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Is the weekend effect really ubiquitous? Retrospective clinical cohort analyses of 30-day mortality by day of week and time of day using linked population data from New South Wales, Australia

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2017-016943
Article Type:	Research
Date Submitted by the Author:	24-Mar-2017
Complete List of Authors:	Baldwin, Heather; Bureau of Health Information; New South Wales Ministry of Health Marashi-Pour, Sadaf; Bureau of Health Information Chen, Hwei-Yang ; Bureau of Health Information Kaldor, Jill; Bureau of Health Information Sutherland, Kim; Bureau of Health Information Levesque, Jean-Frederic; Bureau of Health Information, ; University of New South Wales, Centre for Primary Health Care and Equity
Primary Subject Heading:	Health services research
Secondary Subject Heading:	Health services research, Health policy, Public health
Keywords:	PUBLIC HEALTH, HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Quality in health care < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

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Manuscripts

1 Is the weekend effect really ubiquitous? Retrospective clinical cohort
2 analyses of 30-day mortality by day of week and time of day using
3 linked population data from New South Wales, Australia

4
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19 Word count (abstract + body): 2736

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22 ABSTRACT

23 Objective

24 To examine the associations between day of week and time of admission and 30-day
25 mortality for six clinical conditions: ischaemic and haemorrhagic stroke, acute myocardial
26 infarction, pneumonia, chronic obstructive pulmonary disease and congestive heart failure.

27 Design

28 Retrospective population-based cohort analyses. Hospitalisation records were linked to
29 emergency department and deaths data. Logistic regression models were used, adjusting for
30 casemix and clustering within hospitals.

31 Setting

32 All hospitals in New South Wales, Australia from July 2009 to June 2012.

33 Participants

34 Patients admitted to hospital with a primary diagnosis for one of the six clinical conditions
35 examined.

36 Outcome measures

37 The adjusted odds ratios for all-cause mortality within 30 days of admission, by day of week
38 and time of day.

39 Results

40 A total of 148,722 patients were included in the study, with 17,721 deaths within 30 days of
41 admission. Day of week of admission was not associated with significantly higher adjusted
42 probability of death for five of the six conditions. There was significant variation in mortality
43 for chronic obstructive pulmonary disease by day of week, however, this was not consistent
44 with a weekend effect (Thursday: OR 1.29, 95% CI 1.12–1.48; Friday: OR 1.25, 95%CI
45 1.08–1.44; Saturday: OR 1.18, 95% CI 1.02–1.37; Sunday OR 1.05, 95% CI 0.90–1.22;
46 compared to Monday). There was evidence for a night effect for patients admitted for stroke
47 (ischaemic: OR 1.30, 95% CI 1.17–1.45; haemorrhagic: OR 1.58, 95% CI 1.40–1.78).

48 Conclusions

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2
3 49 Mortality outcomes for these conditions, adjusted for casemix, do not vary in accordance
4
5 50 with the weekend effect hypothesis. Our findings support a growing body of evidence that
6
7 51 questions the ubiquity of the weekend effect.
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11 12 53 **Keywords**

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14 54 Weekend effect, night effect, out-of-hours effect, stroke, AMI, pneumonia, COPD, CHF
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18 19 20 56 **Article summary**

21 22 57 *Strengths and limitations of this study*

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25 58
- 26 • The examined conditions encompass a range of time sensitivity, interventions, acuity
27 and prognosis, providing a gradient to assess potential causality of association.
28
 - 29 • The use of linked hospital admission and emergency department (ED) data allowed
30 complete coverage of hospital admissions for the state, while minimising
31
32 61 misclassification bias from time spent in ED and maximising validity and quality of
33
34 62 diagnosis and comorbidity data.
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36 63
 - 37 • The use of clinical cohorts of patients allows more precise adjustment for casemix
38 than non-specific admissions.
39
 - 40 • Linkage to the Deaths Register allowed the capture of 30-day all-cause mortality.
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42 66
 - 43 • Mortality is a standard indicator, but it may be a blunt tool, and other outcomes may
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45 67 be more sensitive to variation in patient outcomes.
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71 INTRODUCTION

72 In recent years, researchers and policy makers have shown growing interest in the
73 ‘weekend effect’, examining whether patients admitted to hospital at the weekend experience
74 worse outcomes compared to patients admitted during the week. This effect has been
75 observed in numerous studies of health systems around the world, for a wide range of
76 conditions and procedures.¹⁻⁵ Studies have also observed a ‘night effect’, suggesting that the
77 phenomenon may extend to out-of-hours presentation more broadly.¹⁻⁴

78 Considerable uncertainty remains as to the cause of the apparent effect of weekend
79 and night-time (hereafter collectively ‘out-of-hours’) presentation on patient outcomes. Two
80 main hypotheses have been proposed to explain the observed variation: these focus on
81 healthcare service quality and on patient characteristics.² The first hypothesis posits that the
82 poorer outcomes seen among patients admitted on the weekend are explained by lower
83 quality of care out-of-hours. More specifically, putative factors include lower staffing levels,
84 fewer senior consultants and specialists, and reduced availability of diagnostic procedures.³
85 This hypothesis gained considerable traction with policy makers and has contributed to the
86 recent, controversial push towards seven day hospital services in the UK.⁶

87 The second hypothesis proposes that the weekend effect is largely attributable to
88 patient characteristics, and at least partly an artefact of the data. There is little clear evidence
89 that higher mortality is a consequence of staffing levels⁶, and a number of studies have found
90 no significant correlation between consultant seniority or specialist availability and
91 mortality.⁷⁻¹⁰ There is also an increasing body of evidence to suggest that the weekend effect
92 dissipates after adjustment for casemix¹¹, arrival by ambulance as a proxy for illness
93 severity¹² and a higher severity threshold for admission.¹¹ This phenomenon may also be
94 influenced by self-selection, whereby patients wait until the weekend to present to hospital

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3 95 and may therefore present with more advanced disease, and less comprehensive note-taking
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5 96 on the weekend limiting the ability to risk-adjust.¹³
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8 97 The night effect is less extensively studied than the weekend effect, and reasons for
9
10 98 the night effect are usually presumed to be the similar to the weekend effect. The few studies
11
12 99 that have examined the effects of out-of-hours presentation on mortality in Australia have had
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14 100 mixed results.^{3,4,14,15} Previous studies have been limited by using in-hospital mortality only
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16 101 and therefore not capturing deaths that occurred post-discharge¹⁶, reduced ability to
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18 102 adequately risk adjust by focusing on clinically non-specific admissions.^{3,15,17} Further,
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20 103 previous studies have often relied on unlinked emergency department (ED) data⁴, which
21
22 104 contain limited and largely incomplete and inaccurate information on principle diagnosis and
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24 105 comorbidity, or unlinked hospitalisation data, which may be affected by misclassification
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26 106 bias due to time spent in waiting in ED prior to admission.^{14,17}
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30 107 Overall, previous studies have shown that the out-of-hours effect does not apply to
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32 108 all clinical presentations and procedures.^{1-4,7} It is therefore beneficial to investigate conditions
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34 109 for which we can expect that the weekend is more likely to occur, based on theoretical
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36 110 grounds, on clinical plausibility or on previous evidence.²
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40 111 We investigated the existence of the weekend effect and the night effect for acute
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42 112 hospitalisations for various conditions, comprising ischaemic stroke, haemorrhagic stroke,
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44 113 AMI, pneumonia, COPD, and congestive heart failure (CHF), across all hospitals in NSW.
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46 114 These conditions provide insights into a range of aspects of healthcare, including timely
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48 115 delivery of interventions, surgical services, differences in acuity and prognosis, and provide a
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50 116 gradient to assess potential causality of association as they vary in the importance of
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52 117 immediate care. We predicted that if day and time effects exist, they would show strongest
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54 118 effects for the most urgent conditions (stroke and AMI), and be weakest for patients with the
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3 119 least urgent conditions (pneumonia and COPD). We hypothesized that presentations on
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5 120 Saturdays and Sundays would show higher 30-day mortality for the six conditions than
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7 121 presentations that occurred during the week, and that night-time presentations would show
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9 122 higher mortality than presentations that occurred during the day.
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124 **METHODS**

125 Retrospective cohort analyses were performed for the six indicator conditions. Cohorts were
126 identified from all admissions to NSW public and private hospitals for the period of 1 July
127 2009 to 30 June 2012, extracted from the NSW Admitted Patient Data Collection, which is a
128 census of all hospital admissions in NSW. These data were linked to emergency department
129 (ED) attendances in all NSW public hospitals recorded in the Emergency Department Data
130 Collection, representing approximately 85% of all emergency presentations in NSW.^{18,19}
131 Emergency department data were linked to allow the capture of the start day and time of the
132 patients' contact with the hospital system for the episode of illness, minimising any bias
133 imposed by time spent in the emergency department that may affect the day and time of
134 hospitalisation, since patients may spend longer in the ED before admission at night or at
135 weekends. Mortality data were obtained from the NSW Deaths Register. Data were linked by
136 the NSW Centre for Health Record Linkage using probabilistic methods.

137 The principal diagnosis in the patient record, coded using International Classification
138 of Diseases 10th revision Australian modification, was used to identify each clinical cohort.
139 Only records coded as acute and emergency, which were complete for key fields (age, sex,
140 admission date, separation date) were included. Patients aged less than 15 years (ischaemic
141 stroke, haemorrhagic stroke, AMI), 18 years (pneumonia) or 45 years (COPD, CHF) were
142 excluded, consistent with existing mortality indicator definitions for these conditions.^{20,21}

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3 143 AMI patients with a non-specific infarction were excluded to allow adjustment for STEMI,
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5 144 consistent with the existing indicator definition.^{20,21} Transfers and multiple admissions were
6
7 145 identified for each patient to avoid double counting. Contiguous episodes of care separated by
8
9 146 transfers were combined into single periods of care, the most recent of which was used for
10
11 147 analysis.

14 148 Mortality was defined as death (in or out of hospital) occurring within 30 days of the
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16 149 start of the period of care. The day of week of presentation was defined as the first day of
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18 150 contact with the hospital system for the period of care (either hospital admission or ED
19
20 151 presentation). An ED presentation was considered relevant for the hospital admission if it
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22 152 occurred on the same day, or previous day, as the hospital admission. Same day ED
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24 153 presentations were only included if the time was recorded as before the hospital admission
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26 154 time. Night time presentation was defined as first presentation between 18:00 and 07:59,
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28 155 using hospital admission time or ED presentation time as described.

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32 156 Mixed effects logistic regression models were used to investigate the associations
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34 157 between day of week and time of presentation with mortality. To account for clustering of
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36 158 patients within hospitals, hospitals were considered as random effects in the regression
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38 159 models. Risk adjustment was performed to account for casemix factors including age
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40 160 (continuous, tested for curvilinearity), sex, financial year and comorbidities. Condition-
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42 161 specific comorbidity sets defined by the Australian Commission for Safety and Quality in
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44 162 Health Care were used as the basis for building risk adjustment models for each condition,
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46 163 where available (ischaemic stroke, haemorrhagic stroke, AMI, pneumonia), while COPD,
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48 164 CHF used Elixhauser comorbidities.²⁰ Availability of thrombolysis treatment was also
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50 165 considered as a predictive variable for ischaemic stroke, and STEMI status was considered
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52 166 for AMI. Comorbidities were captured across all hospital admissions over a one year period
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54 167 prior to the index admission.

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3 168 Models were selected using backwards selection.²² Factors with a *p*-value of less than
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5 169 0.2 in the univariate analyses were included in the initial full models. Variables with a *p*-
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7 170 value of less than 0.05 were retained in the model. Variables that were not significant at the
8
9 171 20% level in the univariate models were then checked for significance in the backwards-
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11 172 selected model, and retained in the final model where $p < 0.05$. Overall performance of the
12
13 173 models was assessed using c-statistics. Statistical analyses were performed using SAS v9.4
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15 174 (SAS Institute Inc., Cary, NC, USA) and STATA v12.1 (StataCorp LP, Texas, USA).
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21 176 **RESULTS**

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24 177 There were a total of 213,834 acute, emergency hospital admissions for the conditions of
25
26 178 interest during the study period. There were 10,658 admissions excluded due to not meeting
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28 179 eligibility criteria for age, and 2161 patients were excluded who had a non-specified AMI.
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30 180 After accounting for transfers and multiple admissions, there were 148,722 patients were
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32 181 included in the study (table 1). There were 17,721 deaths within 30 days of admission
33
34 182 (11.9%). A total of 127,268 admissions were linked to an ED presentation (85.6%). The
35
36 183 clinical cohorts comprised between 5,740 (haemorrhagic stroke) and 44,508 (pneumonia)
37
38 184 patients that were admitted or presented to between 133 and 183 hospitals. Characteristics of
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40 185 patients are provided by day of week and time of day of arrival in table 2.
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45 186 The most frequent day of admission was Monday, while Saturdays and Sundays had
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47 187 fewer admissions than weekdays for all conditions. More patients were admitted during
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49 188 daytime than at night, regardless of condition.
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52 189 There were no significant associations in the univariate analyses between mortality
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54 190 and day of week for haemorrhagic stroke, AMI, pneumonia, or CHF (table 3). There was
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3 191 significant variation in unadjusted 30-day mortality by day of week for ischaemic stroke and
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5 192 COPD, however this did not show a strict 'weekend effect' (ischaemic stroke: Friday,
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7 193 Saturday and Sunday significantly higher than Monday; COPD: Thursday, Friday and
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9 194 Saturday significantly higher than Monday).

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12 195 There was no significant difference in 30-day mortality by day of week after
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14 196 adjustment for casemix and other factors for five of the six conditions (table 4, figure 1).
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16 197 While Friday and Sunday presentations had significantly higher mortality than Monday for
17
18 198 ischaemic stroke, overall day of the week was not significant in the model. Significant
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20 199 variation in mortality by day of week for COPD was not consistent with a weekend effect
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22 200 (with Thursday, Friday and Saturday being associated with higher mortality compared with
23
24 201 Monday).

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28 202 There was evidence for higher mortality among ischaemic and haemorrhagic stroke
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30 203 patients admitted/presented to hospital overnight. This night effect was observed in both the
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32 204 unadjusted and adjusted analyses (table 3, table 4). There was no evidence of increased
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34 205 mortality among night admissions/presentations for the other conditions. There were no
35
36 206 significant interactions between day of week and time of day for any of the conditions.

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39 207 The models performed moderately well, with c-statistics ranging from 0.68 to 0.82
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41 208 (ischaemic stroke: 0.73, haemorrhagic stroke: 0.68, AMI: 0.81, pneumonia: 0.82, COPD:
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43 209 0.74, CHF: 0.72).

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3 212 **DISCUSSION**

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6 213 *Main findings*

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8 214 Mortality outcomes do not vary in accordance with the weekend effect, after adjusting for
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10 215 casemix, for patients admitted to hospital with stroke, AMI, pneumonia, COPD, or CHF in
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12 216 NSW. We found increased mortality for stroke patients presenting to hospital at night, with
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14
15 217 no evidence for the night effect for the remaining conditions.

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18 218 Our findings support a growing body of evidence that disputes the ubiquity of the
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20 219 weekend effect.^{6,11,13,14,23,24} Of the six conditions investigated in this study, only ischaemic
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22 220 stroke and COPD showed significant variation in crude mortality risk by day of week of
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24 221 presentation. Significant variation remained after risk adjustment for COPD only, and this
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26 222 was not consistent with predictions for the weekend effect, with the highest odds of death
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28 223 occurring on Thursday and Friday. This is consistent with studies which have shown more
29
30 224 complex patterns of temporal variation in that there are some days/times that are different but
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32 225 not specifically ‘the weekend’.²⁴

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36 226 While findings from previous studies for stroke^{10,13,25,26}, AMI^{14,27} and COPD^{14,28} have
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38 227 been conflicting, our results are consistent with those that found no weekend effect
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40 228 (stroke^{1,13,24,29}, AMI^{1,30}, COPD¹⁴). Few studies have examined the weekend effect for patients
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42 229 with pneumonia, however our findings contrast with those of Suissa *et al.*³¹, which showed
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44 230 higher in-hospital mortality for in-patients staying over the weekend with either pneumonia
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46 231 or COPD, regardless of day of admission.

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50 232 We found a significantly higher adjusted risk of death for ischaemic and
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52 233 haemorrhagic stroke patients admitted at night compared to those admitted during the day.
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54 234 This is consistent with other studies of stroke.^{24,25} This finding may reflect factors specific to

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3 235 stroke, such as that strokes occurring at night may take longer to recognise due to reduced
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5 236 activity, and may result in delayed seeking of treatment and therefore higher mortality. That
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7 237 we only observed the night effect for stroke patients suggests that this variation is probably
8
9 238 not attributable to system-wide deficiencies. However, further research to explore reasons for
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11 239 the increase in mortality for stroke patients admitted at night, and the observed variation in
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13 240 mortality for COPD by day of presentation, and will help to understand whether these excess
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15 241 deaths are preventable.

16 17 18 19 242 *Strengths and limitations*

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21
22 243 The conditions we have examined are useful indicators that encompass a range of
23
24 244 time sensitivity, interventions, acuity and prognosis. The use of clinical cohorts of patients
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26 245 allows more precise adjustment for casemix than considering non-specific admissions or
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28 246 presentations. We found no weekend effect either in conditions expected to be less sensitive
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30 247 to reduced staffing and services, nor among the more severe, acute conditions, which confers
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32 248 confidence in the validity of our findings.

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36 249 The use of linked data provides complete coverage of hospital admissions for the
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38 250 conditions of interest in NSW, and minimises several potential biases. Linkage to the Deaths
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40 251 Register provided advantages over many previous studies, capturing death outside of hospital
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42 252 to provide a more complete picture of mortality. While most studies use either hospitalisation
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44 253 data or ED data, the use of linked data in this study minimises misclassification bias in day
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46 254 and time of presentation caused by time spent in ED prior to admission. The use of
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48 255 hospitalisation data from the index and historical admissions of the patients allowed us to
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50 256 maximise the detail and quality of diagnoses and comorbidities. Further, that analysis of three
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52 257 years' complete population data for NSW meant that our cohorts ranged from over 5000 to
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54 258 44,000, which should provide sufficient power to detect statistically significant differences.

