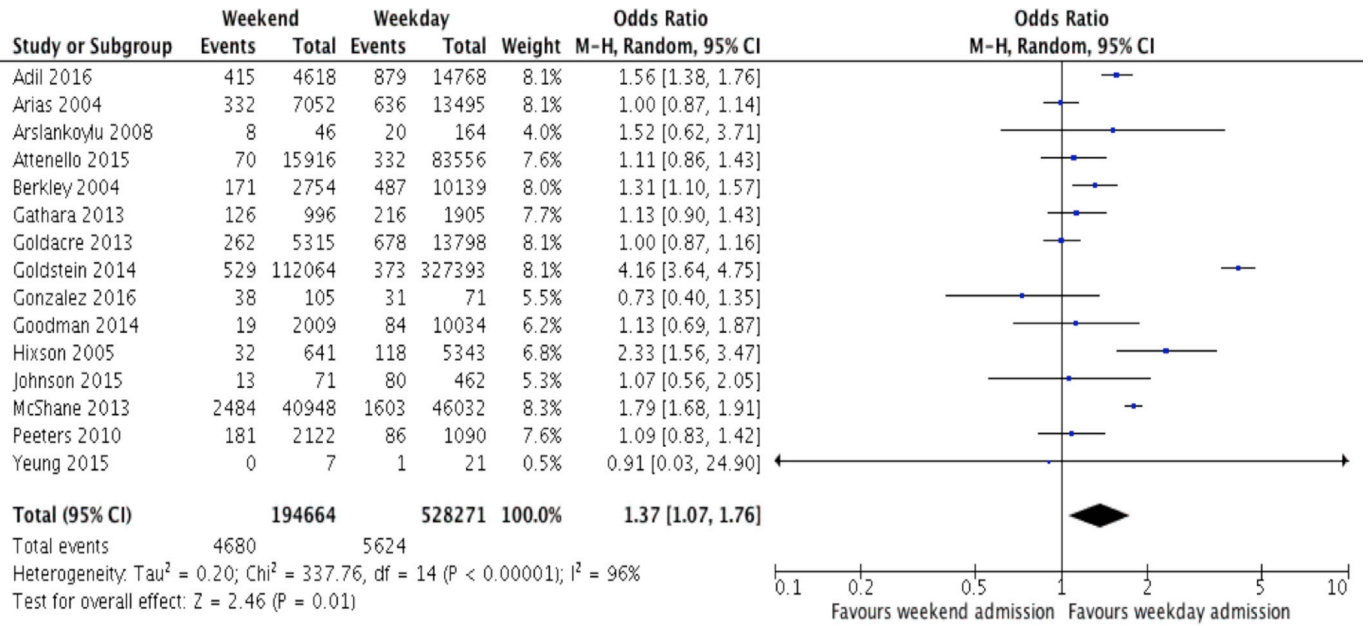


Figure 1 Weekend effect on mortality during admission (unadjusted).

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 (1.67–2.37), 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.

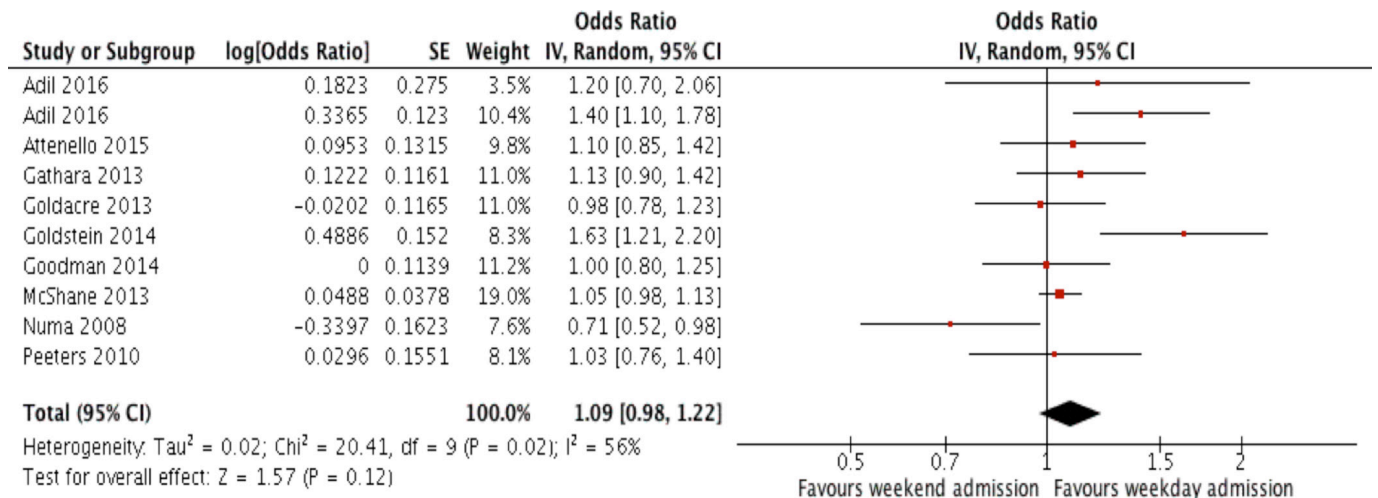


Figure 2 Weekend effect on adjusted mortality during admission.

Table 1 Studies assessing paediatric outcomes and timing of admission

Study group	Study type	Outcome	Exposure	Key result	Comment
Adli <i>et al</i> ⁵ Patients aged 1–18 years admitted to USA hospitals between 2002 and 2011 due to ischaemic or haemorrhagic stroke. 19 386 patients. Cases found from National Inpatient Sample (NIS).	Retrospective cohort	Mortality Length of stay (LOS) Hospital charges Discharge status	Weekend or weekday admission	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 In-hospital 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.	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<0.05) in univariate analysis.
Arias <i>et al</i> ⁶ 20 547 emergency admissions to 15 PICUs in the PICUE database in the USA between 1995 and 2001.	Retrospective cohort	Mortality within 48 hours of admission to PICU.	Weekend (19:00 Friday to 07:00 Monday) or weekday admission Day (07:00–17:00) or evening (17:00–07:00)	No significant difference between weekend and weekday admission regarding severity of illness. Death at the weekend (OR 1.0 (95% CI 0.78 to 1.28)) Death in the evening (OR 1.28 (95% CI 1 to 1.62))	Used PRISM scoring as method for adjusting for illness severity.
Aislankeyulu <i>et al</i> ⁷ 210 consecutive admissions of children aged 1 month–18 years to PICU in a Turkish hospital between 2005 and 2006.	Retrospective cohort	Mortality within 24 hours, 48 hours, 72 hours and overall. Length of stay. Duration of ventilation.	Weekday or weekend (17:00–08:00)	No statistically significant difference in mortality rates between weekend and weekday or daytime and evening. Patients admitted during the daytime had greater PIM2 mortality scores (P=0.01) and greater need for mechanical ventilation (P=0.03)	Used PIM2 scoring as a way of adjusting for illness severity.
Attenello <i>et al</i> ⁸ 99 472 patients aged less than 20 years between 2000 and 2010 with hydrocephalus identified from NIS and KID databases in the USA.	Retrospective cohort	Mortality Routine discharge rate	Weekday or weekend admission Time to shunt insertion	Weekend admission was not associated with increased mortality (P=0.46) Weekend admission was not associated with a significant difference in the routine discharge rate (RR 1.00 (95% CI 0.97 to 1.03), P=0.98)	Multivariate analysis to account for confounding factors that included time to shunt insertion. Adjustment for disease severity, time to procedure and admission acuity.