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3 259 However, it would be interesting to consider the results on the level of individual
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5 260 hospitals, as hospitals may vary in quality of care on weekends, which may be masked in this
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7 261 type of global analysis.
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10 262 Mortality is a useful indicator for health system performance and for evaluating
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12 263 unwarranted variation. However, it is an extreme outcome, and it may be a blunt tool that
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14 264 could mask some variation in patient outcomes. Further research is needed to determine
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16 265 whether the lower staffing levels and resource access on weekends and out-of-hours may
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18 266 exhibit effects on other outcomes or processes, such as adverse events, delays in care, or
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20 267 other quality indicators.
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27 269 **CONCLUSION**

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30 270 We found no evidence for a weekend effect in 30-day mortality for patients admitted
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32 271 with ischaemic or haemorrhagic stroke, AMI, pneumonia, COPD, or CHF. The finding of a
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34 272 night effect for stroke, and variation between days for COPD, highlights that temporal
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36 273 variation in patient outcomes is more complex than the weekend effect, and may have a
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38 274 variety of causes. Our study provides evidence that differences in services provided out-of-
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40 275 hours does not cause temporal variation in mortality outcomes, and suggest that causal links
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42 276 proposed between about hospital staffing and services on weekends and patient mortality may
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44 277 be unwarranted.
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3 280 **Acknowledgements**
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6 281 We thank the NSW Ministry of Health for access to population health data and the NSW
7
8 282 Centre for Health Record Linkage for linking the data sets. We thank Lisa Corscadden for
9
10 283 helpful comments on the manuscript. HJB is supported by the NSW Biostatistics Training
11
12 284 Program.
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15 285 **Contributors**
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17

18 286 HJB, SMP, HYC, JK, KS and JFL contributed to the study design. HJB and SMP cleaned and
19
20 287 analysed the data and HJB produced the figure and tables. All authors contributed to the
21
22 288 interpretation of the results. HJB drafted the manuscript, and all authors contributed to
23
24 289 revising the manuscript. All authors approved the final version of the manuscript.
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27

28 290 **Funding statement**
29
30

31 291 This research received no specific grant from any funding agency in the public, commercial
32
33 292 or not-for-profit sectors.
34
35

36 293 **Competing interests**
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38

39 294 We declare no competing interests.
40
41

42 295 **Data sharing statement**
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45 296 Privacy restrictions for the datasets used in this study prohibit free online availability. Access
46
47 297 to these data may be sought from the data custodians, the New South Wales Ministry of
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49 298 Health.
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301 **REFERENCES**

- 302 1. Bell CM, Redelmeier DA. Mortality among patients admitted to hospitals on
303 weekends as compared with weekdays. *N Engl J Med*. 2001;345(9):663-8.
- 304 2. Lilford RJ, Chen Y-F. The ubiquitous weekend effect: moving past proving it exists
305 to clarifying what causes it. *BMJ Qual Saf*. 2015:bmjqs-2015-004360.
- 306 3. Ruiz M, Bottle A, Aylin PP. The Global Comparators project: international
307 comparison of 30-day in-hospital mortality by day of the week. *BMJ Qual Saf*. 2015:bmjqs-
308 2014-003467.
- 309 4. Concha OP, Gallego B, Hillman K, Delaney GP, Coiera E. Do variations in hospital
310 mortality patterns after weekend admission reflect reduced quality of care or different patient
311 cohorts? A population-based study. *BMJ Qual Saf*. 2014;23(3):215-22.
- 312 5. Vest-Hansen B, Riis AH, Sørensen HT, Christiansen CF. Out-of-hours and weekend
313 admissions to Danish medical departments: admission rates and 30-day mortality for 20
314 common medical conditions. *BMJ Open*. 2015;5(3):e006731.
- 315 6. McKee M. The weekend effect: now you see it, now you don't. *BMJ*. 2016;353:i2750.
- 316 7. Wise J. The weekend effect—how strong is the evidence? *BMJ*. 2016;353.
- 317 8. Ruiz M, Bottle A, Aylin PP. Exploring the impact of consultants' experience on
318 hospital mortality by day of the week: a retrospective analysis of hospital episode statistics.
319 *BMJ Qual Saf*. 2015:bmjqs-2015-004105.
- 320 9. Aldridge C, Bion J, Boyal A, Chen Y-F, Clancy M, Evans T, et al. Weekend specialist
321 intensity and admission mortality in acute hospital trusts in England: a cross-sectional study.
322 *The Lancet*. 2016.
- 323 10. Bray BD, Ayis S, Campbell J, Cloud GC, James M, Hoffman A, et al. Associations
324 between stroke mortality and weekend working by stroke specialist physicians and registered
325 nurses: prospective multicentre cohort study. *PLoS Med*. 2014;11(8):e1001705.

- 1
2
3 326 11. Meacock R, Anselmi L, Kristensen SR, Doran T, Sutton M. Higher mortality rates
4 327 amongst emergency patients admitted to hospital at weekends reflect a lower probability of
5
6 328 admission. *J Health Serv Res Policy*. 2016;0(0):1-8.
7
8
9 329 12. Anselmi L, Meacock R, Kristensen SR, Doran T, Sutton M. Arrival by ambulance
10 330 explains variation in mortality by time of admission: retrospective study of admissions to
11 331 hospital following emergency department attendance in England. *BMJ Qual Saf*. 2016:bmjqs-
12 332 2016-005680.
13
14
15
16
17 333 13. Li L, Rothwell PM. Biases in detection of apparent “weekend effect” on outcome
18 334 with administrative coding data: population based study of stroke. *BMJ*. 2016;353.
19
20
21 335 14. Clarke M, Wills RA, Bowman R, Zimmerman P, Fong K, Coory M, et al. Exploratory
22 336 study of the ‘weekend effect’ for acute medical admissions to public hospitals in Queensland,
23 337 Australia. *Intern Med J*. 2010;40(11):777-83.
24
25
26
27
28 338 15. Singla AA, Guy GS, Field JB, Ma N, Babidge WJ, Maddern GJ. No weak days?
29 339 Impact of day in the week on surgical mortality. *ANZ J Surg*. 2015.
30
31
32 340 16. Coiera E, Wang Y, Magrabi F, Concha OP, Gallego B, Runciman W. Predicting the
33 341 cumulative risk of death during hospitalization by modeling weekend, weekday and diurnal
34 342 mortality risks. *BMC Health Serv Res*. 2014;14(1):1.
35
36
37
38
39 343 17. Bhonagiri D, Pilcher DV, Bailey MJ. Increased mortality associated with after-hours
40 344 and weekend admission to the intensive care unit: a retrospective analysis. *Med J Aust*.
41 345 2011;194(6):287-92.
42
43
44
45 346 18. Bureau of Health Information. Hospital Quarterly Technical supplement: Measures of
46 347 emergency department performance and activity. April to June 2010. Sydney (NSW); 2010.
47
48
49 348 19. Bureau of Health Information. Hospital Quarterly Technical Supplement: Measures of
50 349 emergency department performance, January to March 2012. Sydney (NSW); 2012.
51
52
53
54 350 20. Bureau of Health Information. Spotlight on measurement: 30-day mortality following
55 351 hospitalisation, five clinical conditions, NSW, July 2009 - June 2012. Sydney (NSW), 2013.
56
57
58
59
60

- 1
2
3 352 21. Australian Commission of Safety and Quality in Health Care. National core, hospital-
4 353 based outcome indicator specification. Consultation Draft. Sydney: ACSQHC; 2012.
5
6
7 354 22. Hosmer D, Lemeshow S, May S. Applied survival analysis. Hoboken. NJ: John Wiley
8 355 & Sons; 2008.
9
10
11
12 356 23. Mikulich O, Callaly E, Bennett K, O'Riordan D, Silke B. The increased mortality
13 357 associated with a weekend emergency admission is due to increased illness severity and
14 358 altered case-mix. *Acute Med.* 2010;10(4):182-7.
15
16
17
18 359 24. Bray BD, Cloud GC, James MA, Hemingway H, Paley L, Stewart K, et al. Weekly
19 360 variation in health-care quality by day and time of admission: a nationwide, registry-based,
20 361 prospective cohort study of acute stroke care. *The Lancet.* 2016.
21
22
23
24 362 25. Sorita A, Ahmed A, Starr SR, Thompson KM, Reed DA, Dabrh AMA, et al. Off-hour
25 363 presentation and outcomes in patients with acute ischemic stroke: a systematic review and
26 364 meta-analysis. *Eur J Intern Med.* 2014;25(4):394-400.
27
28
29
30
31 365 26. Roberts SE, Thorne K, Akbari A, Samuel DG, Williams JG. Mortality following
32 366 stroke, the weekend effect and related factors: record linkage study. *PLoS One.*
33 367 2015;10(6):e0131836.
34
35
36
37 368 27. Sorita A, Ahmed A, Starr SR, Thompson KM, Reed DA, Prokop L, et al. Off-hour
38 369 presentation and outcomes in patients with acute myocardial infarction: systematic review
39 370 and meta-analysis. *BMJ.* 2014;348:f7393.
40
41
42
43 371 28. Barba R, Zapatero A, Losa JE, Marco J, Plaza S, Rosado C, et al. The impact of
44 372 weekends on outcome for acute exacerbations of COPD. *Eur Respir J.* 2012;39(1):46-50.
45
46
47
48 373 29. Turin TC, Kita Y, Rumana N, Ichikawa M, Sugihara H, Morita Y, et al. Case fatality
49 374 of stroke and day of the week: is the weekend effect an artifact? *Cerebrovasc Dis.*
50 375 2008;26(6):606-11.
51
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3 376 30. Hansen KW, Hvelplund A, Abildstrøm SZ, Prescott E, Madsen M, Madsen JK, et al.
4 377 Prognosis and treatment in patients admitted with acute myocardial infarction on weekends
5 378 and weekdays from 1997 to 2009. *Int J Cardiol.* 2013;168(2):1167-73.
6
7
8
9 379 31. Suissa S, Dell’Aniello S, Suissa D, Ernst P. Friday and weekend hospital stays:
10 380 effects on mortality. *Eur Respir J.* 2014;44(3):627-33.
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382 **Table 1.** Numbers of patients admitted to hospital in NSW between July 2009 and June 2012 for the conditions
 383 examined, number and percentage of deaths within 30 days, by day and time of presentation. Only patients who
 384 met the study inclusion criteria are counted.

Condition	Day of week							Time of Day		Total
	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Day	Night	
Ischaemic stroke (145 hospitals)										
Admissions ¹	2240	2168	2082	2070	2010	1868	1916	9858	4496	14354
Deaths	257	281	281	247	291	267	287	1241	670	1911
30-day mortality (%)	11.5	13.0	13.5	11.9	14.5	14.3	15.0	12.6	14.9	13.3
Haemorrhagic stroke (133 hospitals)										
Admissions ¹	905	894	818	830	853	703	737	3676	2064	5740
Deaths	303	296	288	255	286	254	264	1127	819	1946
30-day mortality (%)	33.5	33.1	35.2	30.7	33.5	36.1	35.8	30.7	39.7	33.9
Acute myocardial infarction (172 hospitals)										
Admissions ¹	4493	4332	4248	4241	4388	4004	3869	16309	13266	29575
Deaths	331	321	320	337	347	292	290	1233	1005	2238
30-day mortality (%)	7.4	7.4	7.5	8.0	7.9	7.3	7.5	7.6	7.6	7.6
Pneumonia (183 hospitals)										
Admissions ¹	7097	6354	6419	6366	6489	5754	6029	27382	17126	44508
Deaths	775	627	703	677	679	667	656	2929	1855	4784
30-day mortality (%)	10.9	9.9	11.0	10.6	10.5	11.6	10.9	10.7	10.8	10.8
Chronic obstructive pulmonary disease (177 hospitals)										
Admissions ¹	4794	4272	4193	4114	4116	3664	3786	17674	11265	28939
Deaths	459	436	426	476	479	408	367	1891	1160	3051
30-day mortality (%)	9.6	10.2	10.2	11.6	11.6	11.1	9.7	10.7	10.3	10.5
Congestive heart failure (177 hospitals)										
Admissions ¹	4325	3935	3828	3799	3780	2962	2977	16046	9560	25606
Deaths	628	568	577	549	566	462	441	2369	1422	3791
30-day mortality (%)	14.5	14.4	15.1	14.5	15.0	15.6	14.8	14.8	14.9	14.8

385 ¹Day of admission or preceding/related emergency department presentation

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387 **Table 2.** Demographic and clinical characteristics of patients with acute, emergency hospital admissions for the
 388 conditions of interest by time of admission, NSW, July 2009 - June 2012. Conditions included are ischaemic
 389 stroke, haemorrhagic stroke, acute myocardial infarction, pneumonia, chronic obstructive pulmonary disease,
 390 and congestive heart failure.

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Characteristic	Day of week		Time of day	
	Weekday	Weekend	Day	Night
	N = 110,453 (%)	N = 38,269 (%)	N = 90,945 (%)	N = 57,777 (%)
Age groups				
15-39	4,361 (4.0)	1,580 (4.1)	3,501 (3.9)	2,440 (4.2)
40-59	16,623 (15.1)	5,804 (15.2)	13,044 (14.3)	9,383 (16.2)
60-79	46,943 (42.5)	16,178 (42.3)	38,593 (42.4)	24,528 (42.5)
80+	42,526 (38.5)	14,707 (38.4)	35,807 (39.4)	21,426 (37.1)
Age (years; median (IQR))	75.8 (63.9-84.1)	75.8 (63.7-84.2)	76.2 (64.5-84.3)	75.1 (62.9-83.9)
Gender				
Female	50,318 (45.6)	17,407 (45.5)	42,300 (46.5)	25,425 (44.0)
Male	60,135 (54.4)	20,862 (54.5)	48,645 (53.5)	32,352 (56.0)
Charlson comorbidity index				
0	74,780 (67.7)	25,954 (67.8)	61,248 (67.4)	39,486 (68.3)
1-2	28,678 (26.0)	9,859 (25.8)	23,930 (26.3)	14,607 (25.3)
3+	6,995 (6.3)	2,456 (6.4)	5,767 (6.3)	3,684 (6.4)
Admitted via ED	93,799 (84.9)	33,469 (87.5)	76,835 (84.5)	50,433 (87.3)

392 Day = 08:00-17:59, night = 18:00-07:59, ED = emergency department

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395 **Table 3.** Unadjusted odds ratios for 30-day mortality for day of week and time of day of hospital admission or ED presentation. Hospital is included as a random effect.

Variable	Ischaemic stroke		Haemorrhagic stroke		AMI		Pneumonia		COPD		CHF	
	Unadjusted Odds Ratio	P-value	Unadjusted Odds Ratio	P-value	Unadjusted Odds Ratio	P-value	Unadjusted Odds Ratio	P-value	Unadjusted Odds Ratio	P-value	Unadjusted Odds Ratio	P-value
Day of week		0.006		0.271		0.879		0.092		0.003		0.813
Monday	Reference		Reference		Reference		Reference		Reference		Reference	
Tuesday	1.14 (0.95-1.37)	0.152	0.97 (0.80-1.19)	0.789	1.00 (0.86-1.18)	0.964	0.90 (0.80-1.00)	0.052	1.07 (0.93-1.23)	0.332	0.99 (0.88-1.12)	0.927
Wednesday	1.20 (1.00-1.44)	0.051	1.07 (0.88-1.31)	0.493	1.02 (0.87-1.20)	0.787	1.01 (0.90-1.12)	0.916	1.07 (0.93-1.23)	0.354	1.05 (0.93-1.18)	0.462
Thursday	1.04 (0.86-1.25)	0.668	0.87 (0.71-1.07)	0.194	1.08 (0.92-1.27)	0.321	0.97 (0.87-1.08)	0.600	1.24 (1.08-1.42)	0.002	0.99 (0.88-1.13)	0.929
Friday	1.30 (1.09-1.56)	0.004	1.00 (0.82-1.23)	0.969	1.08 (0.92-1.26)	0.355	0.95 (0.85-1.06)	0.346	1.24 (1.08-1.42)	0.002	1.04 (0.92-1.17)	0.566
Saturday	1.28 (1.07-1.54)	0.008	1.12 (0.91-1.38)	0.288	0.99 (0.84-1.16)	0.887	1.07 (0.96-1.20)	0.211	1.18 (1.02-1.36)	0.023	1.09 (0.96-1.24)	0.195
Sunday	1.35 (1.12-1.61)	0.001	1.10 (0.90-1.36)	0.352	1.02 (0.86-1.20)	0.843	1.00 (0.89-1.12)	0.981	1.01 (0.88-1.17)	0.866	1.03 (0.90-1.17)	0.712
Time of day		0.001		<0.001		0.967		0.750		0.231		0.794
Day	Reference		Reference		Reference		Reference		Reference		Reference	
Night	1.22 (1.10-1.35)		1.49 (1.33-1.67)		1.00 (0.92-1.09)		1.01 (0.95-1.07)		0.95 (0.88-1.03)		1.01 (0.94-1.08)	

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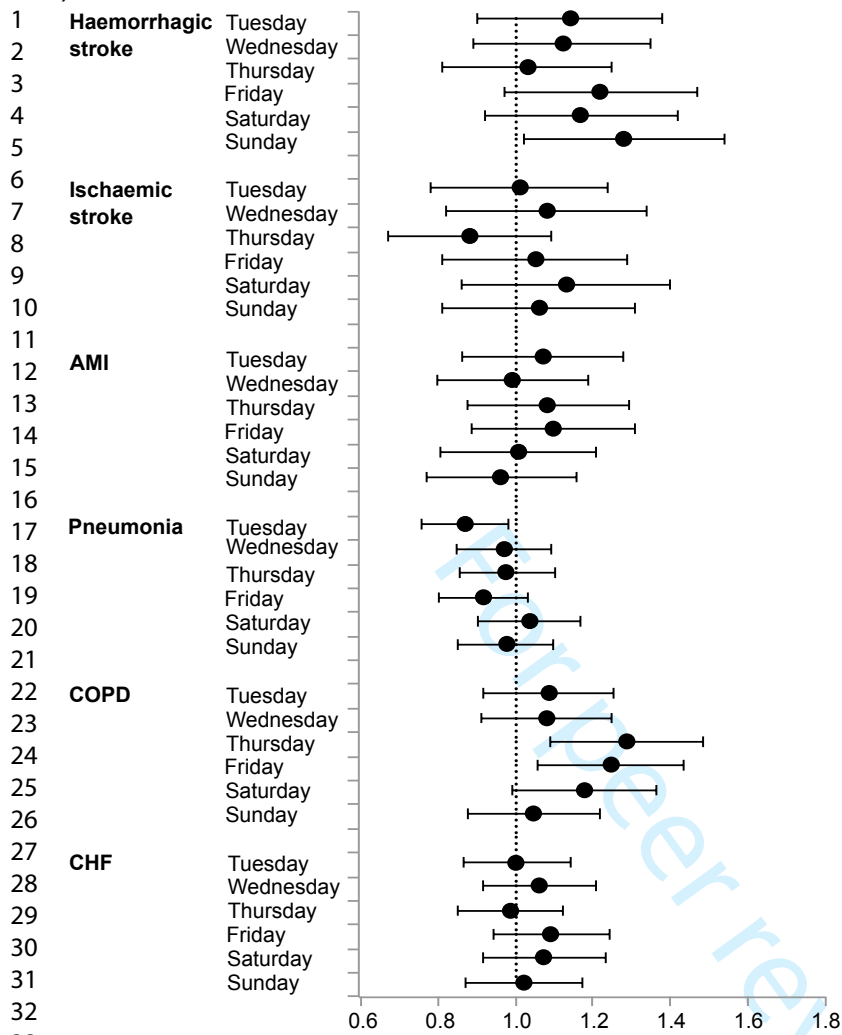
Table 4. Adjusted odds-ratios for 30-day mortality by day of week and time of day of hospital admission or ED presentation. Models were adjusted for age, sex, and comorbidities (final model results for all variables are provided in supplementary table S1). Hospital is included as a random effect.