Berkley <i>et al</i> ⁹ 12 893 children aged ≤90 days admitted to a rural Kenyan hospital between 1998 and 2001.	Prospective cohort	Mortality within 4 hours, 4–48 hours and after 48 hours	Weekend or weekday admission	Adjusted for illness severity, weekend admission; death within 4 hours was increased (OR 2.05 (95% CI 1.26 to 3.31)) as was death within 4–48 hours (OR 1.54 (95% CI 1.17 to 2.03)) Death beyond 48 hours was not (OR 1.09 (95% CI 0.8 to 1.47))	Created their own prognostic indicator score and used this to adjust for illness severity.
Desai <i>et al</i> ¹⁰ 580 patients less than 18 years undergoing 710 emergency neurosurgical procedures between 2011 and 2014 in a Texas Children's Hospital.	Retrospective cohort	Mortality Surgical complications (including infection, CSF leakage, postoperative haemorrhage, and new neurological deficit)	Weekday hours (07:20–19:00) or weekday out-of-hours or weekend (Saturday 12:00–Sunday 24:00) procedure	Combined morbidity and mortality at nights and weekends OR 1.79 (95% CI 1.083 to 2.961), P=0.0227 No significant difference in mortality (P=0.058), but only three deaths in total. No significant differences in complications between groups.	Accounted for baseline health status using anaesthetic scoring system (ASA).
Goldacre <i>et al</i> ¹¹ All patients with a discharge diagnosis of meningococcal disease as per HES and mortality records from 1999 to 2010. 12 697 patients aged less than 15 years.	Retrospective cohort	Mortality	Weekend or weekday admission	30-day case fatality rates showed no evidence of increased mortality for patients admitted at weekend (P=0.92) No significant change when adjusted for confounding factors	Adjusted for sex, age, year of admission, IMD score and day of the week of admission
Goldstein <i>et al</i> ¹² 439 457 patients less than 18 years old requiring surgery abscess drainage, appendicectomy, hernia repair (P shunt) on same day as admission using the NIS and KID databases between 1988 and 2010.	Retrospective cohort	Mortality Haemorrhage Accidental puncture or laceration Wound dehiscence Wound infection Blood transfusion	Weekend or weekday admission	Risk of death (OR 1.63 (95% CI 1.21 to 2.2)) Accidental puncture or laceration (OR 1.4 (95% CI 1.12 to 1.74)) Blood transfusion (OR 1.14 (95% CI 1.01 to 1.26))	Looked at number 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
Gonzalez <i>et al</i> ¹³ 176 patients aged less than 18 years undergoing extracorporeal life support (ECMO) between 2004 and 2015 in a tertiary centre in the USA	Retrospective cohort	Mortality Survival to discharge Complications including haemorrhage, cannula repositioning and conversion from venovenous to venoarterial ECMO	Regular hours (07:00–19:00) or out-of-hours (including weekends) (off hours)	The overall complication rate was lower in off-hours group (45.7% versus 61.9% P=0.034)	The most common indication for ECMO were congenital diaphragmatic hernia (CDH) and persistent pulmonary haemorrhage (23%)

Continued

Table 1 Continued

Study group	Study type	Outcome	Exposure	Key result	Comment
Goodman <i>et al</i> ¹⁴ Children with newly diagnosed acute lymphocytic leukaemia or acute myeloid leukaemia admitted to hospital between 1999 and 2011 and identified by the Pediatric Health Information System database. 12 043 admissions in 43 USA hospitals.	Retrospective cohort	Mortality during primary admission Length of inpatient stay Time to chemotherapy Organ system failure	Weekend or weekday admission	Weekend mortality rate (OR 1.0 (95% CI 0.8 to 1.6)) 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)	Adjusted for severity of illness at presentation defined as requiring PICU within 48 hours of hospital admission, demographics and hospital level.
Hixson <i>et al</i> ¹⁵ 5968 patients aged 0–21 years admitted to a PICU in a single hospital in the USA between 1996 and 2003.	Prospective cohort	Mortality prior to discharge from hospital	Weekday or weekend Daytime (07:00–19:00) or evening (19:00–07:00)	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	Used PRISM3 to assess for illness severity.
McCorry <i>et al</i> ¹⁶ All patients less than 18 years admitted to a PICU between 2009 and 2012. 23 419 admissions to 99 USA PICUs	Retrospective cohort	Mortality during PICU admission	Inhours (07:00–18:59 Monday–Friday) or off-hours (19:00–06:59 or Saturday/Sunday anytime)	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	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.
McShane <i>et al</i> ¹⁷ All patients admitted to 29 PICUs in England and Wales between 2006 and 2011. 86 980 patients and 4087 deaths.	Retrospective cohort	Mortality before discharge from PICU	Out-of-hours (nights, weekends and public holidays) or inhours admission	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<0.0001) but not for emergency admissions (OR 0.93 (95% CI 0.86 to 1.01), P=0.07)	Adjustment PIM2, year of admission, sex ethnicity, age group and diagnostic group
Numa <i>et al</i> ¹⁸ 4456 emergency PICU admissions of children aged 0–14 years in an Australian hospital between 1997 and 2006.	Prospective cohort	PICU mortality Length of stay	Inhours (08:00–18:00 Monday–Friday and 08:00–12:00 Saturday–Sunday) or after-hours (all other times)	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 inhours admissions.	Used paediatric index of mortality (PIM) scoring to adjust for illness severity.
Nwosu <i>et al</i> ¹⁹ All inpatient deaths (3934) at a tertiary referral hospital in Nigeria occurring between 1998 and 2007.	Retrospective cohort	Mortality	Weekend or weekday	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.	Ages ranged from a few hours to 94 years
Peeters <i>et al</i> ²⁰ All emergency PICU admissions for children aged less than 18 years in two hospitals in the Netherlands between 2003 and 2007. 3212 admissions	Prospective cohort	PICU mortality Duration of ventilation Length of PICU admission	Office hours (08:00–18:00 Monday–Friday) or off-hours (18:00–08:00 Monday–Friday and all weekends and bank holidays)	66% patients admitted during off-hours. Adjusting for severity of illness, there was no significant effect of off-hours admission on mortality. PIM1 score (OR 0.95 (95% CI 0.71 to 1.27), P=0.73) PRISM2 score (OR 1.03 (95% CI 0.76 to 1.39), P=0.82)	Used PIM1 and PRISM2 scoring systems to adjust for severity of illness.
Sayari <i>et al</i> ²¹ Patients admitted between 1997 and 2009 aged less than 8 days and undergoing repair of tracheo-oesophageal fistula and oesophageal atresia underwent repair. Cases found from KID US 2913 cases.	Retrospective cohort	Hospital mortality Complications Resource use Total charges	Weekend or weekday procedure	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).	Additional adjustment made for comorbid risk factors.
Auger <i>et al</i> ²² 55 383 paediatric patients from a US hospital between 2006 and 2012. Newborns and children who died were excluded.	Retrospective cohort	Unplanned readmission within 30 days of discharge	Weekend admission or weekend discharge	Weekend admission had significantly higher odds of unplanned readmission adjusted (OR=1.09 (95% CI 1.004 to 1.18), P=0.05). Being discharged on the weekend was not associated with unplanned readmission adjusted (OR=0.97 (95% CI 0.91 to 1.03)).	ICD9 codes used to identify children with chronic complex conditions.
Yeung <i>et al</i> ²³ 28 patients between 2005 and 2010 undergoing oesophageal atresia with tracheo-oesophageal fistula repair at a tertiary children's hospital Canada.	Retrospective cohort	Mortality Intraoperative complications Oesophageal complications Pneumothorax	Inhours (08:00–15:30 Monday–Friday) or after-hours (remaining time period including weekends and bank holidays)	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<0.0001. No significant difference in mortality.	Small sample size.
Miller <i>et al</i> ²⁴ Review of 140 reported paediatric medication errors occurring in a tertiary USA paediatric hospital in 2008.	Retrospective cohort	Medication dispensing errors (pharmacy and nursing)	Day or night or weekday (Monday 07:00–Friday 18:59) or weekend	Weekday day nursing shift 1.17 errors/1000 doses versus weekend 2.55 errors/1000 doses (P=0.0004) or versus night 2.12 errors/1000 doses dispensed (P=0.005). No significant association between time and severity of the error.	Administration errors were most common.