Variable	Ischaemic stroke		Haemorrhagic stroke		AMI		Pneumonia		COPD		CHF	
	Adjusted Odds Ratio	P-value	Adjusted Odds Ratio	P-value	Adjusted Odds Ratio	P-value	Adjusted Odds Ratio	P-value	Adjusted Odds Ratio	P-value	Adjusted Odds Ratio	P-value
Day of week		0.136		0.404		0.741		0.136		0.003		0.660
Monday	Reference		Reference		Reference		Reference		Reference		Reference	
Tuesday	1.14 (0.95-1.38)	0.167	1.01 (0.82-1.24)	0.926	1.07 (0.90-1.28)	0.451	0.87 (0.77-0.98)	0.023	1.09 (0.94-1.25)	0.269	1.00 (0.88-1.14)	0.971
Wednesday	1.12 (0.93-1.35)	0.242	1.08 (0.88-1.34)	0.451	0.99 (0.83-1.19)	0.936	0.97 (0.86-1.09)	0.606	1.08 (0.93-1.25)	0.298	1.06 (0.93-1.21)	0.373
Thursday	1.03 (0.84-1.25)	0.803	0.88 (0.71-1.09)	0.228	1.08 (0.91-1.29)	0.371	0.98 (0.87-1.10)	0.720	1.29 (1.12-1.48)	0.001	0.99 (0.87-1.12)	0.829
Friday	1.22 (1.01-1.47)	0.039	1.05 (0.85-1.29)	0.653	1.10 (0.92-1.31)	0.303	0.92 (0.81-1.03)	0.156	1.25 (1.08-1.44)	0.002	1.09 (0.96-1.24)	0.175
Saturday	1.17 (0.96-1.42)	0.112	1.13 (0.91-1.40)	0.275	1.01 (0.84-1.21)	0.941	1.03 (0.92-1.17)	0.578	1.18 (1.02-1.37)	0.030	1.07 (0.94-1.23)	0.315
Sunday	1.28 (1.06-1.54)	0.012	1.06 (0.85-1.31)	0.595	0.96 (0.80-1.16)	0.681	0.97 (0.86-1.10)	0.670	1.05 (0.90-1.22)	0.550	1.02 (0.89-1.17)	0.784
Time of day		<0.001		<0.001		0.200		0.861		0.905		0.525
Day	Reference		Reference		Reference		Reference		Reference		Reference	
Night	1.30 (1.17-1.45)		1.58 (1.40-1.78)		1.07 (0.97-1.17)		1.01 (0.94-1.08)		1.00 (0.92-1.08)		1.02 (0.95-1.10)	

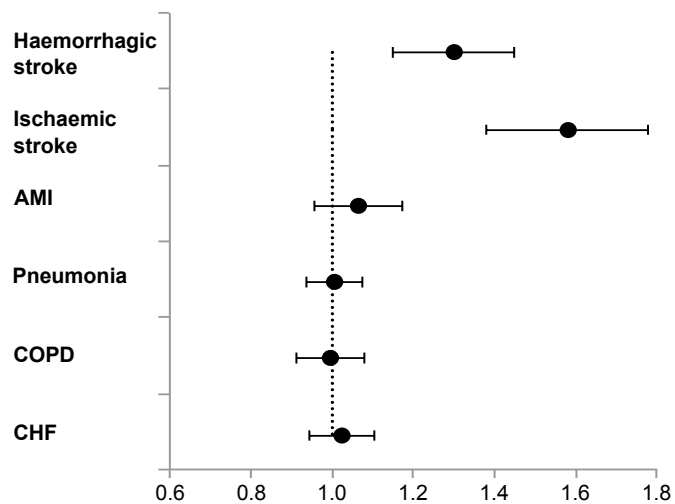
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3 399 **Figure 1.** a) Adjusted odds ratios for 30-day mortality for day of week of presentation by clinical
4 400 condition. Reference group is Monday (dotted line). b) adjusted odds ratios for 30-day mortality for
5 401 presentation to hospital at night compared to during the day, by clinical condition. AMI = acute
6 402 myocardial infarction, COPD = chronic obstructive pulmonary disease, CHF = congestive heart
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SUPPLEMENTARY MATERIAL

Table S1. Final multivariable model results for 30-day mortality by day of week and time of day of hospital or ED presentation for ischaemic and haemorrhagic stroke, AMI, pneumonia, COPD and CHF.

Condition	Odds Ratio	<i>p</i> -value	Condition	Odds Ratio (95% CI)	<i>p</i> -value
Variable	(95% CI)		Variable		
Ischaemic stroke			Haemorrhagic stroke		
Day of week (ref = Mon)		0.136	Day of week (ref = Mon)		0.404
Tuesday	1.14 (0.95-1.38)	0.167	Tuesday	1.01 (0.82-1.24)	0.926
Wednesday	1.12 (0.93-1.35)	0.242	Wednesday	1.08 (0.88-1.34)	0.451
Thursday	1.03 (0.84-1.25)	0.803	Thursday	0.88 (0.71-1.09)	0.228
Friday	1.22 (1.01-1.47)	0.039	Friday	1.05 (0.85-1.29)	0.653
Saturday	1.17 (0.96-1.42)	0.112	Saturday	1.13 (0.91-1.40)	0.275
Sunday	1.28 (1.06-1.54)	0.012	Sunday	1.06 (0.85-1.31)	0.595
Night	1.30 (1.17-1.45)	<0.001	Night	1.58 (1.40-1.78)	<0.001
Sex (ref = male)	1.32 (1.19-1.47)	<0.001	Sex (ref = male)	1.39 (1.24-1.56)	<0.001
Age (centred)	1.06 (1.06-1.07)	<0.001	Age (centred)	1.04 (1.04-1.05)	<0.001
Age (squared)	1.00 (1.00-1.00)	<0.001	Heart	1.47 (1.16-1.87)	0.001
Kidney	1.70 (1.48-1.97)	<0.001	Malignancy	2.75 (2.20-3.45)	<0.001
Heart	1.95 (1.66-2.28)	<0.001	Previous H-stroke	0.61 (0.48-0.77)	<0.001
Malignancy	2.64 (2.15-3.24)	<0.001			
AMI			Pneumonia		
Day of week (ref = Mon)		0.741	Day of week (ref=Mon)		0.136
Tuesday	1.07 (0.90-1.28)	0.451	Tuesday	0.87 (0.77-0.98)	0.023
Wednesday	0.99 (0.83-1.19)	0.936	Wednesday	0.97 (0.86-1.09)	0.606

Thursday	1.08 (0.91-1.29)	0.371	Thursday	0.98 (0.87-1.10)	0.720
Friday	1.10 (0.92-1.31)	0.303	Friday	0.92 (0.81-1.03)	0.156
Saturday	1.01 (0.84-1.21)	0.941	Saturday	1.03 (0.92-1.17)	0.578
Sunday	0.96 (0.80-1.16)	0.681	Sunday	0.97 (0.86-1.10)	0.670
Night	1.07 (0.97-1.17)	0.200	Night	1.01 (0.94-1.08)	0.861
Age (centred)	1.06 (1.05-1.06)	<0.001	Financial year (ref = 2009)		<0.001
Age (squared)	1.00 (1.00-1.00)	<0.001	2010	0.89 (0.82-0.96)	0.004
STEMI	2.71 (2.44-3.01)	<0.001	2011	0.73 (0.67-0.79)	<0.001
Dementia	2.10 (1.77-2.48)	<0.001	Age (centred)	1.05 (1.05-1.05)	<0.001
Hypotension	1.29 (1.14-1.46)	<0.001	Age (squared)	1.00 (1.00-1.00)	<0.001
Shock	9.38 (7.79-11.30)	<0.001	Dementia	2.66 (2.42-2.92)	<0.001
Kidney	2.32 (2.07-2.60)	<0.001	Hypotension	1.19 (1.09-1.30)	<0.001
Heart	1.77 (1.58-1.98)	<0.001	Shock	4.03 (3.35-4.85)	<0.001
Dysrhythmia	1.72 (1.55-1.90)	<0.001	Kidney	1.93 (1.79-2.09)	<0.001
Malignancy	2.38 (1.94-2.92)	<0.001	Heart	1.60 (1.48-1.74)	<0.001
Hypertension	0.67 (0.61-0.74)	<0.001	Dysrhythmia	1.35 (1.24-1.46)	<0.001
Cerebrovascular	2.34 (1.95-2.81)	<0.001	Malignancy	5.53 (5.06-6.05)	<0.001
			Hypertension	0.79 (0.73-0.86)	<0.001
			Cerebrovascular	1.94 (1.69-2.22)	<0.001
			Other COPD	1.17 (1.08-1.28)	<0.001
			Liver disease	2.21 (1.78-2.76)	<0.001
			Parkinsons	1.70 (1.36-2.12)	<0.001
COPD			CHF		
Day of week (ref = Mon)		0.003	Day of week (ref=Mon)		0.660
Tuesday	1.09 (0.94-1.25)	0.269	Tuesday	1.00 (0.88-1.14)	0.971
Wednesday	1.08 (0.93-1.25)	0.298	Wednesday	1.06 (0.93-1.21)	0.373
Thursday	1.29 (1.12-1.48)	0.001	Thursday	0.99 (0.87-1.12)	0.829

Friday	1.25 (1.08-1.44)	0.002	Friday	1.09 (0.96-1.24)	0.175
Saturday	1.18 (1.02-1.37)	0.030	Saturday	1.07 (0.94-1.23)	0.315
Sunday	1.05 (0.90-1.22)	0.550	Sunday	1.02 (0.89-1.17)	0.784
Night	1.00 (0.92-1.08)	0.905	Night	1.02 (0.95-1.10)	0.525
Financial year (ref = 2009)		<0.001	Financial year (ref = 2009)		<0.001
2010	0.77 (0.70-0.85)	<0.001	2010	0.89 (0.81-0.97)	0.009
2011	0.50 (0.45-0.55)	<0.001	2011	0.67 (0.62-0.74)	<0.001
Prev acute COPD episode (ref = 0)^		<0.001	Prev acute CHF episode (ref = 0)^		<0.001
1 previous episode	1.67 (1.51-1.85)	<0.001	1 previous episode	1.39 (1.26-1.52)	<0.001
2 previous episodes	2.13 (1.86-2.43)	<0.001	2 previous episodes	1.70 (1.48-1.97)	<0.001
3+ previous episodes	3.04 (2.69-3.44)	<0.001	3+ previous episodes	2.52 (2.14-2.96)	<0.001
Sex (ref=male)	0.82 (0.76-0.89)	<0.001	Sex (ref = male)	0.90 (0.84-0.97)	0.008
Age (centred)	1.03 (1.03-1.04)	<0.001	Age (centred)	1.05 (1.05-1.06)	<0.001
Age (squared)	1.00 (1.00-1.00)	0.013	Age (squared)	1.00 (1.00-1.00)	0.003
CHF	1.47 (1.34-1.61)	<0.001	Pulmonary circ. disord.	1.21 (1.09-1.35)	<0.001
Pulmonary circ. disord.	1.66 (1.46-1.89)	<0.001	Peripheral vascular disord.	1.19 (1.04-1.37)	0.013
Neurological disord.	1.31 (1.05-1.64)	0.016	Hypertension (comp/uncomp)	0.83 (0.77-0.90)	<0.001
Diabetes (comp.)	0.83 (0.73-0.95)	0.005	Paralysis	1.65 (1.34-2.04)	<0.001
Liver disease	1.98 (1.50-2.61)	<0.001	Neurological disorders	1.65 (1.39-1.97)	<0.001
Metastatic cancer	3.06 (2.38-3.95)	<0.001	Chronic pulmonary disease	1.23 (1.13-1.34)	<0.001
Solid tumour w/o metast.	1.42 (1.17-1.72)	<0.001	Renal failure	1.88 (1.73-2.03)	<0.001
Weight loss	1.89 (1.68-2.11)	<0.001	Liver disease	2.78 (2.29-3.38)	<0.001
Fluid/electrolyte dis.	1.81 (1.66-1.98)	<0.001	Lymphoma	2.24 (1.57-3.19)	<0.001
Psychoses	2.10 (1.47-3.00)	<0.001	Metastatic cancer	3.07 (2.44-3.86)	<0.001
			Coagulopathy	1.29 (1.15-1.46)	<0.001
			Weight loss	1.61 (1.43-1.83)	<0.001
			Fluid/electrolyte disorders	1.57 (1.45-1.69)	<0.001
			Deficiency anaemia	0.78 (0.68-0.90)	<0.001

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STROBE Statement—Checklist of items that should be included in reports of *cohort studies*

	Item No	Recommendation	Checked (page #)
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5-6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	6-7
		(b) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-7
Bias	9	Describe any efforts to address potential sources of bias	6-7
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7-8
		(b) Describe any methods used to examine subgroups and interactions	7
		(c) Explain how missing data were addressed	6
		(d) If applicable, explain how loss to follow-up was addressed	NA
		(e) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8, 19
		(b) Indicate number of participants with missing data for each variable of interest	8
		(c) Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	Report numbers of outcome events or summary measures over time	18
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear	20,21

		which confounders were adjusted for and why they were included	
		(b) Report category boundaries when continuous variables were categorized	NA
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	considered
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10,11
Discussion			
Key results	18	Summarise key results with reference to study objectives	9
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	10,11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11,12
Generalisability	21	Discuss the generalisability (external validity) of the study results	11,12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	12

*Give information separately for exposed and unexposed groups.

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

BMJ Open

Is the weekend effect really ubiquitous? Retrospective clinical cohort analyses of 30-day mortality by day of week and time of day using linked population data from New South Wales, Australia

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2017-016943.R1
Article Type:	Research
Date Submitted by the Author:	15-Sep-2017
Complete List of Authors:	Baldwin, Heather; Bureau of Health Information; New South Wales Ministry of Health Marashi-Pour, Sadaf; Bureau of Health Information Chen, Hwei-Yang ; Bureau of Health Information Kaldor, Jill; Bureau of Health Information Sutherland, Kim; Bureau of Health Information Levesque, Jean-Frederic; Bureau of Health Information, ; University of New South Wales, Centre for Primary Health Care and Equity
Primary Subject Heading:	Health services research
Secondary Subject Heading:	Health services research, Health policy, Public health
Keywords:	PUBLIC HEALTH, HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Quality in health care < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

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1 Is the weekend effect really ubiquitous? Retrospective clinical cohort
2 analyses of 30-day mortality by day of week and time of day using
3 linked population data from New South Wales, Australia

4
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19 Word count (abstract + body): 3401

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22 ABSTRACT

23 Objective

24 To examine the associations between day of week and time of admission and 30-day
25 mortality for six clinical conditions: ischaemic and haemorrhagic stroke, acute myocardial
26 infarction, pneumonia, chronic obstructive pulmonary disease and congestive heart failure.

27 Design

28 Retrospective population-based cohort analyses. Hospitalisation records were linked to
29 emergency department and deaths data. Random effect logistic regression models were used,
30 adjusting for casemix and taking into account clustering within hospitals.

31 Setting

32 All hospitals in New South Wales, Australia from July 2009 to June 2012.

33 Participants

34 Patients admitted to hospital with a primary diagnosis for one of the six clinical conditions
35 examined.

36 Outcome measures

37 Adjusted odds ratios for all-cause mortality within 30 days of admission, by day of week and
38 time of day.

39 Results

40 A total of 148,722 patients were included in the study, with 17,721 deaths within 30 days of
41 admission. Day of week of admission was not associated with significantly higher likelihood
42 of death for five of the six conditions after adjusting for casemix. There was significant
43 variation in mortality for chronic obstructive pulmonary disease by day of week, however,
44 this was not consistent with a strict weekend effect (Thursday: OR 1.29, 95% CI 1.12–1.48;
45 Friday: OR 1.25, 95%CI 1.08–1.44; Saturday: OR 1.18, 95% CI 1.02–1.37; Sunday OR 1.05,
46 95% CI 0.90–1.22; compared to Monday). There was evidence for a night effect for patients
47 admitted for stroke (ischaemic: OR 1.30, 95% CI 1.17–1.45; haemorrhagic: OR 1.58, 95% CI
48 1.40–1.78).

49 **Conclusions**

50 Mortality outcomes for these conditions, adjusted for casemix, do not vary in accordance
51 with the weekend effect hypothesis. Our findings support a growing body of evidence that
52 questions the ubiquity of the weekend effect.

54 **Keywords**

55 Weekend effect, night effect, out-of-hours effect, stroke, AMI, pneumonia, COPD, CHF

57 **Article summary**

58 *Strengths and limitations of this study*

- 59 • The examined conditions encompass a range of time sensitivity, interventions, acuity
60 and prognosis, providing a gradient to assess potential causality of association.
- 61 • The use of linked hospital admission and emergency department (ED) data allowed
62 complete coverage of hospital admissions for the state, while minimising
63 misclassification bias from time spent in ED and maximising validity and quality of
64 diagnosis and comorbidity data.
- 65 • The use of clinical cohorts of patients allows more precise adjustment for casemix
66 than non-specific admissions.
- 67 • Linkage to the Deaths Register allowed the capture of 30-day all-cause mortality.
68 While mortality is a standard indicator, other outcomes may be more sensitive to
69 variation in patient outcomes.
- 70 • We focussed on the NSW health system as a whole and did not explore the possible
71 weekend effect at hospital level.