Continued

Table 1 Continued

Study group	Study type	Outcome	Exposure	Key result	Comment
Thompson <i>et al</i> ²⁵ Children less than 2 years of age with a primary admission diagnosis of failure to thrive between 2003 and 2011 in 42 US hospitals. 23 332 cases from the PHIS database.	Retrospective cohort	Length of hospital stay Cost of admission	Weekend or weekday admission	Patients admitted at the weekend had longer LOS incident rate ratio (IRR) (1.2 (95% CI 1.18 to 1.22), P<0.002). Weekend admissions cost more and had an increased LOS of 1.93 days	Results adjusted for the number of discharge diagnoses.
Fendler <i>et al</i> ²⁶ 10 042 patients admitted to a ward treating haemato-oncology, diabetic and nephrology patients in children's hospital in Poland between 2000 and 2010.	Retrospective cohort	Length of hospital stay	Weekend or weekday admission	Weekend admission was associated with a longer duration of hospital stay by 1.86 days (95% CI 1.6 to 2.13).	Controlled for other clinical factors.
Johnson <i>et al</i> ²⁷ Patients with a diagnosis of hypoplastic left heart syndrome or other single right ventricle anomalies and a planned Norwood procedure.	Retrospective cohort	Mortality Hospital length of stay Transplant-free survival Intensive care unit length of stay Days of mechanical ventilation	Weekend or weekday admission and day of procedure	No difference in death (P=0.9), hospital (P=0.7) or ICU (P=0.5) length of stay, days ventilated (P=0.3) between weekend and weekday groups.	Known risk factors for poor post-Norwood procedure outcomes were controlled for.

CSF, cerebrospinal fluid; HES, hospital episode statistics; ICD9, international classification of diseases; IMD, index of multiple deprivation score; KID, Kids' Inpatient Database; PHIS, paediatric health information system; PICU, paediatric intensive care unit; PRISM, paediatric risk of mortality score; RR, relative risk; SCBU, special care baby unit; VP, ventriculoperitoneal shunt.

Complication rates

A number of studies have assessed whether complications were increased at the weekend. The complications included increased unplanned readmission rates,²² increased complication rates,^{10 12 13 21 23} treatment delay¹⁴ and increased medication errors.²⁴ In a study of 55 383 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.²² 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.¹⁰ In a small study of 28 patients undergoing oesophageal atresia and trachea-oesophageal repair, there were significantly more oesophageal leaks in those admitted after-hours²³ and this was associated with a longer postoperative length of ventilation (16.1 vs 9.3 days).²³ Those findings²³ 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).²¹ 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.¹² In contrast, the overall complication rate was lower out of hours in 176 children requiring extracorporeal membrane oxygenation in a tertiary centre.¹³ 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).¹⁴ 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).¹⁴ 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).²⁴

Length of stay

Five studies have reported the effect of timing of admission on length of stay.^{14 18 25–27} 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,^{18 27} 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.²⁵ Among 10 042 patients admitted to a ward in a children's hospital in Poland that treated haemato-oncology, diabetic and nephrology patients, after controlling for clinical factors, weekend admission was associated with a longer duration of hospital stay by on average 1.86 days.²⁶ 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

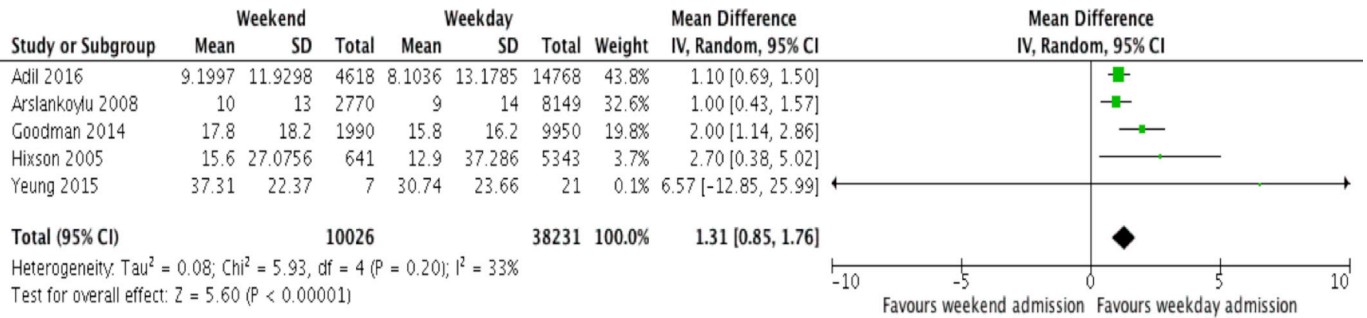


Figure 3 Weekend effect on length of hospital stay.

stay, length of PICU stay, duration of ventilation or mortality.²⁷ Furthermore, 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.¹⁸ 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,¹¹ no significant differences were reported between weekend and weekday admissions and in the other¹⁷ an increase in mortality was seen only in planned weekend admissions and not emergency weekend admissions. Those results¹⁷ 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.² 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.²⁸ The Royal College of Nursing²⁹ and the RCPCH³⁰ have issued documents detailing standards of staffing and expectations of care for children admitted to hospital. An audit of the medical standards by RCPCH,³¹ 2 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.³²

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.

Contributors LR, MPM and SJC undertook the literature search, and TR and AG undertook the analysis. All authors were involved in the preparation of the manuscript and approved the final version.

Funding This research was supported by the National Institute for Health Research (NIHR) Biomedical Research Centre at Guy's and St Thomas' NHS Foundation Trust and King's College London.

Disclaimer The views expressed are those of the authors and not necessarily those of the NHS, the NIHR or the Department of Health.

Competing interests None declared.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement We agree to sharing data if requested.

© Article author(s) (or their employer(s) unless otherwise stated in the text of the article) 2018. All rights reserved. No commercial use is permitted unless otherwise expressly granted.

REFERENCES

- Bell CM, Redelmeier DA. Mortality among patients admitted to hospitals on weekends as compared with weekdays. *N Engl J Med* 2001;345:663–8.
- Freemantle N, Richardson M, Wood J, et al. Weekend hospitalization and additional risk of death: an analysis of inpatient data. *J R Soc Med* 2012;105:74–84.
- Walker AS, Mason A, Quan TP, et al. Mortality risks associated with emergency admissions during weekends and public holidays: an analysis of electronic health records. *Lancet* 2017;390:62–72.