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56 73 **INTRODUCTION**
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8 74 In recent years, researchers and policy makers have shown growing interest in the
9
10 75 ‘weekend effect’, examining whether patients admitted to hospital at the weekend experience
11
12 76 worse outcomes compared to patients admitted during the week. This effect has been
13
14 77 observed in numerous studies of health systems around the world, for a wide range of
15
16 78 conditions and procedures.¹⁻⁶ Studies have also observed a ‘night effect’, suggesting that the
17
18 79 phenomenon may extend to out-of-hours presentation more broadly.¹⁻⁴
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22 80 Considerable uncertainty remains as to the cause of the apparent effect of weekend
23
24 81 and night-time (hereafter collectively ‘out-of-hours’) presentation on patient outcomes. Two
25
26 82 main hypotheses have been proposed to explain the observed variation: these focus on
27
28 83 healthcare service quality and on patient characteristics.² The first hypothesis posits that the
29
30 84 poorer outcomes seen among patients admitted on the weekend are explained by lower
31
32 85 quality of care out-of-hours. More specifically, putative factors include lower staffing levels,
33
34 86 fewer senior consultants and specialists, and reduced availability of diagnostic procedures.³
35
36 87 This hypothesis gained considerable traction with policy makers and has contributed to the
37
38 88 recent, controversial push towards seven day hospital services in the UK.⁷
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42 89 The second hypothesis proposes that the weekend effect is largely attributable to
43
44 90 patient characteristics, and at least partly an artefact of the data. There is little clear evidence
45
46 91 that higher mortality is a consequence of staffing levels⁷, and a number of studies have found
47
48 92 no significant correlation between consultant seniority or specialist availability and
49
50 93 mortality.⁸⁻¹¹ There is also an increasing body of evidence to suggest that the weekend effect
51
52 94 dissipates after adjustment for casemix¹², arrival by ambulance as a proxy for illness
53
54 95 severity¹³ and a higher severity threshold for admission.¹² This phenomenon may also be
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3 96 influenced by self-selection, whereby patients wait until the weekend to present to hospital
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5 97 and may therefore present with more advanced disease, and less comprehensive note-taking
6
7 98 on the weekend limiting the ability to risk-adjust.¹⁴
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10 99 The night effect is less extensively studied than the weekend effect, and reasons for
11
12 100 the night effect are usually presumed to be similar to the weekend effect. The few studies that
13
14 101 have examined the effects of out-of-hours presentation on mortality in Australia have had
15
16 102 mixed results.^{3,4,15,16} Previous studies have been limited by using in-hospital mortality only
17
18 103 and therefore not capturing deaths that occurred post-discharge¹⁷, reduced ability to
19
20 104 adequately risk adjust by focusing on clinically non-specific admissions.^{3,16,18} Further,
21
22 105 previous studies have often relied on unlinked emergency department (ED) data⁴, which
23
24 106 contain limited and largely incomplete and inaccurate information on principle diagnosis and
25
26 107 comorbidity, or unlinked hospitalisation data, which may be affected by misclassification
27
28 108 bias due to time spent in waiting in ED prior to admission.^{15,18}
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32 109 Overall, previous studies have shown that the out-of-hours effect does not apply to
33
34 110 all clinical presentations and procedures.^{1-4,8} It is therefore beneficial to investigate conditions
35
36 111 for which we can expect that the weekend is more likely to occur, based on theoretical
37
38 112 grounds, on clinical plausibility or on previous evidence.²
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42 113 We investigated the existence of the weekend effect and the night effect for acute
43
44 114 hospitalisations for various conditions, comprising ischaemic stroke, haemorrhagic stroke,
45
46 115 acute myocardial infarction (AMI), pneumonia, chronic obstructive pulmonary disease
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48 116 (COPD), and congestive heart failure (CHF), across all hospitals in New South Wales
49
50 117 (NSW). These conditions provide insights into a range of aspects of healthcare, including
51
52 118 timely delivery of interventions, surgical services, differences in acuity and prognosis, and
53
54 119 provide a gradient to assess potential causality of association as they vary in the importance
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3 120 of immediate care. We predicted that if day and time effects exist, they would show strongest
4
5 121 effects for the most urgent conditions (stroke and AMI), and be weakest for patients with the
6
7 122 least urgent conditions (pneumonia and COPD). We hypothesized that presentations on
8
9 123 Saturdays and Sundays would show higher 30-day mortality for the six conditions than
10
11 124 presentations that occurred during the week, and that night-time presentations would show
12
13 125 higher mortality than presentations that occurred during the day.
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17 126

19 127 **METHODS**

22 128 Retrospective cohort analyses were performed for the six indicator conditions. Cohorts were
23
24 129 identified from all admissions to NSW public and private hospitals for the period of 1 July
25
26 130 2009 to 30 June 2012, extracted from the NSW Admitted Patient Data Collection, which is a
27
28 131 census of all hospital admissions in NSW. These data were linked to emergency department
29
30 132 (ED) attendances in all NSW public hospitals recorded in the Emergency Department Data
31
32 133 Collection, representing approximately 85% of all emergency presentations in NSW.^{19,20}
33
34 134 Emergency department data were linked to allow the capture of the start day and time of the
35
36 135 patients' contact with the hospital system for the episode of illness, minimising any bias
37
38 136 imposed by time spent in the ED that may affect the day and time of hospitalisation, since
39
40 137 patients may spend longer in the ED before admission at night or at weekends. Mortality data
41
42 138 were obtained from the NSW Deaths Register. Data were linked by the NSW Centre for
43
44 139 Health Record Linkage using probabilistic methods based on personal identifiers. The
45
46 140 estimated false positive rate for the current version of the Master Linkage Key is 5 per
47
48 141 1000.²¹
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53 142 The principal diagnosis in the patient record, coded using International Classification
54
55 143 of Diseases 10th revision Australian modification, was used to identify each clinical cohort.
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3 144 Only complete records of admissions coded as acute and emergency were included. The
4
5 145 proportion of records excluded for missing values on key variables such as age, sex, date of
6
7 146 admission and separation, type of care and emergency status was less than 0.1%. Patients
8
9 147 aged less than 15 years (ischaemic stroke, haemorrhagic stroke, AMI), 18 years (pneumonia)
10
11 148 or 45 years (COPD, CHF) were excluded, consistent with existing mortality indicator
12
13 149 definitions for these conditions, due to low mortality rates among these groups.^{22,23} AMI can
14
15 150 be classified as ST-elevated myocardial infarction (STEMI) or non-ST elevated myocardial
16
17 151 infarction (non-STEMI) based on the electrocardiogram reading, or unspecified AMI when
18
19 152 diagnostic records are unavailable. STEMI is associated with higher mortality at 30 days
20
21 153 compared to non-STEMI, and the unspecified group is a heterogeneous mix of critically
22
23 154 unwell patients who died before their AMI could be specified and patients for whom
24
25 155 diagnostic records were less precise, so AMI patients with a non-specific infarction were
26
27 156 excluded to allow adjustment for STEMI.^{22,23} Transfers and multiple contiguous
28
29 157 hospitalisations were considered as a single period of care. For patients with multiple periods
30
31 158 of care during the study period, only the last period of care was included in the analyses.
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36 159 Mortality was defined as death (in or out of hospital) occurring within 30 days of the
37
38 160 start of the period of care. The day of week of presentation was defined as the first day of
39
40 161 contact with the hospital system for the period of care (either hospital admission or ED
41
42 162 presentation). Patients dead on arrival to ED and not admitted to hospital were excluded. An
43
44 163 ED presentation was considered relevant for the hospital admission if it occurred on the same
45
46 164 day, or previous day, as the hospital admission. Same day ED presentations were only
47
48 165 included if the time was recorded as before the hospital admission time. In this study, the
49
50 166 weekend comprises Saturday and Sunday, while weekdays are defined as Monday through
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52 167 Friday. Night time presentation was defined as first presentation between 18:00 and 07:59,
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54 168 using hospital admission time or ED presentation time as described.
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3 169 Random effects logistic regression models were used to investigate associations
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5 170 between day of week, or time of presentation, with mortality. To account for clustering of
6
7 171 patients within hospitals, hospitals were considered as random effects in the regression
8
9 172 models. Risk adjustment was performed to account for casemix factors including age
10
11 173 (continuous, tested for curvilinearity), sex, year and comorbidities. Condition-specific
12
13 174 comorbidity sets defined by the Australian Commission for Safety and Quality in Health Care
14
15 175 were used as the basis for building risk adjustment models for each condition, where
16
17 176 available (ischaemic stroke, haemorrhagic stroke, AMI, pneumonia), while COPD and CHF
18
19 177 used Elixhauser comorbidities.²² Availability of thrombolysis treatment was also considered
20
21 178 as a predictive variable for ischaemic stroke, and STEMI status was considered for AMI.
22
23 179 Comorbidities were captured across all hospital admissions over a one year period prior to the
24
25 180 index admission. Interactions between day of the week and night time presentations were also
26
27 181 explored in the final models using likelihood ratio tests.

31 182 Models were selected using backwards selection.²⁴ Factors with a *p*-value of less than
32
33 183 0.2 in the univariate analyses were included in the initial full models. Variables with a *p*-
34
35 184 value of less than 0.05 were retained in the model. Variables that were not significant at the
36
37 185 20% level in the univariate models were then checked for significance in the backwards-
38
39 186 selected model, and retained in the final model where $p < 0.05$. Overall performance of the
40
41 187 models was assessed using c-statistics. In order to capture daily variation, 30-day mortality
42
43 188 risks for each day of the week were compared against a reference weekday (Monday). We
44
45 189 define observation of a weekend effect as significantly higher odds of 30-day mortality on
46
47 190 weekend days (Saturday and Sunday) compared to Monday. To validate our findings,
48
49 191 additional analyses were performed comparing weekend days against weekdays. Statistical
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51 192 analyses were performed using SAS v9.4 (SAS Institute Inc., Cary, NC, USA) and STATA
52
53 193 v12.1 (StataCorp LP, Texas, USA).

194

195 RESULTS

196 There were a total of 213,834 acute, emergency hospital admissions for the conditions of
197 interest during the study period. There were 10,658 admissions excluded as they did not meet
198 the eligibility criteria for age, and 2161 patients were excluded who had a non-specified AMI.
199 After accounting for transfers and multiple admissions, there were 148,722 patients were
200 included in the study (table 1). There were 17,721 deaths within 30 days of admission
201 (11.9%). A total of 127,268 admissions were linked to an ED presentation (85.6%). The
202 clinical cohorts comprised between 5,740 (haemorrhagic stroke) and 44,508 (pneumonia)
203 patients that were admitted or presented to between 133 and 183 hospitals. Characteristics of
204 patients are provided by day of week and time of day of arrival in table 2.

205 The most frequent day of presentation was Monday, while Saturdays and Sundays had
206 fewer presentations than weekdays for all conditions. More patients were admitted during
207 daytime than at night, regardless of condition.

208 There were no significant associations in the univariate analyses between mortality
209 and day of week, for haemorrhagic stroke, AMI, pneumonia, or CHF (table 3). There was
210 significant variation in unadjusted 30-day mortality by day of week for ischaemic stroke and
211 COPD, however this did not show a strict 'weekend effect' (ischaemic stroke: Friday,
212 Saturday and Sunday significantly higher than Monday; COPD: Thursday, Friday and
213 Saturday significantly higher than Monday).

214 There was no significant difference in 30-day mortality by day of week after
215 adjustment for casemix and other factors for five of the six conditions (table 4, figure 1).
216 While Friday and Sunday presentations had significantly higher mortality than Monday for

1
2
3 217 ischaemic stroke, overall day of the week was not significant in the model. Significant
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5 218 variation in mortality by day of week for COPD was not consistent with a weekend effect
6
7 219 (with Thursday, Friday and Saturday being associated with higher mortality compared with
8
9 220 Monday).

11
12 221 There was evidence for higher mortality among ischaemic and haemorrhagic stroke
13
14 222 patients who presented to hospital overnight. This night effect was observed in both the
15
16 223 unadjusted and adjusted analyses (table 3, table 4). There was no evidence of increased
17
18 224 mortality among night admissions for the other conditions. There were no significant
19
20 225 interactions between day of week and time of day, after adjustment for confounding factors,
21
22 226 for any of the conditions.

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25
26 227 The models performed moderately well, with c-statistics ranging from 0.68 to 0.82
27
28 228 (ischaemic stroke: 0.73, haemorrhagic stroke: 0.68, AMI: 0.81, pneumonia: 0.82, COPD:
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30 229 0.74, CHF: 0.72).

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33 230 Results from the analyses comparing 30-day mortality on pooled weekend versus
34
35 231 weekdays showed that the weekend was associated with a higher unadjusted likelihood of 30-
36
37 232 day mortality compared with weekday for ischaemic stroke and pneumonia (table 5).
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39 233 However, after taking into account other risk factors, no significant differences were
40
41 234 observed in 30-day mortality between weekdays and weekend for any of the conditions
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43 235 studied.

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48 49 50 237 **DISCUSSION**

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53 238 *Main findings*

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3 239 Mortality outcomes do not vary in accordance with the weekend effect, after adjusting for
4
5 240 casemix, for patients admitted to hospital with stroke, AMI, pneumonia, COPD, or CHF in
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7 241 NSW. We found increased mortality for stroke patients presenting to hospital at night, with
8
9 242 no evidence for the night effect for the remaining conditions.

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12 243 Our findings support a growing body of evidence that disputes the ubiquity of the
13
14 244 weekend effect.^{7,12,14,15,25,26} Of the six conditions investigated in this study, only ischaemic
15
16 245 stroke and COPD showed significant variation in crude mortality risk by day of week of
17
18 246 presentation. Significant variation remained after risk adjustment for COPD only, and this
19
20 247 was not consistent with predictions for the weekend effect, with the highest odds of death
21
22 248 within 30 days was found for those who presented on Thursday and Friday. When weekend
23
24 249 and week days were pooled, there were no significant differences in odds of death after
25
26 250 adjusting for other risk factors. This is consistent with studies which have shown more
27
28 251 complex patterns of temporal variation in that there are some days/times that are different but
29
30 252 not specifically 'the weekend'.^{4,17,26,27}

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34 253 While findings from previous studies for stroke^{11,14,28,29}, AMI^{15,30} and COPD^{15,31} have
35
36 254 been conflicting, our results are consistent with those that found no weekend effect
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38 255 (stroke^{1,14,26,32}, AMI^{1,33}, COPD¹⁵). A recent meta-analysis found no weekend effect for COPD
39
40 256 and pneumonia, although it did find significant effects for intracerebral haemorrhage,
41
42 257 ischaemic stroke and myocardial infarction³⁴. However, on comparing effects between
43
44 258 continents, Oceania was found to have the lowest overall increase in odds of death (OR =
45
46 259 1.04; compared to South America, OR = 1.47), suggesting that the weekend effect may be
47
48 260 highly heterogenous and dependent not only on clinical conditions but also on hospital
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50 261 contexts, regional policy and other factors that may vary widely by geographic setting.
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3 262 We observed that the numbers of admissions were lower at weekends in New South
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5 263 Wales, and that the number of deaths within 30 days are generally proportionate to the
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7 264 number of admissions. This is in contrast to the findings of previous studies.^{1,6,12,35} There are
8
9 265 a number of differences between our study and some of the previously published work which
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11 266 may explain these differences. The use of 30-day mortality through linkage to the Deaths
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13 267 Register, as opposed to in-hospital death^{1,3,6,12,13,35} allows the capture not only of patients who
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15 268 died in hospital, but also those died in community due to variation in care or early discharge.
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17
18 269 This provides a more complete picture of mortality.

20
21 270 Further, our study has examined six specific clinical conditions, as opposed to all
22
23 271 emergency conditions.^{3,4,12,35} Not all emergency admissions have the same urgency or acuity
24
25 272 for treatment, and the conditions we have examined are useful indicators that encompass a
26
27 273 range of time sensitivity, interventions, acuity and prognosis. The use of clinical cohorts of
28
29 274 patients allows more precise adjustment for case-mix than considering non-specific
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31 275 admissions. We found no effect on mortality of weekend presentation either in conditions
32
33 276 expected to be less sensitive to reduced staffing and services, nor among the more severe,
34
35 277 acute conditions, which confers confidence in the validity of our findings. Our analyses
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37 278 comprised three years' complete population data for NSW with cohorts ranging from over
38
39 279 5000 to 44,000, which should provide sufficient power to detect statistically significant
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41 280 differences.

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45 281 In contrast to other studies, the use of linked hospitalisation and emergency
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47 282 department data provides complete coverage of hospital admissions for the conditions of
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49 283 interest in NSW, and minimises several potential biases. While most studies use either
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51 284 hospital admission data^{1,6,35} or ED data^{3,4}, the use of linked data in this study minimises
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53 285 misclassification bias in day and time of presentation caused by time spent in ED prior to
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3 286 admission. Additionally, the use of hospitalisation data from the index and historical
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5 287 admissions of the patients allowed us to maximise the detail and quality of diagnoses and
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7 288 comorbidities. This increases our confidence in our finding of no evidence for increased
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9 289 mortality associated with weekend presentation.

10
11 290 We found significantly higher adjusted risk of death for ischaemic and haemorrhagic
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13 291 stroke patients who presented at night compared to those who presented during the day. This
14
15 292 is consistent with other studies of stroke.^{26,28} This finding may reflect factors specific to
16
17 293 stroke, such as that strokes occurring at night may take longer to recognise due to reduced
18
19 294 activity, and may result in delayed seeking of treatment and therefore higher mortality. That
20
21 295 we only observed the night effect for stroke patients suggests that this variation is probably
22
23 296 not attributable to system-wide deficiencies. However, further research to explore reasons for
24
25 297 the increase in mortality for stroke patients admitted at night, and the observed variation in
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27 298 mortality for COPD by day of presentation, including potential contributions from poorer
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29 299 community care, will help to understand whether these excess deaths are preventable.

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34 300 Our study is limited by a lack contextual information in our data about the differences
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36 301 in weekend and weekday or night time and day time practice, such as the availability of
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38 302 clinical or laboratory staff. It would be interesting to consider the results on the level of
39
40 303 individual hospitals, as hospital variation in quality of care on weekends may be masked in
41
42 304 this type of global analysis.

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45 305 Mortality is a useful indicator for health system performance and for evaluating
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47 306 unwarranted variation. However, it is an extreme outcome, and it may be a blunt tool that
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49 307 could mask some variation in patient outcomes. Further research is needed to determine
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51 308 whether the lower staffing levels and resource access on weekends and out-of-hours may
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3 309 exhibit effects on other outcomes or processes, such as adverse events, delays in care, or
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5 310 other quality indicators.
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9
10 312 **CONCLUSION**

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13 313 We found no evidence for a weekend effect in 30-day mortality for patients admitted
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15 314 with ischaemic or haemorrhagic stroke, AMI, pneumonia, COPD, or CHF. The finding of a
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17 315 night effect for stroke, and variation between days for COPD, highlights that temporal
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19 316 variation in patient outcomes is more complex than the weekend effect, and may have a
20
21 317 variety of causes. Our study provides evidence that differences in services provided out-of-
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23 318 hours does not cause temporal variation in mortality outcomes, and suggest that causal links
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25 319 proposed between about hospital staffing and services on weekends and patient mortality may
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28 320 be unwarranted.
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3 321 **Acknowledgements**
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6 322 We thank the NSW Ministry of Health for access to population health data and the NSW
7
8 323 Centre for Health Record Linkage for linking the data sets. We thank Lisa Corscadden for
9
10 324 helpful comments on the manuscript. HJB is supported by the NSW Biostatistics Training
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12 325 Program.
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15 326 **Contributors**
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18 327 HJB, SMP, HYC, JK, KS and JFL contributed to the study design. HJB and SMP cleaned and
19
20 328 analysed the data and HJB produced the figure and tables. All authors contributed to the
21
22 329 interpretation of the results. HJB drafted the manuscript, and all authors contributed to
23
24 330 revising the manuscript. All authors approved the final version of the manuscript.
25
26
27

28 331 **Funding statement**
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30

31 332 This research received no specific grant from any funding agency in the public, commercial
32
33 333 or not-for-profit sectors.
34
35

36 334 **Competing interests**
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39 335 We declare no competing interests.
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42 336 **Data sharing statement**
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45 337 Privacy restrictions for the datasets used in this study prohibit free online availability. Access
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47 338 to these data may be sought from the data custodians, the New South Wales Ministry of
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342 **REFERENCES**

- 343 1. Bell CM, Redelmeier DA. Mortality among patients admitted to hospitals on
344 weekends as compared with weekdays. *N Engl J Med*. 2001;345(9):663-8.
- 345 2. Lilford RJ, Chen Y-F. The ubiquitous weekend effect: moving past proving it exists
346 to clarifying what causes it. *BMJ Qual Saf*. 2015:bmjqs-2015-004360.
- 347 3. Ruiz M, Bottle A, Aylin PP. The Global Comparators project: international
348 comparison of 30-day in-hospital mortality by day of the week. *BMJ Qual Saf*. 2015:bmjqs-
349 2014-003467.
- 350 4. Concha OP, Gallego B, Hillman K, Delaney GP, Coiera E. Do variations in hospital
351 mortality patterns after weekend admission reflect reduced quality of care or different patient
352 cohorts? A population-based study. *BMJ Qual Saf*. 2014;23(3):215-22.
- 353 5. Vest-Hansen B, Riis AH, Sørensen HT, Christiansen CF. Out-of-hours and weekend
354 admissions to Danish medical departments: admission rates and 30-day mortality for 20
355 common medical conditions. *BMJ Open*. 2015;5(3):e006731.
- 356 6. Freemantle N, Richardson M, Wood J, Ray D, Khosla S, Shahian D, et al. Weekend
357 hospitalization and additional risk of death: an analysis of inpatient data. *J R Soc Med*.
358 2012;105(2):74-84.
- 359 7. McKee M. The weekend effect: now you see it, now you don't. *BMJ*. 2016;353:i2750.
- 360 8. Wise J. The weekend effect—how strong is the evidence? *BMJ*. 2016;353.
- 361 9. Ruiz M, Bottle A, Aylin PP. Exploring the impact of consultants' experience on
362 hospital mortality by day of the week: a retrospective analysis of hospital episode statistics.
363 *BMJ Qual Saf*. 2015:bmjqs-2015-004105.
- 364 10. Aldridge C, Bion J, Boyal A, Chen Y-F, Clancy M, Evans T, et al. Weekend specialist
365 intensity and admission mortality in acute hospital trusts in England: a cross-sectional study.
366 *The Lancet*. 2016.