- 4 Office for National Statistics 2016. *Childhood mortality rates in England and Wales*, 2014. Published online April 2016.
- 5 Adil MM, Vidal G, Beslow LA. Weekend effect in children with stroke in the nationwide inpatient sample. *Stroke* 2016;47:1436–43.
- 6 Arias Y, Taylor DS, Marcin JP. Association between evening admissions and higher mortality rates in the pediatric intensive care unit. *Pediatrics* 2004;113:e530–4.
- 7 Arslankoylu AE, Bayrakci B, Oymak Y, et al. Admission time and mortality rates. *Indian J Pediatr* 2008;75:691–4.
- 8 Attenello FJ, Christian E, Wen T, et al. Reevaluating the weekend effect on patients with hydrocephalus undergoing operative shunt intervention. *J Neurosurg* 2016;17:156–62.
- 9 Berkley JA, Brent A, Mwangi I, et al. Mortality among Kenyan children admitted to a rural district hospital on weekends as compared with weekdays. *Pediatrics* 2004;114:1737–8.
- 10 Desai V, Gonda D, Ryan SL, et al. The effect of weekend and after-hours surgery on morbidity and mortality rates in pediatric neurosurgery patients. *J Neurosurg Pediatr* 2015;16:726–31.
- 11 Goldacre MJ, Maisonneuve JJ. Mortality from meningococcal disease by day of the week: English national linked database study. *J Public Health* 2013;35:413–21.
- 12 Goldstein SD, Papandria DJ, Aboagye J, et al. The "weekend effect" in pediatric surgery - increased mortality for children undergoing urgent surgery during the weekend. *J Pediatr Surg* 2014;49:1087–91.
- 13 Gonzalez KW, Dalton BG, Weaver KL, et al. Effect of timing of cannulation on outcome for pediatric extracorporeal life support. *Pediatr Surg Int* 2016;32:665–9.
- 14 Goodman EK, Reilly AF, Fisher BT, et al. Association of weekend admission with hospital length of stay, time to chemotherapy, and risk for respiratory failure in pediatric patients with newly diagnosed leukemia at freestanding US children's hospitals. *JAMA Pediatr* 2014;168:925–31.
- 15 Hixson ED, Davis S, Morris S, et al. Do weekends or evenings matter in a pediatric intensive care unit? *Pediatr Crit Care Med* 2005;6:523–30.
- 16 McCrory MC, Gower EW, Simpson SL, et al. Off-hours admission to pediatric intensive care and mortality. *Pediatrics* 2014;134:e1345–53.
- 17 McShane P, Draper ES, McKinney PA, et al. Effects of out-of-hours and winter admissions and number of patients per unit on mortality in pediatric intensive care. *J Pediatr* 2013;163:1039–44.
- 18 Numa A, Williams G, Awad J, et al. After-hours admissions are not associated with increased risk-adjusted mortality in pediatric intensive care. *Intensive Care Med* 2008;34:148–51.
- 19 Nwosu BO, Eke NO, Obi-Nwosu A, et al. Weekend versus weekday hospital deaths: analysis of in-patient data in a Nigerian tertiary healthcare center. *Niger J Clin Pract* 2013;16:501–4.
- 20 Peeters B, Jansen NJ, Bollen CW, et al. Off-hours admission and mortality in two pediatric intensive care units without 24-h in-house senior staff attendance. *Intensive Care Med* 2010;36:1923–7.
- 21 Sayari AJ, Tashiro J, Wang B, et al. Weekday vs. weekend repair of esophageal atresia and tracheoesophageal fistula. *J Pediatr Surg* 2016;51:739–42.
- 22 Auger KA, Davis MM. Pediatric weekend admission and increased unplanned readmission rates. *J Hosp Med* 2015;10:743–5.
- 23 Yeung A, Butterworth SA. A comparison of surgical outcomes between in-hours and after-hours tracheoesophageal fistula repairs. *J Pediatr Surg* 2015;50:805–8.
- 24 Miller AD, Piro CC, Rudisill CN, et al. Nighttime and weekend medication error rates in an inpatient pediatric population. *Ann Pharmacother* 2010;44:1739–46.
- 25 Thompson RT, Bennett WE, Finnell SM, et al. Increased length of stay and costs associated with weekend admissions for failure to thrive. *Pediatrics* 2013;131:e805–e810.
- 26 Fendler W, Baranowska-Jazwiecka A, Hogendorf A, et al. Weekend matters: Friday and Saturday admissions are associated with prolonged hospitalization of children. *Clin Pediatr* 2013;52:875–8.
- 27 Johnson JT, Sleeper LA, Chen S, et al. Associations between day of admission and day of surgery on outcome and resource utilization in infants with hypoplastic left heart syndrome who underwent stage I Palliation (from the Single Ventricle Reconstruction Trial). *Am J Cardiol* 2015;116:1263–9.
- 28 Royal College of Paediatrics and Child Health. *Paediatric rota gaps and vacancies 2016*. 5-11 Theobalds Road, London: Royal College of Paediatrics and Child Health, 2015.
- 29 Royal College of Nursing. *Defining staffing levels for children and young people's services*. Cavendish Square, London: Royal College of Nursing, 2013.
- 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.
- 31 Royal College of Paediatrics and Child Health. *Back to facing the future: an audit of acute paediatrics service standards in the UK. Executive summary*. 5-11 Theobalds Road, London: Royal College of Paediatrics and Child Health, 2013.
- 32 Royal College of Paediatrics and Child Health. *Consultant delivered care. An evaluation of new ways of working in Paediatrics*. 5-11 Theobalds Road, London: Royal College of Paediatrics and Child Health, 2012.