- 1
2
3 367 11. Bray BD, Ayis S, Campbell J, Cloud GC, James M, Hoffman A, et al. Associations
4 368 between stroke mortality and weekend working by stroke specialist physicians and registered
5 369 nurses: prospective multicentre cohort study. *PLoS Med.* 2014;11(8):e1001705.
6
7
8
9 370 12. Meacock R, Anselmi L, Kristensen SR, Doran T, Sutton M. Higher mortality rates
10 371 amongst emergency patients admitted to hospital at weekends reflect a lower probability of
11 372 admission. *J Health Serv Res Policy.* 2016;0(0):1-8.
12
13
14
15 373 13. Anselmi L, Meacock R, Kristensen SR, Doran T, Sutton M. Arrival by ambulance
16 374 explains variation in mortality by time of admission: retrospective study of admissions to
17 375 hospital following emergency department attendance in England. *BMJ Qual Saf.* 2016:bmjqs-
18 376 2016-005680.
19
20
21
22
23 377 14. Li L, Rothwell PM. Biases in detection of apparent “weekend effect” on outcome
24 378 with administrative coding data: population based study of stroke. *BMJ.* 2016;353.
25
26
27
28 379 15. Clarke M, Wills RA, Bowman R, Zimmerman P, Fong K, Coory M, et al. Exploratory
29 380 study of the ‘weekend effect’ for acute medical admissions to public hospitals in Queensland,
30 381 Australia. *Intern Med J.* 2010;40(11):777-83.
31
32
33
34 382 16. Singla AA, Guy GS, Field JB, Ma N, Babidge WJ, Maddern GJ. No weak days?
35 383 Impact of day in the week on surgical mortality. *ANZ J Surg.* 2015.
36
37
38
39 384 17. Coiera E, Wang Y, Magrabi F, Concha OP, Gallego B, Runciman W. Predicting the
40 385 cumulative risk of death during hospitalization by modeling weekend, weekday and diurnal
41 386 mortality risks. *BMC Health Serv Res.* 2014;14(1):1.
42
43
44
45 387 18. Bhonagiri D, Pilcher DV, Bailey MJ. Increased mortality associated with after-hours
46 388 and weekend admission to the intensive care unit: a retrospective analysis. *Med J Aust.*
47 389 2011;194(6):287-92.
48
49
50
51 390 19. Bureau of Health Information. Hospital Quarterly Technical supplement: Measures of
52 391 emergency department performance and activity. April to June 2010. Sydney (NSW); 2010.
53
54
55
56
57
58
59
60

- 1
2
3 392 20. Bureau of Health Information. Hospital Quarterly Technical Supplement: Measures of
4 393 emergency department performance, January to March 2012. Sydney (NSW); 2012.
- 5
6
7 394 21. Centre for Health Record Linkage. CHeReL—quality assurance. 2017. Available at:
8 395 <http://www.cherel.org.au/quality-assurance>. Retrieved May 30, 2017.
- 9
10
11
12 396 22. Bureau of Health Information. Spotlight on measurement: 30-day mortality following
13 397 hospitalisation, five clinical conditions, NSW, July 2009 - June 2012. Sydney (NSW), 2013.
- 14
15
16 398 23. Australian Commission of Safety and Quality in Health Care. National core, hospital-
17 399 based outcome indicator specification. Consultation Draft. Sydney: ACSQHC; 2012.
- 20
21 400 24. Hosmer D, Lemeshow S, May S. Applied survival analysis. Hoboken. NJ: John Wiley
22 401 & Sons; 2008.
- 23
24
25 402 25. Mikulich O, Callaly E, Bennett K, O'Riordan D, Silke B. The increased mortality
26 403 associated with a weekend emergency admission is due to increased illness severity and
27 404 altered case-mix. *Acute Medicine*. 2010;10(4):182-7.
- 28
29
30 405 26. Bray BD, Cloud GC, James MA, Hemingway H, Paley L, Stewart K, et al. Weekly
31 406 variation in health-care quality by day and time of admission: a nationwide, registry-based,
32 407 prospective cohort study of acute stroke care. *The Lancet*. 2016.
- 33
34
35 408 27. Lyndon A, Lee HC, Gay C, Gilbert WM, Gould JB, Lee KA. Effect of time of birth
36 409 on maternal morbidity during childbirth hospitalization in California. *Am J Obstet Gynecol*.
37 410 2015;213(5):705. e1-. e11.
- 38
39
40 411 28. Sorita A, Ahmed A, Starr SR, Thompson KM, Reed DA, Dabrh AMA, et al. Off-hour
41 412 presentation and outcomes in patients with acute ischemic stroke: a systematic review and
42 413 meta-analysis. *Eur J Intern Med*. 2014;25(4):394-400.
- 43
44
45 414 29. Roberts SE, Thorne K, Akbari A, Samuel DG, Williams JG. Mortality following
46 415 stroke, the weekend effect and related factors: record linkage study. *PLoS ONE*.
47 416 2015;10(6):e0131836.

- 1
2
3 417 30. Sorita A, Ahmed A, Starr SR, Thompson KM, Reed DA, Prokop L, et al. Off-hour
4 418 presentation and outcomes in patients with acute myocardial infarction: systematic review
5 419 and meta-analysis. *BMJ*. 2014;348:f7393.
6
7
8
9 420 31. Barba R, Zapatero A, Losa JE, Marco J, Plaza S, Rosado C, et al. The impact of
10 421 weekends on outcome for acute exacerbations of COPD. *Eur Respir J*. 2012;39(1):46-50.
11
12
13 422 32. Turin TC, Kita Y, Rumana N, Ichikawa M, Sugihara H, Morita Y, et al. Case fatality
14 423 of stroke and day of the week: is the weekend effect an artifact? *Cerebrovasc Dis*.
15 424 2008;26(6):606-11.
16
17
18
19
20 425 33. Hansen KW, Hvelplund A, Abildstrøm SZ, Prescott E, Madsen M, Madsen JK, et al.
21 426 Prognosis and treatment in patients admitted with acute myocardial infarction on weekends
22 427 and weekdays from 1997 to 2009. *Int J Cardiol*. 2013;168(2):1167-73.
23
24
25
26 428 34. Hoshijima H, Takeuchi R, Mihara T, Kuratani N, Mizuta K, Wajima Zi, et al.
27 429 Weekend versus weekday admission and short-term mortality: A meta-analysis of 88 cohort
28 430 studies including 56,934,649 participants. *Medicine*. 2017;96(17).
29
30
31
32 431 35. Aylin P, Yunus A, Bottle A, Majeed A, Bell D. Weekend mortality for emergency
33 432 admissions. A large, multicentre study. *Qual Saf Health Care*. 2010;19(3):213-7.
34
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434 **Table 1.** Numbers of patients admitted to hospital in NSW between July 2009 and June 2012 for the conditions
 435 examined, number and percentage of deaths within 30 days, by day and time of presentation¹.

Condition	Day of week							Time of Day		Total
	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Day	Night	
Ischaemic stroke (145 hospitals)										
Admissions ¹	2240	2168	2082	2070	2010	1868	1916	9858	4496	14354
Deaths	257	281	281	247	291	267	287	1241	670	1911
30-day mortality (%)	11.5	13.0	13.5	11.9	14.5	14.3	15.0	12.6	14.9	13.3
Haemorrhagic stroke (133 hospitals)										
Admissions ¹	905	894	818	830	853	703	737	3676	2064	5740
Deaths	303	296	288	255	286	254	264	1127	819	1946
30-day mortality (%)	33.5	33.1	35.2	30.7	33.5	36.1	35.8	30.7	39.7	33.9
Acute myocardial infarction (172 hospitals)										
Admissions ¹	4493	4332	4248	4241	4388	4004	3869	16309	13266	29575
Deaths	331	321	320	337	347	292	290	1233	1005	2238
30-day mortality (%)	7.4	7.4	7.5	8.0	7.9	7.3	7.5	7.6	7.6	7.6
Pneumonia (183 hospitals)										
Admissions ¹	7097	6354	6419	6366	6489	5754	6029	27382	17126	44508
Deaths	775	627	703	677	679	667	656	2929	1855	4784
30-day mortality (%)	10.9	9.9	11.0	10.6	10.5	11.6	10.9	10.7	10.8	10.8
Chronic obstructive pulmonary disease (177 hospitals)										
Admissions ¹	4794	4272	4193	4114	4116	3664	3786	17674	11265	28939
Deaths	459	436	426	476	479	408	367	1891	1160	3051
30-day mortality (%)	9.6	10.2	10.2	11.6	11.6	11.1	9.7	10.7	10.3	10.5
Congestive heart failure (177 hospitals)										
Admissions ¹	4325	3935	3828	3799	3780	2962	2977	16046	9560	25606
Deaths	628	568	577	549	566	462	441	2369	1422	3791
30-day mortality (%)	14.5	14.4	15.1	14.5	15.0	15.6	14.8	14.8	14.9	14.8

436 ¹Day of hospital admission or associated preceding emergency department presentation

437

438 **Table 2.** Demographic and clinical characteristics of patients with acute, emergency hospital admissions for the
 439 conditions of interest by day of week and time of day of presentation¹, NSW, July 2009 - June 2012.

440

Characteristic	Day of week		Time of day	
	Weekday N = 110,453 (%)	Weekend N = 38,269 (%)	Day N = 90,945 (%)	Night N = 57,777 (%)
Age groups				
15-39	4,361 (4.0)	1,580 (4.1)	3,501 (3.9)	2,440 (4.2)
40-59	16,623 (15.1)	5,804 (15.2)	13,044 (14.3)	9,383 (16.2)
60-79	46,943 (42.5)	16,178 (42.3)	38,593 (42.4)	24,528 (42.5)
80+	42,526 (38.5)	14,707 (38.4)	35,807 (39.4)	21,426 (37.1)
Age (years; median (IQR))	75.8 (63.9-84.1)	75.8 (63.7-84.2)	76.2 (64.5-84.3)	75.1 (62.9-83.9)
Gender				
Female	50,318 (45.6)	17,407 (45.5)	42,300 (46.5)	25,425 (44.0)
Male	60,135 (54.4)	20,862 (54.5)	48,645 (53.5)	32,352 (56.0)
Charlson comorbidity index				
0	74,780 (67.7)	25,954 (67.8)	61,248 (67.4)	39,486 (68.3)
1-2	28,678 (26.0)	9,859 (25.8)	23,930 (26.3)	14,607 (25.3)
3+	6,995 (6.3)	2,456 (6.4)	5,767 (6.3)	3,684 (6.4)
Admitted via ED	93,799 (84.9)	33,469 (87.5)	76,835 (84.5)	50,433 (87.3)

441 ¹Day of hospital admission or associated preceding emergency department presentation

442 Conditions included are ischaemic stroke, haemorrhagic stroke, acute myocardial infarction, pneumonia, chronic
 443 obstructive pulmonary disease, and congestive heart failure.

444

445 **Table 3.** Unadjusted odds ratios for 30-day mortality for day of week and time of day of presentation¹.

Variable	Ischaemic stroke		Haemorrhagic stroke		AMI		Pneumonia		COPD		CHF	
	Unadjusted Odds Ratio	P-value	Unadjusted Odds Ratio	P-value	Unadjusted Odds Ratio	P-value	Unadjusted Odds Ratio	P-value	Unadjusted Odds Ratio	P-value	Unadjusted Odds Ratio	P-value
Day of week		0.006		0.271		0.879		0.092		0.003		0.813
Monday	Reference		Reference		Reference		Reference		Reference		Reference	
Tuesday	1.14 (0.95-1.37)	0.152	0.97 (0.80-1.19)	0.789	1.00 (0.86-1.18)	0.964	0.90 (0.80-1.00)	0.052	1.07 (0.93-1.23)	0.332	0.99 (0.88-1.12)	0.927
Wednesday	1.20 (1.00-1.44)	0.051	1.07 (0.88-1.31)	0.493	1.02 (0.87-1.20)	0.787	1.01 (0.90-1.12)	0.916	1.07 (0.93-1.23)	0.354	1.05 (0.93-1.18)	0.462
Thursday	1.04 (0.86-1.25)	0.668	0.87 (0.71-1.07)	0.194	1.08 (0.92-1.27)	0.321	0.97 (0.87-1.08)	0.600	1.24 (1.08-1.42)	0.002	0.99 (0.88-1.13)	0.929
Friday	1.30 (1.09-1.56)	0.004	1.00 (0.82-1.23)	0.969	1.08 (0.92-1.26)	0.355	0.95 (0.85-1.06)	0.346	1.24 (1.08-1.42)	0.002	1.04 (0.92-1.17)	0.566
Saturday	1.28 (1.07-1.54)	0.008	1.12 (0.91-1.38)	0.288	0.99 (0.84-1.16)	0.887	1.07 (0.96-1.20)	0.211	1.18 (1.02-1.36)	0.023	1.09 (0.96-1.24)	0.195
Sunday	1.35 (1.12-1.61)	0.001	1.10 (0.90-1.36)	0.352	1.02 (0.86-1.20)	0.843	1.00 (0.89-1.12)	0.981	1.01 (0.88-1.17)	0.866	1.03 (0.90-1.17)	0.712
Time of day		0.001		<0.001		0.967		0.750		0.231		0.794
Day	Reference		Reference		Reference		Reference		Reference		Reference	
Night	1.22 (1.10-1.35)		1.49 (1.33-1.67)		1.00 (0.92-1.09)		1.01 (0.95-1.07)		0.95 (0.88-1.03)		1.01 (0.94-1.08)	

¹Day of hospital admission or associated preceding emergency department presentation

Hospital is included as a random effect.

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447 **Table 4.** Adjusted odds-ratios for 30-day mortality by day of week and time of day of presentation¹.

Variable	Ischaemic stroke		Haemorrhagic stroke		AMI		Pneumonia		COPD		CHF	
	Adjusted Odds Ratio	P-value	Adjusted Odds Ratio	P-value	Adjusted Odds Ratio	P-value	Adjusted Odds Ratio	P-value	Adjusted Odds Ratio	P-value	Adjusted Odds Ratio	P-value
Day of week		0.136		0.404		0.741		0.136		0.003		0.660
Monday	Reference		Reference		Reference		Reference		Reference		Reference	
Tuesday	1.14 (0.95-1.38)	0.167	1.01 (0.82-1.24)	0.926	1.07 (0.90-1.28)	0.451	0.87 (0.77-0.98)	0.023	1.09 (0.94-1.25)	0.269	1.00 (0.88-1.14)	0.971
Wednesday	1.12 (0.93-1.35)	0.242	1.08 (0.88-1.34)	0.451	0.99 (0.83-1.19)	0.936	0.97 (0.86-1.09)	0.606	1.08 (0.93-1.25)	0.298	1.06 (0.93-1.21)	0.373
Thursday	1.03 (0.84-1.25)	0.803	0.88 (0.71-1.09)	0.228	1.08 (0.91-1.29)	0.371	0.98 (0.87-1.10)	0.720	1.29 (1.12-1.48)	0.001	0.99 (0.87-1.12)	0.829
Friday	1.22 (1.01-1.47)	0.039	1.05 (0.85-1.29)	0.653	1.10 (0.92-1.31)	0.303	0.92 (0.81-1.03)	0.156	1.25 (1.08-1.44)	0.002	1.09 (0.96-1.24)	0.175
Saturday	1.17 (0.96-1.42)	0.112	1.13 (0.91-1.40)	0.275	1.01 (0.84-1.21)	0.941	1.03 (0.92-1.17)	0.578	1.18 (1.02-1.37)	0.030	1.07 (0.94-1.23)	0.315
Sunday	1.28 (1.06-1.54)	0.012	1.06 (0.85-1.31)	0.595	0.96 (0.80-1.16)	0.681	0.97 (0.86-1.10)	0.670	1.05 (0.90-1.22)	0.550	1.02 (0.89-1.17)	0.784
Time of day		<0.001		<0.001		0.200		0.861		0.905		0.525
Day	Reference		Reference		Reference		Reference		Reference		Reference	
Night	1.30 (1.17-1.45)		1.58 (1.40-1.78)		1.07 (0.97-1.17)		1.01 (0.94-1.08)		1.00 (0.92-1.08)		1.02 (0.95-1.10)	

448 ¹Day of hospital admission or associated preceding emergency department presentation

449 Models were adjusted for age, sex, and comorbidities (final model results for all variables are provided in supplementary table S1). Hospital is included as a random effect.

450

451 **Table 5.** Unadjusted and adjusted odds ratios for 30-day mortality for day of week, categorized as weekend versus weekday, of hospital presentation¹ using random effect

452 logistic regression models

Variable	Ischaemic stroke		Haemorrhagic stroke		AMI		Pneumonia		COPD		CHF	
	Odds ratio	P-value	Odds ratio	P-value	Odds ratio	P-value	Odds ratio	P-value	Odds ratio	P-value	Odds ratio	P-value
Unadjusted												
Day of week		0.006		0.057		0.498		0.042		0.617		0.310
Weekday	Reference		Reference		Reference		Reference		Reference		Reference	
Weekend	1.16 (1.04-1.29)		1.13 (1.00-1.28)		0.97 (0.88-1.07)		1.07 (1.00-1.15)		0.98 (0.90-1.07)		1.04 (0.96-1.13)	
Adjusted												
Day of week		0.067		0.197		0.261		0.135		0.686		0.686
Weekday	Reference		Reference		Reference		Reference		Reference		Reference	
Weekend	1.11 (0.99-1.24)		1.09 (0.96-1.24)		0.94 (0.84-1.05)		1.06 (0.98-1.14)		0.98 (0.90-1.07)		1.02 (0.93-1.11)	
Time of day		<0.001		<0.001		0.210		0.939		0.930		0.930
Day	Reference		Reference		Reference		Reference		Reference		Reference	
Night	1.30 (1.17-1.45)		1.57 (1.40-1.77)		1.06 (0.97-1.17)		1.00 (0.94-1.07)		1.00 (0.92-1.08)		1.02 (0.95-1.10)	0.930

453 ¹Day of hospital admission or associated preceding emergency department presentation

454 Adjusted models included age, sex and comorbidities. All models included hospital as a random effect.

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3 455 **Figure 1.** a) Adjusted odds ratios for 30-day mortality for day of week of presentation by
4 456 clinical condition. Reference group is Monday (dotted line). b) adjusted odds ratios for 30-
5 457 day mortality for presentation to hospital at night compared to during the day, by clinical
6 458 condition. AMI = acute myocardial infarction, COPD = chronic obstructive pulmonary
7 459 disease, CHF = congestive heart failure.
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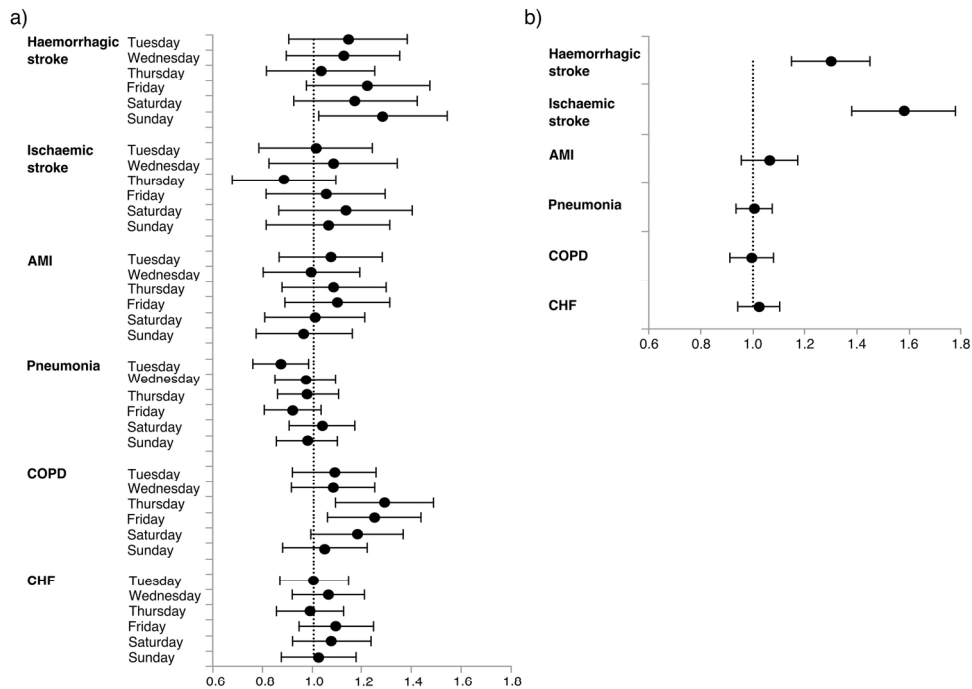


Figure 1. a) Adjusted odds ratios for 30-day mortality for day of week of admission by clinical condition. Reference group is Monday (dotted line). b) adjusted odds ratios for 30-day mortality for admission to hospital at night compared to during the day, by clinical condition. AMI = acute myocardial infarction, COPD = chronic obstructive pulmonary disease, CHF = congestive heart failure.

165x131mm (300 x 300 DPI)

SUPPLEMENTARY MATERIAL

Table S1. Final multivariable model results for 30-day mortality by day of week and time of day of hospital admission or related, preceding ED presentation for ischaemic and haemorrhagic stroke, AMI, pneumonia, COPD and CHF.

Condition Variable	Odds Ratio (95% CI)	p-value	Condition Variable	Odds Ratio (95% CI)	p-value
Ischaemic stroke			Haemorrhagic stroke		
Day of week (ref = Mon)		0.136	Day of week (ref = Mon)		0.404
Tuesday	1.14 (0.95-1.38)	0.167	Tuesday	1.01 (0.82-1.24)	0.926
Wednesday	1.12 (0.93-1.35)	0.242	Wednesday	1.08 (0.88-1.34)	0.451
Thursday	1.03 (0.84-1.25)	0.803	Thursday	0.88 (0.71-1.09)	0.228
Friday	1.22 (1.01-1.47)	0.039	Friday	1.05 (0.85-1.29)	0.653
Saturday	1.17 (0.96-1.42)	0.112	Saturday	1.13 (0.91-1.40)	0.275
Sunday	1.28 (1.06-1.54)	0.012	Sunday	1.06 (0.85-1.31)	0.595
Night	1.30 (1.17-1.45)	<0.001	Night	1.58 (1.40-1.78)	<0.001
Sex (ref = male)	1.32 (1.19-1.47)	<0.001	Sex (ref = male)	1.39 (1.24-1.56)	<0.001
Age (centred)	1.06 (1.06-1.07)	<0.001	Age (centred)	1.04 (1.04-1.05)	<0.001
Age (squared)	1.00 (1.00-1.00)	<0.001	Heart failure	1.47 (1.16-1.87)	0.001
Renal failure	1.70 (1.48-1.97)	<0.001	Malignancy	2.75 (2.20-3.45)	<0.001
Heart failure	1.95 (1.66-2.28)	<0.001	Previous H-stroke	0.61 (0.48-0.77)	<0.001
Malignancy	2.64 (2.15-3.24)	<0.001			
AMI			Pneumonia		
Day of week (ref = Mon)		0.741	Day of week (ref=Mon)		0.136
Tuesday	1.07 (0.90-1.28)	0.451	Tuesday	0.87 (0.77-0.98)	0.023
Wednesday	0.99 (0.83-1.19)	0.936	Wednesday	0.97 (0.86-1.09)	0.606
Thursday	1.08 (0.91-1.29)	0.371	Thursday	0.98 (0.87-1.10)	0.720
Friday	1.10 (0.92-1.31)	0.303	Friday	0.92 (0.81-1.03)	0.156
Saturday	1.01 (0.84-1.21)	0.941	Saturday	1.03 (0.91-1.16)	0.578
Sunday	0.96 (0.80-1.16)	0.681	Sunday	0.97 (0.86-1.10)	0.670
Night	1.07 (0.97-1.17)	0.200	Night	1.00 (0.94-1.07)	0.861
Age (centred)	1.06 (1.05-1.06)	<0.001	Financial year (ref = 2009)		<0.001
Age (squared)	1.00 (1.00-1.00)	<0.001	2010	0.90 (0.83-0.97)	0.004
STEMI	2.71 (2.44-3.01)	<0.001	2011	0.74 (0.68-0.80)	<0.001
Dementia	2.10 (1.77-2.48)	<0.001	Age (centred)	1.05 (1.05-1.05)	<0.001
Hypotension	1.29 (1.14-1.46)	<0.001	Age (squared)	1.00 (1.00-1.00)	<0.001
Shock	9.38 (7.79-11.30)	<0.001	Dementia	2.66 (2.42-2.92)	<0.001
Renal failure	2.32 (2.07-2.60)	<0.001	Hypotension	1.18 (1.08-1.28)	<0.001
Heart failure	1.77 (1.58-1.98)	<0.001	Shock	4.02 (3.34-4.84)	<0.001
Dysrhythmia	1.72 (1.55-1.90)	<0.001	Renal failure	1.84 (1.70-1.99)	<0.001
Malignancy	2.38 (1.94-2.92)	<0.001	Heart failure	1.55 (1.43-1.68)	<0.001
Hypertension	0.67 (0.61-0.74)	<0.001	Dysrhythmia	1.32 (1.22-1.42)	<0.001
Cerebrovascular disease	2.34 (1.95-2.81)	<0.001	Malignancy	5.54 (5.07-6.05)	<0.001
			Cerebrovascular disease	1.82 (1.59-2.08)	<0.001
			Other COPD	1.17 (1.08-1.27)	<0.001
			Liver disease	2.81 (1.75-2.71)	<0.001
			Parkinsons	1.69 (1.35-2.11)	<0.001

COPD			CHF		
Day of week (ref = Mon)		0.003	Day of week (ref=Mon)		0.660
Tuesday	1.09 (0.94-1.25)	0.269	Tuesday	1.00 (0.88-1.14)	0.971
Wednesday	1.08 (0.93-1.25)	0.298	Wednesday	1.06 (0.93-1.21)	0.373
Thursday	1.29 (1.12-1.48)	0.001	Thursday	0.99 (0.87-1.12)	0.829
Friday	1.25 (1.08-1.44)	0.002	Friday	1.09 (0.96-1.24)	0.175
Saturday	1.18 (1.02-1.37)	0.030	Saturday	1.07 (0.94-1.23)	0.315
Sunday	1.05 (0.90-1.22)	0.550	Sunday	1.02 (0.89-1.17)	0.784
Night	1.00 (0.92-1.08)	0.905	Night	1.02 (0.95-1.10)	0.525
Financial year (ref = 2009)		<0.001	Financial year (ref = 2009)		<0.001
2010	0.77 (0.70-0.85)	<0.001	2010	0.89 (0.81-0.97)	0.009
2011	0.50 (0.45-0.55)	<0.001	2011	0.67 (0.62-0.74)	<0.001
Prev acute COPD episode (ref = 0) ¹		<0.001	Prev acute CHF episode (ref = 0) ¹		<0.001
1 previous episode	1.67 (1.51-1.85)	<0.001	1 previous episode	1.39 (1.26-1.52)	<0.001
2 previous episodes	2.13 (1.86-2.43)	<0.001	2 previous episodes	1.70 (1.48-1.97)	<0.001
3+ previous episodes	3.04 (2.69-3.44)	<0.001	3+ previous episodes	2.52 (2.14-2.96)	<0.001
Sex (ref=male)	0.82 (0.76-0.89)	<0.001	Sex (ref = male)	0.90 (0.84-0.97)	0.008
Age (centred)	1.03 (1.03-1.04)	<0.001	Age (centred)	1.05 (1.05-1.06)	<0.001
Age (squared)	1.00 (1.00-1.00)	0.013	Age (squared)	1.00 (1.00-1.00)	0.003
CHF	1.47 (1.34-1.61)	<0.001	Pulmonary circ. disord.	1.21 (1.09-1.35)	<0.001
Pulmonary circ. disord.	1.66 (1.46-1.89)	<0.001	Peripheral vascular disord.	1.19 (1.04-1.37)	0.013
Neurological disord.	1.31 (1.05-1.64)	0.016	Hypertension (comp/uncomp)	0.83 (0.77-0.90)	<0.001
Diabetes (comp.)	0.83 (0.73-0.95)	0.005	Paralysis	1.65 (1.34-2.04)	<0.001
Liver disease	1.98 (1.50-2.61)	<0.001	Neurological disorders	1.65 (1.39-1.97)	<0.001
Metastatic cancer	3.06 (2.38-3.95)	<0.001	Chronic pulmonary disease	1.23 (1.13-1.34)	<0.001
Solid tumour w/o metast.	1.42 (1.17-1.72)	<0.001	Renal failure	1.88 (1.73-2.03)	<0.001
Weight loss	1.89 (1.68-2.11)	<0.001	Liver disease	2.78 (2.29-3.38)	<0.001
Fluid/electrolyte dis.	1.81 (1.66-1.98)	<0.001	Lymphoma	2.24 (1.57-3.19)	<0.001
Psychoses	2.10 (1.47-3.00)	<0.001	Metastatic cancer	3.07 (2.44-3.86)	<0.001
			Coagulopathy	1.29 (1.15-1.46)	<0.001
			Weight loss	1.61 (1.43-1.83)	<0.001
			Fluid/electrolyte disorders	1.57 (1.45-1.69)	<0.001
			Deficiency anaemia	0.78 (0.68-0.90)	<0.001

¹lookback to 2004

STROBE Statement—Checklist of items that should be included in reports of *cohort studies*

	Item No	Recommendation	Checked (page #)
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5-6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	6-7
		(b) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-7
Bias	9	Describe any efforts to address potential sources of bias	6-7
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7-8
		(b) Describe any methods used to examine subgroups and interactions	7
		(c) Explain how missing data were addressed	6
		(d) If applicable, explain how loss to follow-up was addressed	NA
		(e) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8, 19
		(b) Indicate number of participants with missing data for each variable of interest	8
		(c) Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	Report numbers of outcome events or summary measures over time	18
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear	20,21

		which confounders were adjusted for and why they were included	
		(b) Report category boundaries when continuous variables were categorized	NA
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	considered
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10,11
Discussion			
Key results	18	Summarise key results with reference to study objectives	9
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	10,11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11,12
Generalisability	21	Discuss the generalisability (external validity) of the study results	11,12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	12

*Give information separately for exposed and unexposed groups.

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

BMJ Open

Is the weekend effect really ubiquitous? Retrospective clinical cohort analyses of 30-day mortality by day of week and time of day using linked population data from New South Wales, Australia

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2017-016943.R2
Article Type:	Research
Date Submitted by the Author:	16-Nov-2017
Complete List of Authors:	Baldwin, Heather; Bureau of Health Information; New South Wales Ministry of Health Marashi-Pour, Sadaf; Bureau of Health Information Chen, Hwei-Yang ; Bureau of Health Information Kaldor, Jill; Bureau of Health Information Sutherland, Kim; Bureau of Health Information Levesque, Jean-Frederic; Bureau of Health Information, ; University of New South Wales, Centre for Primary Health Care and Equity
Primary Subject Heading:	Health services research
Secondary Subject Heading:	Health services research, Health policy, Public health
Keywords:	PUBLIC HEALTH, HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Quality in health care < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

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1 Is the weekend effect really ubiquitous? Retrospective clinical cohort
2 analyses of 30-day mortality by day of week and time of day using
3 linked population data from New South Wales, Australia

4
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17

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19 Word count (abstract + body): 3401

20

21

22 ABSTRACT

23 Objective

24 To examine the associations between day of week and time of admission and 30-day
25 mortality for six clinical conditions: ischaemic and haemorrhagic stroke, acute myocardial
26 infarction, pneumonia, chronic obstructive pulmonary disease and congestive heart failure.

27 Design

28 Retrospective population-based cohort analyses. Hospitalisation records were linked to
29 emergency department and deaths data. Random effect logistic regression models were used,
30 adjusting for casemix and taking into account clustering within hospitals.

31 Setting

32 All hospitals in New South Wales, Australia from July 2009 to June 2012.

33 Participants

34 Patients admitted to hospital with a primary diagnosis for one of the six clinical conditions
35 examined.

36 Outcome measures

37 Adjusted odds ratios for all-cause mortality within 30 days of admission, by day of week and
38 time of day.

39 Results

40 A total of 148,722 patients were included in the study, with 17,721 deaths within 30 days of
41 admission. Day of week of admission was not associated with significantly higher likelihood
42 of death for five of the six conditions after adjusting for casemix. There was significant
43 variation in mortality for chronic obstructive pulmonary disease by day of week, however,
44 this was not consistent with a strict weekend effect (Thursday: OR 1.29, 95% CI 1.12–1.48;
45 Friday: OR 1.25, 95%CI 1.08–1.44; Saturday: OR 1.18, 95% CI 1.02–1.37; Sunday OR 1.05,
46 95% CI 0.90–1.22; compared to Monday). There was evidence for a night effect for patients
47 admitted for stroke (ischaemic: OR 1.30, 95% CI 1.17–1.45; haemorrhagic: OR 1.58, 95% CI
48 1.40–1.78).

49 **Conclusions**

50 Mortality outcomes for these conditions, adjusted for casemix, do not vary in accordance
51 with the weekend effect hypothesis. Our findings support a growing body of evidence that
52 questions the ubiquity of the weekend effect.

54 **Keywords**

55 Weekend effect, night effect, out-of-hours effect, stroke, AMI, pneumonia, COPD, CHF

57 **Article summary**

58 *Strengths and limitations of this study*

- 59 • The examined conditions encompass a range of time sensitivity, interventions, acuity
60 and prognosis, providing a gradient to assess potential causality of association.
- 61 • The use of linked hospital admission and emergency department (ED) data allowed
62 complete coverage of hospital admissions for the state, while minimising
63 misclassification bias from time spent in ED and maximising validity and quality of
64 diagnosis and comorbidity data.
- 65 • The use of clinical cohorts of patients allows more precise adjustment for casemix
66 than non-specific admissions.
- 67 • Linkage to the Deaths Register allowed the capture of 30-day all-cause mortality.
68 While mortality is a standard indicator, other outcomes may be more sensitive to
69 variation in patient outcomes.
- 70 • We focussed on the NSW health system as a whole and did not explore the possible
71 weekend effect at hospital level.

72

73 INTRODUCTION

74 In recent years, researchers and policy makers have shown growing interest in the
75 ‘weekend effect’, examining whether patients admitted to hospital at the weekend experience
76 worse outcomes compared to patients admitted during the week. This effect has been
77 observed in numerous studies of health systems around the world, for a wide range of
78 conditions and procedures.¹⁻⁶ Studies have also observed a ‘night effect’, suggesting that the
79 phenomenon may extend to out-of-hours presentation more broadly.¹⁻⁴

80 Considerable uncertainty remains as to the cause of the apparent effect of weekend
81 and night-time (hereafter collectively ‘out-of-hours’) presentation on patient outcomes. Two
82 main hypotheses have been proposed to explain the observed variation: these focus on
83 healthcare service quality and on patient characteristics.² The first hypothesis posits that the
84 poorer outcomes seen among patients admitted on the weekend are explained by lower
85 quality of care out-of-hours. More specifically, putative factors include lower staffing levels,
86 fewer senior consultants and specialists, and reduced availability of diagnostic procedures.³
87 This hypothesis gained considerable traction with policy makers and has contributed to the
88 recent, controversial push towards seven day hospital services in the UK.⁷

89 The second hypothesis proposes that the weekend effect is largely attributable to
90 patient characteristics, and at least partly a data artefact resulting from insufficient
91 information on patient characteristics in administrative datasets. There is little clear evidence
92 that higher mortality is a consequence of staffing levels⁷, and a number of studies have found
93 no significant correlation between consultant seniority or specialist availability and
94 mortality.⁸⁻¹¹ There is also an increasing body of evidence to suggest that the weekend effect
95 dissipates after adjustment for casemix¹², arrival by ambulance as a proxy for illness

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3 96 severity¹³ and a higher severity threshold for admission.¹² This phenomenon may be
4
5 97 influenced by self-selection, whereby patients wait until the weekend to present to hospital
6
7 98 and may therefore present with more advanced disease, and less comprehensive note-taking
8
9 99 on the weekend limiting the ability to risk-adjust.¹⁴
10

11
12 100 The night effect is less extensively studied than the weekend effect, and reasons for
13
14 101 the night effect are usually presumed to be similar to the weekend effect. The few studies that
15
16 102 have examined the effects of out-of-hours presentation on mortality in Australia have had
17
18 103 mixed results.^{3,4,15,16} Previous studies have been limited by using in-hospital mortality only
19
20 104 and therefore not capturing deaths that occurred post-discharge¹⁷, reduced ability to
21
22 105 adequately risk adjust by focusing on clinically non-specific admissions.^{3,16,18} Further,
23
24 106 previous studies have often relied on unlinked emergency department (ED) data⁴, which
25
26 107 contain limited and largely incomplete and inaccurate information on principle diagnosis and
27
28 108 comorbidity, or unlinked hospitalisation data, which may be affected by misclassification
29
30 109 bias due to time spent in waiting in ED prior to admission.^{15,18}
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34
35 110 Overall, previous studies have shown that the out-of-hours effect does not apply to
36
37 111 all clinical presentations and procedures.^{1-4,8} It is therefore beneficial to investigate conditions
38
39 112 for which we can expect that the weekend is more likely to occur, based on theoretical
40
41 113 grounds, on clinical plausibility or on previous evidence.²
42
43

44 114 We investigated the existence of the weekend effect and the night effect for acute
45
46 115 hospitalisations for various conditions, comprising ischaemic stroke, haemorrhagic stroke,
47
48 116 acute myocardial infarction (AMI), pneumonia, chronic obstructive pulmonary disease
49
50 117 (COPD), and congestive heart failure (CHF), across all hospitals in New South Wales
51
52 118 (NSW). These conditions provide insights into a range of aspects of healthcare, including
53
54 119 timely delivery of interventions, surgical services, differences in acuity and prognosis, and
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3 120 provide a gradient to assess potential causality of association as they vary in the importance
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5 121 of immediate care. We predicted that if day and time effects exist, they would show strongest
6
7 122 effects for the most urgent conditions (stroke and AMI), and be weakest for patients with the
8
9 123 least urgent conditions (pneumonia and COPD). We hypothesized that presentations on
10
11 124 Saturdays and Sundays would show higher 30-day mortality for the six conditions than
12
13 125 presentations that occurred during the week, and that night-time presentations would show
14
15 126 higher mortality than presentations that occurred during the day.
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22 128 **METHODS**

23
24 129 Retrospective cohort analyses were performed for the six indicator conditions. Cohorts were
25
26 130 identified from all admissions to NSW public and private hospitals for the period of 1 July
27
28 131 2009 to 30 June 2012, extracted from the NSW Admitted Patient Data Collection, which is a
29
30 132 census of all hospital admissions in NSW. These data were linked to emergency department
31
32 133 (ED) attendances in all NSW public hospitals recorded in the Emergency Department Data
33
34 134 Collection, representing approximately 85% of all emergency presentations in NSW.^{19,20}
35
36 135 Emergency department data were linked to allow the capture of the start day and time of the
37
38 136 patients' contact with the hospital system for the episode of illness, minimising any bias
39
40 137 imposed by time spent in the ED that may affect the day and time of hospitalisation, since
41
42 138 patients may spend longer in the ED before admission at night or at weekends. Mortality data
43
44 139 were obtained from the NSW Deaths Register. Data were linked by the NSW Centre for
45
46 140 Health Record Linkage using probabilistic methods based on personal identifiers. The
47
48 141 estimated false positive rate for the current version of the Master Linkage Key is 5 per
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50 142 1000.²¹
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3 143 The principal diagnosis in the patient record, coded using International Classification
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5 144 of Diseases 10th revision Australian modification, was used to identify each clinical cohort.
6
7 145 Only complete records of admissions coded as acute and emergency were included. The
8
9 146 proportion of records excluded for missing values on key variables such as age, sex, date of
10
11 147 admission and separation, type of care and emergency status was less than 0.1%. Patients
12
13 148 aged less than 15 years (ischaemic stroke, haemorrhagic stroke, AMI), 18 years (pneumonia)
14
15 149 or 45 years (COPD, CHF) were excluded, consistent with existing mortality indicator
16
17 150 definitions for these conditions, due to low mortality rates among these groups.^{22,23} AMI can
18
19 151 be classified as ST-elevated myocardial infarction (STEMI) or non-ST elevated myocardial
20
21 152 infarction (non-STEMI) based on the electrocardiogram reading, or unspecified AMI when
22
23 153 diagnostic records are unavailable. STEMI is associated with higher mortality at 30 days
24
25 154 compared to non-STEMI, and the unspecified group is a heterogeneous mix of critically
26
27 155 unwell patients who died before their AMI could be specified and patients for whom
28
29 156 diagnostic records were less precise, so AMI patients with a non-specific infarction were
30
31 157 excluded to allow adjustment for STEMI.^{22,23} Transfers and multiple contiguous
32
33 158 hospitalisations were considered as a single period of care. For patients with multiple periods
34
35 159 of care during the study period, only the last period of care was included in the analyses.
36
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40 160 Mortality was defined as death (in or out of hospital) occurring within 30 days of the
41
42 161 start of the period of care. The day of week of presentation was defined as the first day of
43
44 162 contact with the hospital system for the period of care (either hospital admission or ED
45
46 163 presentation). Patients dead on arrival to ED and not admitted to hospital were excluded. An
47
48 164 ED presentation was considered relevant for the hospital admission if it occurred on the same
49
50 165 day, or previous day, as the hospital admission. Same day ED presentations were only
51
52 166 included if the time was recorded as before the hospital admission time. In this study, the
53
54 167 weekend comprises Saturday and Sunday, while weekdays are defined as Monday through
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3 168 Friday. Night time presentation was defined as first presentation between 18:00 and 07:59,
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5 169 using hospital admission time or ED presentation time as described.
6
7

8 170 Random effects logistic regression models were used to investigate associations
9
10 171 between day of week, or time of presentation, with mortality. To account for clustering of
11
12 172 patients within hospitals, hospitals were considered as random effects in the regression
13
14 173 models. Risk adjustment was performed to account for casemix factors including age
15
16 174 (continuous, tested for curvilinearity), sex, year and comorbidities. Condition-specific
17
18 175 comorbidity sets defined by the Australian Commission for Safety and Quality in Health Care
19
20 176 were used as the basis for building risk adjustment models for each condition, where
21
22 177 available (ischaemic stroke, haemorrhagic stroke, AMI, pneumonia), while COPD and CHF
23
24 178 used Elixhauser comorbidities.²² Availability of thrombolysis treatment was also considered
25
26 179 as a predictive variable for ischaemic stroke, and STEMI status was considered for AMI.
27
28 180 Comorbidities were captured across all hospital admissions over a one year period prior to the
29
30 181 index admission. Interactions between day of the week and night time presentations were also
31
32 182 explored in the final models using likelihood ratio tests.
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37 183 Models were selected using backwards selection.²⁴ Factors with a *p*-value of less than
38
39 184 0.2 in the univariate analyses were included in the initial full models. Variables with a *p*-
40
41 185 value of less than 0.05 were retained in the model. Variables that were not significant at the
42
43 186 20% level in the univariate models were then checked for significance in the backwards-
44
45 187 selected model, and retained in the final model where $p < 0.05$. Overall performance of the
46
47 188 models was assessed using c-statistics. In order to capture daily variation, 30-day mortality
48
49 189 risks for each day of the week were compared against a reference weekday (Monday). We
50
51 190 define observation of a weekend effect as significantly higher odds of 30-day mortality on
52
53 191 weekend days (Saturday and Sunday) compared to Monday. To validate our findings,
54
55 192 additional analyses were performed comparing weekend days against weekdays. Statistical
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193 analyses were performed using SAS v9.4 (SAS Institute Inc., Cary, NC, USA) and STATA
194 v12.1 (StataCorp LP, Texas, USA).

195

196 **RESULTS**

197 There were a total of 213,834 acute, emergency hospital admissions for the conditions of
198 interest during the study period. There were 10,658 admissions excluded as they did not meet
199 the eligibility criteria for age, and 2161 patients were excluded who had a non-specified AMI.
200 After accounting for transfers and multiple admissions, there were 148,722 patients were
201 included in the study (table 1). There were 17,721 deaths within 30 days of admission
202 (11.9%). A total of 127,268 admissions were linked to an ED presentation (85.6%). The
203 clinical cohorts comprised between 5,740 (haemorrhagic stroke) and 44,508 (pneumonia)
204 patients that were admitted or presented to between 133 and 183 hospitals. Characteristics of
205 patients are provided by day of week and time of day of arrival in table 2.

206 The most frequent day of presentation was Monday, while Saturdays and Sundays had
207 fewer presentations than weekdays for all conditions. More patients were admitted during
208 daytime than at night, regardless of condition.

209 There were no significant associations in the univariate analyses between mortality
210 and day of week, for haemorrhagic stroke, AMI, pneumonia, or CHF (table 3). There was
211 significant variation in unadjusted 30-day mortality by day of week for ischaemic stroke and
212 COPD, however this did not show a strict 'weekend effect' (ischaemic stroke: Friday,
213 Saturday and Sunday significantly higher than Monday; COPD: Thursday, Friday and
214 Saturday significantly higher than Monday).

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3 215 There was no significant difference in 30-day mortality by day of week after
4
5 216 adjustment for casemix and other factors for five of the six conditions (table 4, figure 1).
6
7 217 While Friday and Sunday presentations had significantly higher mortality than Monday for
8
9 218 ischaemic stroke, overall day of the week was not significant in the model. Significant
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11 219 variation in mortality by day of week for COPD was not consistent with a weekend effect
12
13 220 (with Thursday, Friday and Saturday being associated with higher mortality compared with
14
15 221 Monday).

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17
18 222 There was evidence for higher mortality among ischaemic and haemorrhagic stroke
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20 223 patients who presented to hospital overnight. This night effect was observed in both the
21
22 224 unadjusted and adjusted analyses (table 3, table 4). There was no evidence of increased
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24 225 mortality among night admissions for the other conditions. There were no significant
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26 226 interactions between day of week and time of day, after adjustment for confounding factors,
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28 227 for any of the conditions.

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32 228 The models performed moderately well, with c-statistics ranging from 0.68 to 0.82
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34 229 (ischaemic stroke: 0.73, haemorrhagic stroke: 0.68, AMI: 0.81, pneumonia: 0.82, COPD:
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36 230 0.74, CHF: 0.72).

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39 231 Results from the analyses comparing 30-day mortality on pooled weekend versus
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41 232 weekdays showed that the weekend was associated with a higher unadjusted likelihood of 30-
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43 233 day mortality compared with weekday for ischaemic stroke and pneumonia (table 5).
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45 234 However, after taking into account other risk factors, no significant differences were
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47 235 observed in 30-day mortality between weekdays and weekend for any of the conditions
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49 236 studied.

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3 238 **DISCUSSION**

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6 239 *Main findings*

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8 240 Mortality outcomes do not vary in accordance with the weekend effect, after adjusting for
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10 241 casemix, for patients admitted to hospital with stroke, AMI, pneumonia, COPD, or CHF in
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12 242 NSW. We found increased mortality for stroke patients presenting to hospital at night, with
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15 243 no evidence for the night effect for the remaining conditions.

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18 244 Our findings support a growing body of evidence that disputes the ubiquity of the
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20 245 weekend effect.^{7,12,14,15,25,26} Of the six conditions investigated in this study, only ischaemic
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22 246 stroke and COPD showed significant variation in crude mortality risk by day of week of
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24 247 presentation. Significant variation remained after risk adjustment for COPD only, and this
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26 248 was not consistent with predictions for the weekend effect, with the highest odds of death
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28 249 within 30 days was found for those who presented on Thursday and Friday. When weekend
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30 250 and week days were pooled, there were no significant differences in odds of death after
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32 251 adjusting for other risk factors. This is consistent with studies which have shown more
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34 252 complex patterns of temporal variation in that there are some days/times that are different but
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36 253 not specifically 'the weekend'.^{4,17,26,27}

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40 254 While findings from previous studies for stroke^{11,14,28,29}, AMI^{15,30} and COPD^{15,31} have
41
42 255 been conflicting, our results are consistent with those that found no weekend effect
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44 256 (stroke^{1,14,26,32}, AMI^{1,33}, COPD¹⁵). A recent meta-analysis found no weekend effect for COPD
45
46 257 and pneumonia, although it did find significant effects for intracerebral haemorrhage,
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48 258 ischaemic stroke and myocardial infarction³⁴. However, on comparing effects between
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50 259 continents, Oceania was found to have the lowest overall increase in odds of death (OR =
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52 260 1.04; compared to South America, OR = 1.47), suggesting that the weekend effect may be

261 highly heterogenous and dependent not only on clinical conditions but also on hospital
262 contexts, regional policy and other factors that may vary widely by geographic setting.

263 We observed that the numbers of admissions were lower at weekends in New South
264 Wales, and that the number of deaths within 30 days are generally proportionate to the
265 number of admissions. This is in contrast to the findings of previous studies.^{1,6,12,35} There are
266 a number of differences between our study and some of the previously published work which
267 may explain these differences. The use of 30-day mortality through linkage to the Deaths
268 Register as opposed to in-hospital death^{1,3,6,12,13,35} allows the capture not only of patients who
269 died in hospital, but also those died in community due to variation in care or early discharge.
270 This provides a more complete picture of mortality.

271 Further, our study has examined six specific clinical conditions, as opposed to all
272 emergency conditions.^{3,4,12,35} Not all emergency admissions have the same urgency or acuity
273 for treatment, and the conditions we have examined are useful indicators that encompass a
274 range of time sensitivity, interventions, acuity and prognosis. The use of clinical cohorts of
275 patients allows more precise adjustment for case-mix than considering non-specific
276 admissions. We found no effect on mortality of weekend presentation either in conditions
277 expected to be less sensitive to reduced staffing and services, nor among the more severe,
278 acute conditions, which confers confidence in the validity of our findings. Our analyses
279 comprised three years' complete population data for NSW with cohorts ranging from over
280 5000 to 44,000, which should provide sufficient power to detect statistically significant
281 differences.

282 In contrast to other studies, the use of linked hospitalisation and emergency
283 department data provides complete coverage of hospital admissions for the conditions of
284 interest in NSW, and minimises several potential biases. While most studies use either

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3 285 hospital admission data^{1,6,35} or ED data^{3,4}, the use of linked data in this study minimises
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5 286 misclassification bias in day and time of presentation caused by time spent in ED prior to
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7 287 admission. Additionally, the use of hospitalisation data from the index and historical
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9 288 admissions of the patients allowed us to maximise the detail and quality of diagnoses and
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11 289 comorbidities. This increases our confidence in our finding of no evidence for increased
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13 290 mortality associated with weekend presentation.

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15
16 291 We found significantly higher adjusted risk of death for ischaemic and haemorrhagic
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18 292 stroke patients who presented at night compared to those who presented during the day. This
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20 293 is consistent with other studies of stroke.^{26,28} This finding may reflect factors specific to
21
22 294 stroke, such as that strokes occurring at night may take longer to recognise due to reduced
23
24 295 activity, and may result in delayed seeking of treatment and therefore higher mortality. That
25
26 296 we only observed the night effect for stroke patients suggests that this variation is probably
27
28 297 not attributable to system-wide deficiencies. However, further research to explore reasons for
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30 298 the increase in mortality for stroke patients admitted at night, and the observed variation in
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32 299 mortality for COPD by day of presentation, including potential contributions from poorer
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34 300 community care, will help to understand whether these excess deaths are preventable.

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38 301 Our study is limited by a lack contextual information in our data about the differences
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40 302 in weekend and weekday or night time and day time practice, such as the availability of
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42 303 clinical or laboratory staff. It would be interesting to consider the results on the level of
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44 304 individual hospitals, as hospital variation in quality of care on weekends may be masked in
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46 305 this type of global analysis.

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50 306 Mortality is a useful indicator for health system performance and for evaluating
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52 307 unwarranted variation. However, it is an extreme outcome, and it may be a blunt tool that
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54 308 could mask some variation in patient outcomes. Further research is needed to determine

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3 309 whether the lower staffing levels and resource access on weekends and out-of-hours may
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5 310 exhibit effects on other outcomes or processes, such as adverse events, delays in care, or
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7 311 other quality indicators.
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11 12 313 **CONCLUSION**

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15 314 By identifying patients admitted through ED, and taking out-of-hospital deaths into account,
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17 315 this study was able to investigate the weekend effect by following the patient journey from
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19 316 prior to admission to after discharge. We found no evidence for a strict weekend effect in 30-
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21 317 day mortality for patients admitted with ischaemic or haemorrhagic stroke, AMI, pneumonia,
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23 318 COPD, or CHF. The finding of a night effect for stroke, and some variation between days for
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25 319 COPD, highlights that temporal variation in patient outcomes is complex and may have a
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27 320 variety of causes. Our findings increase the weight of evidence challenging the existence of
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29 321 the weekend effect.
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33 34 322 **Acknowledgements**

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36
37 323 We thank the NSW Ministry of Health for access to population health data and the NSW
38
39 324 Centre for Health Record Linkage for linking the data sets. We thank Lisa Corscadden for
40
41 325 helpful comments on the manuscript. HJB is supported by the NSW Biostatistics Training
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43 326 Program.
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46 47 327 **Contributors**

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50 328 HJB, SMP, HYC, JK, KS and JFL contributed to the study design. HJB and SMP cleaned and
51
52 329 analysed the data and HJB produced the figure and tables. All authors contributed to the
53
54 330 interpretation of the results. HJB drafted the manuscript, and all authors contributed to
55
56 331 revising the manuscript. All authors approved the final version of the manuscript.
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3 332 **Funding statement**
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5
6 333 This research received no specific grant from any funding agency in the public, commercial
7
8 334 or not-for-profit sectors.
9

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11 335 **Competing interests**
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13
14 336 We declare no competing interests.
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17 337 **Data sharing statement**
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20 338 Privacy restrictions for the datasets used in this study prohibit free online availability. Access
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22 339 to these data may be sought from the data custodians, the New South Wales Ministry of
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24 340 Health.
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343 **REFERENCES**

- 344 1. Bell CM, Redelmeier DA. Mortality among patients admitted to hospitals on
345 weekends as compared with weekdays. *N Engl J Med*. 2001;345(9):663-8.
- 346 2. Lilford RJ, Chen Y-F. The ubiquitous weekend effect: moving past proving it exists
347 to clarifying what causes it. *BMJ Qual Saf*. 2015:bmjqs-2015-004360.
- 348 3. Ruiz M, Bottle A, Aylin PP. The Global Comparators project: international
349 comparison of 30-day in-hospital mortality by day of the week. *BMJ Qual Saf*. 2015:bmjqs-
350 2014-003467.
- 351 4. Concha OP, Gallego B, Hillman K, Delaney GP, Coiera E. Do variations in hospital
352 mortality patterns after weekend admission reflect reduced quality of care or different patient
353 cohorts? A population-based study. *BMJ Qual Saf*. 2014;23(3):215-22.
- 354 5. Vest-Hansen B, Riis AH, Sørensen HT, Christiansen CF. Out-of-hours and weekend
355 admissions to Danish medical departments: admission rates and 30-day mortality for 20
356 common medical conditions. *BMJ Open*. 2015;5(3):e006731.
- 357 6. Freemantle N, Richardson M, Wood J, Ray D, Khosla S, Shahian D, et al. Weekend
358 hospitalization and additional risk of death: an analysis of inpatient data. *J R Soc Med*.
359 2012;105(2):74-84.
- 360 7. McKee M. The weekend effect: now you see it, now you don't. *BMJ*. 2016;353:i2750.
- 361 8. Wise J. The weekend effect—how strong is the evidence? *BMJ*. 2016;353.
- 362 9. Ruiz M, Bottle A, Aylin PP. Exploring the impact of consultants' experience on
363 hospital mortality by day of the week: a retrospective analysis of hospital episode statistics.
364 *BMJ Qual Saf*. 2015:bmjqs-2015-004105.
- 365 10. Aldridge C, Bion J, Boyal A, Chen Y-F, Clancy M, Evans T, et al. Weekend specialist
366 intensity and admission mortality in acute hospital trusts in England: a cross-sectional study.
367 *The Lancet*. 2016.

- 1
2
3 368 11. Bray BD, Ayis S, Campbell J, Cloud GC, James M, Hoffman A, et al. Associations
4 369 between stroke mortality and weekend working by stroke specialist physicians and registered
5 370 nurses: prospective multicentre cohort study. *PLoS Med.* 2014;11(8):e1001705.
6
7
8
9 371 12. Meacock R, Anselmi L, Kristensen SR, Doran T, Sutton M. Higher mortality rates
10 372 amongst emergency patients admitted to hospital at weekends reflect a lower probability of
11 373 admission. *J Health Serv Res Policy.* 2016;0(0):1-8.
12
13
14
15 374 13. Anselmi L, Meacock R, Kristensen SR, Doran T, Sutton M. Arrival by ambulance
16 375 explains variation in mortality by time of admission: retrospective study of admissions to
17 376 hospital following emergency department attendance in England. *BMJ Qual Saf.* 2016:bmjqs-
18 377 2016-005680.
19
20
21
22
23 378 14. Li L, Rothwell PM. Biases in detection of apparent “weekend effect” on outcome
24 379 with administrative coding data: population based study of stroke. *BMJ.* 2016;353.
25
26
27
28 380 15. Clarke M, Wills RA, Bowman R, Zimmerman P, Fong K, Coory M, et al. Exploratory
29 381 study of the ‘weekend effect’ for acute medical admissions to public hospitals in Queensland,
30 382 Australia. *Intern Med J.* 2010;40(11):777-83.
31
32
33
34 383 16. Singla AA, Guy GS, Field JB, Ma N, Babidge WJ, Maddern GJ. No weak days?
35 384 Impact of day in the week on surgical mortality. *ANZ J Surg.* 2015.
36
37
38
39 385 17. Coiera E, Wang Y, Magrabi F, Concha OP, Gallego B, Runciman W. Predicting the
40 386 cumulative risk of death during hospitalization by modeling weekend, weekday and diurnal
41 387 mortality risks. *BMC Health Serv Res.* 2014;14(1):1.
42
43
44
45 388 18. Bhonagiri D, Pilcher DV, Bailey MJ. Increased mortality associated with after-hours
46 389 and weekend admission to the intensive care unit: a retrospective analysis. *Med J Aust.*
47 390 2011;194(6):287-92.
48
49
50
51 391 19. Bureau of Health Information. Hospital Quarterly Technical supplement: Measures of
52 392 emergency department performance and activity. April to June 2010. Sydney (NSW); 2010.
53
54
55
56
57
58
59
60

- 1
2
3 393 20. Bureau of Health Information. Hospital Quarterly Technical Supplement: Measures of
4 394 emergency department performance, January to March 2012. Sydney (NSW); 2012.
- 5
6
7 395 21. Centre for Health Record Linkage. CHeReL—quality assurance. 2017. Available at:
8 396 <http://www.cherel.org.au/quality-assurance>. Retrieved May 30, 2017.
- 9
10
11
12 397 22. Bureau of Health Information. Spotlight on measurement: 30-day mortality following
13 398 hospitalisation, five clinical conditions, NSW, July 2009 - June 2012. Sydney (NSW), 2013.
- 14
15
16 399 23. Australian Commission of Safety and Quality in Health Care. National core, hospital-
17 400 based outcome indicator specification. Consultation Draft. Sydney: ACSQHC; 2012.
- 18
19
20
21 401 24. Hosmer D, Lemeshow S, May S. Applied survival analysis. Hoboken. NJ: John Wiley
22 402 & Sons; 2008.
- 23
24
25
26 403 25. Mikulich O, Callaly E, Bennett K, O'Riordan D, Silke B. The increased mortality
27 404 associated with a weekend emergency admission is due to increased illness severity and
28 405 altered case-mix. *Acute Medicine*. 2010;10(4):182-7.
- 29
30
31
32 406 26. Bray BD, Cloud GC, James MA, Hemingway H, Paley L, Stewart K, et al. Weekly
33 407 variation in health-care quality by day and time of admission: a nationwide, registry-based,
34 408 prospective cohort study of acute stroke care. *The Lancet*. 2016.
- 35
36
37
38 409 27. Lyndon A, Lee HC, Gay C, Gilbert WM, Gould JB, Lee KA. Effect of time of birth
39 410 on maternal morbidity during childbirth hospitalization in California. *Am J Obstet Gynecol*.
40 411 2015;213(5):705. e1-. e11.
- 41
42
43
44 412 28. Sorita A, Ahmed A, Starr SR, Thompson KM, Reed DA, Dabrh AMA, et al. Off-hour
45 413 presentation and outcomes in patients with acute ischemic stroke: a systematic review and
46 414 meta-analysis. *Eur J Intern Med*. 2014;25(4):394-400.
- 47
48
49
50
51 415 29. Roberts SE, Thorne K, Akbari A, Samuel DG, Williams JG. Mortality following
52 416 stroke, the weekend effect and related factors: record linkage study. *PLoS ONE*.
53 417 2015;10(6):e0131836.

- 1
2
3 418 30. Sorita A, Ahmed A, Starr SR, Thompson KM, Reed DA, Prokop L, et al. Off-hour
4 419 presentation and outcomes in patients with acute myocardial infarction: systematic review
5 420 and meta-analysis. *BMJ*. 2014;348:f7393.
6
7
8
9 421 31. Barba R, Zapatero A, Losa JE, Marco J, Plaza S, Rosado C, et al. The impact of
10 422 weekends on outcome for acute exacerbations of COPD. *Eur Respir J*. 2012;39(1):46-50.
11
12
13 423 32. Turin TC, Kita Y, Rumana N, Ichikawa M, Sugihara H, Morita Y, et al. Case fatality
14 424 of stroke and day of the week: is the weekend effect an artifact? *Cerebrovasc Dis*.
15 425 2008;26(6):606-11.
16
17
18
19
20 426 33. Hansen KW, Hvelplund A, Abildstrøm SZ, Prescott E, Madsen M, Madsen JK, et al.
21 427 Prognosis and treatment in patients admitted with acute myocardial infarction on weekends
22 428 and weekdays from 1997 to 2009. *Int J Cardiol*. 2013;168(2):1167-73.
23
24
25
26 429 34. Hoshijima H, Takeuchi R, Mihara T, Kuratani N, Mizuta K, Wajima Zi, et al.
27 430 Weekend versus weekday admission and short-term mortality: A meta-analysis of 88 cohort
28 431 studies including 56,934,649 participants. *Medicine*. 2017;96(17).
29
30
31
32 432 35. Aylin P, Yunus A, Bottle A, Majeed A, Bell D. Weekend mortality for emergency
33 433 admissions. A large, multicentre study. *Qual Saf Health Care*. 2010;19(3):213-7.
34
35
36 434
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435 **Table 1.** Numbers of patients admitted to hospital in NSW between July 2009 and June 2012 for the conditions
 436 examined, number and percentage of deaths within 30 days, by day and time of presentation¹.

Condition	Day of week							Time of Day		Total
	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Day	Night	
Ischaemic stroke (145 hospitals)										
Admissions ¹	2240	2168	2082	2070	2010	1868	1916	9858	4496	14354
Deaths	257	281	281	247	291	267	287	1241	670	1911
30-day mortality (%)	11.5	13.0	13.5	11.9	14.5	14.3	15.0	12.6	14.9	13.3
Haemorrhagic stroke (133 hospitals)										
Admissions ¹	905	894	818	830	853	703	737	3676	2064	5740
Deaths	303	296	288	255	286	254	264	1127	819	1946
30-day mortality (%)	33.5	33.1	35.2	30.7	33.5	36.1	35.8	30.7	39.7	33.9
Acute myocardial infarction (172 hospitals)										
Admissions ¹	4493	4332	4248	4241	4388	4004	3869	16309	13266	29575
Deaths	331	321	320	337	347	292	290	1233	1005	2238
30-day mortality (%)	7.4	7.4	7.5	8.0	7.9	7.3	7.5	7.6	7.6	7.6
Pneumonia (183 hospitals)										
Admissions ¹	7097	6354	6419	6366	6489	5754	6029	27382	17126	44508
Deaths	775	627	703	677	679	667	656	2929	1855	4784
30-day mortality (%)	10.9	9.9	11.0	10.6	10.5	11.6	10.9	10.7	10.8	10.8
Chronic obstructive pulmonary disease (177 hospitals)										
Admissions ¹	4794	4272	4193	4114	4116	3664	3786	17674	11265	28939
Deaths	459	436	426	476	479	408	367	1891	1160	3051
30-day mortality (%)	9.6	10.2	10.2	11.6	11.6	11.1	9.7	10.7	10.3	10.5
Congestive heart failure (177 hospitals)										
Admissions ¹	4325	3935	3828	3799	3780	2962	2977	16046	9560	25606
Deaths	628	568	577	549	566	462	441	2369	1422	3791
30-day mortality (%)	14.5	14.4	15.1	14.5	15.0	15.6	14.8	14.8	14.9	14.8

437 ¹Day of hospital admission or associated preceding emergency department presentation

438

439 **Table 2.** Demographic and clinical characteristics of patients with acute, emergency hospital admissions for the
 440 conditions of interest by day of week and time of day of presentation¹, NSW, July 2009 - June 2012.

441

Characteristic	Day of week		Time of day	
	Weekday N = 110,453 (%)	Weekend N = 38,269 (%)	Day N = 90,945 (%)	Night N = 57,777 (%)
Age groups				
15-39	4,361 (4.0)	1,580 (4.1)	3,501 (3.9)	2,440 (4.2)
40-59	16,623 (15.1)	5,804 (15.2)	13,044 (14.3)	9,383 (16.2)
60-79	46,943 (42.5)	16,178 (42.3)	38,593 (42.4)	24,528 (42.5)
80+	42,526 (38.5)	14,707 (38.4)	35,807 (39.4)	21,426 (37.1)
Age (years; median (IQR))	75.8 (63.9-84.1)	75.8 (63.7-84.2)	76.2 (64.5-84.3)	75.1 (62.9-83.9)
Gender				
Female	50,318 (45.6)	17,407 (45.5)	42,300 (46.5)	25,425 (44.0)
Male	60,135 (54.4)	20,862 (54.5)	48,645 (53.5)	32,352 (56.0)
Charlson comorbidity index				
0	74,780 (67.7)	25,954 (67.8)	61,248 (67.4)	39,486 (68.3)
1-2	28,678 (26.0)	9,859 (25.8)	23,930 (26.3)	14,607 (25.3)
3+	6,995 (6.3)	2,456 (6.4)	5,767 (6.3)	3,684 (6.4)
Admitted via ED	93,799 (84.9)	33,469 (87.5)	76,835 (84.5)	50,433 (87.3)

442 ¹Day of hospital admission or associated preceding emergency department presentation

443 Conditions included are ischaemic stroke, haemorrhagic stroke, acute myocardial infarction, pneumonia, chronic
 444 obstructive pulmonary disease, and congestive heart failure.

445

446 **Table 3.** Unadjusted odds ratios for 30-day mortality for day of week and time of day of presentation¹.

Variable	Ischaemic stroke		Haemorrhagic stroke		AMI		Pneumonia		COPD		CHF	
	Unadjusted Odds Ratio	P-value	Unadjusted Odds Ratio	P-value	Unadjusted Odds Ratio	P-value	Unadjusted Odds Ratio	P-value	Unadjusted Odds Ratio	P-value	Unadjusted Odds Ratio	P-value
Day of week		0.006		0.271		0.879		0.092		0.003		0.813
Monday	Reference		Reference		Reference		Reference		Reference		Reference	
Tuesday	1.14 (0.95-1.37)	0.152	0.97 (0.80-1.19)	0.789	1.00 (0.86-1.18)	0.964	0.90 (0.80-1.00)	0.052	1.07 (0.93-1.23)	0.332	0.99 (0.88-1.12)	0.927
Wednesday	1.20 (1.00-1.44)	0.051	1.07 (0.88-1.31)	0.493	1.02 (0.87-1.20)	0.787	1.01 (0.90-1.12)	0.916	1.07 (0.93-1.23)	0.354	1.05 (0.93-1.18)	0.462
Thursday	1.04 (0.86-1.25)	0.668	0.87 (0.71-1.07)	0.194	1.08 (0.92-1.27)	0.321	0.97 (0.87-1.08)	0.600	1.24 (1.08-1.42)	0.002	0.99 (0.88-1.13)	0.929
Friday	1.30 (1.09-1.56)	0.004	1.00 (0.82-1.23)	0.969	1.08 (0.92-1.26)	0.355	0.95 (0.85-1.06)	0.346	1.24 (1.08-1.42)	0.002	1.04 (0.92-1.17)	0.566
Saturday	1.28 (1.07-1.54)	0.008	1.12 (0.91-1.38)	0.288	0.99 (0.84-1.16)	0.887	1.07 (0.96-1.20)	0.211	1.18 (1.02-1.36)	0.023	1.09 (0.96-1.24)	0.195
Sunday	1.35 (1.12-1.61)	0.001	1.10 (0.90-1.36)	0.352	1.02 (0.86-1.20)	0.843	1.00 (0.89-1.12)	0.981	1.01 (0.88-1.17)	0.866	1.03 (0.90-1.17)	0.712
Time of day		0.001		<0.001		0.967		0.750		0.231		0.794
Day	Reference		Reference		Reference		Reference		Reference		Reference	
Night	1.22 (1.10-1.35)		1.49 (1.33-1.67)		1.00 (0.92-1.09)		1.01 (0.95-1.07)		0.95 (0.88-1.03)		1.01 (0.94-1.08)	

¹Day of hospital admission or associated preceding emergency department presentation

Hospital is included as a random effect.

447

448 **Table 4.** Adjusted odds-ratios for 30-day mortality by day of week and time of day of presentation¹.

Variable	Ischaemic stroke		Haemorrhagic stroke		AMI		Pneumonia		COPD		CHF	
	Adjusted Odds Ratio	P-value	Adjusted Odds Ratio	P-value	Adjusted Odds Ratio	P-value	Adjusted Odds Ratio	P-value	Adjusted Odds Ratio	P-value	Adjusted Odds Ratio	P-value
Day of week		0.136		0.404		0.741		0.136		0.003		0.660
Monday	Reference		Reference		Reference		Reference		Reference		Reference	
Tuesday	1.14 (0.95-1.38)	0.167	1.01 (0.82-1.24)	0.926	1.07 (0.90-1.28)	0.451	0.87 (0.77-0.98)	0.023	1.09 (0.94-1.25)	0.269	1.00 (0.88-1.14)	0.971
Wednesday	1.12 (0.93-1.35)	0.242	1.08 (0.88-1.34)	0.451	0.99 (0.83-1.19)	0.936	0.97 (0.86-1.09)	0.606	1.08 (0.93-1.25)	0.298	1.06 (0.93-1.21)	0.373
Thursday	1.03 (0.84-1.25)	0.803	0.88 (0.71-1.09)	0.228	1.08 (0.91-1.29)	0.371	0.98 (0.87-1.10)	0.720	1.29 (1.12-1.48)	0.001	0.99 (0.87-1.12)	0.829
Friday	1.22 (1.01-1.47)	0.039	1.05 (0.85-1.29)	0.653	1.10 (0.92-1.31)	0.303	0.92 (0.81-1.03)	0.156	1.25 (1.08-1.44)	0.002	1.09 (0.96-1.24)	0.175
Saturday	1.17 (0.96-1.42)	0.112	1.13 (0.91-1.40)	0.275	1.01 (0.84-1.21)	0.941	1.03 (0.92-1.17)	0.578	1.18 (1.02-1.37)	0.030	1.07 (0.94-1.23)	0.315
Sunday	1.28 (1.06-1.54)	0.012	1.06 (0.85-1.31)	0.595	0.96 (0.80-1.16)	0.681	0.97 (0.86-1.10)	0.670	1.05 (0.90-1.22)	0.550	1.02 (0.89-1.17)	0.784
Time of day		<0.001		<0.001		0.200		0.861		0.905		0.525
Day	Reference		Reference		Reference		Reference		Reference		Reference	
Night	1.30 (1.17-1.45)		1.58 (1.40-1.78)		1.07 (0.97-1.17)		1.01 (0.94-1.08)		1.00 (0.92-1.08)		1.02 (0.95-1.10)	

449 ¹Day of hospital admission or associated preceding emergency department presentation

450 Models were adjusted for age, sex, and comorbidities (final model results for all variables are provided in supplementary table S1). Hospital is included as a random effect.

451

452 **Table 5.** Unadjusted and adjusted odds ratios for 30-day mortality for day of week, categorized as weekend versus weekday, of hospital presentation¹ using random effect
 453 logistic regression models

Variable	Ischaemic stroke		Haemorrhagic stroke		AMI		Pneumonia		COPD		CHF	
	Odds ratio	P-value	Odds ratio	P-value	Odds ratio	P-value	Odds ratio	P-value	Odds ratio	P-value	Odds ratio	P-value
Unadjusted												
Day of week		0.006		0.057		0.498		0.042		0.617		0.310
Weekday	Reference		Reference		Reference		Reference		Reference		Reference	
Weekend	1.16 (1.04-1.29)		1.13 (1.00-1.28)		0.97 (0.88-1.07)		1.07 (1.00-1.15)		0.98 (0.90-1.07)		1.04 (0.96-1.13)	
Adjusted												
Day of week		0.067		0.197		0.261		0.135		0.686		0.686
Weekday	Reference		Reference		Reference		Reference		Reference		Reference	
Weekend	1.11 (0.99-1.24)		1.09 (0.96-1.24)		0.94 (0.84-1.05)		1.06 (0.98-1.14)		0.98 (0.90-1.07)		1.02 (0.93-1.11)	
Time of day		<0.001		<0.001		0.210		0.939		0.930		0.930
Day	Reference		Reference		Reference		Reference		Reference		Reference	
Night	1.30 (1.17-1.45)		1.57 (1.40-1.77)		1.06 (0.97-1.17)		1.00 (0.94-1.07)		1.00 (0.92-1.08)		1.02 (0.95-1.10)	0.930

454 ¹Day of hospital admission or associated preceding emergency department presentation

455 Adjusted models included age, sex and comorbidities. All models included hospital as a random effect.

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2
3 456 **Figure 1.** a) Adjusted odds ratios for 30-day mortality for day of week of presentation by
4 457 clinical condition. Reference group is Monday (dotted line). b) adjusted odds ratios for 30-
5 458 day mortality for presentation to hospital at night compared to during the day, by clinical
6 459 condition. AMI = acute myocardial infarction, COPD = chronic obstructive pulmonary
7 460 disease, CHF = congestive heart failure.
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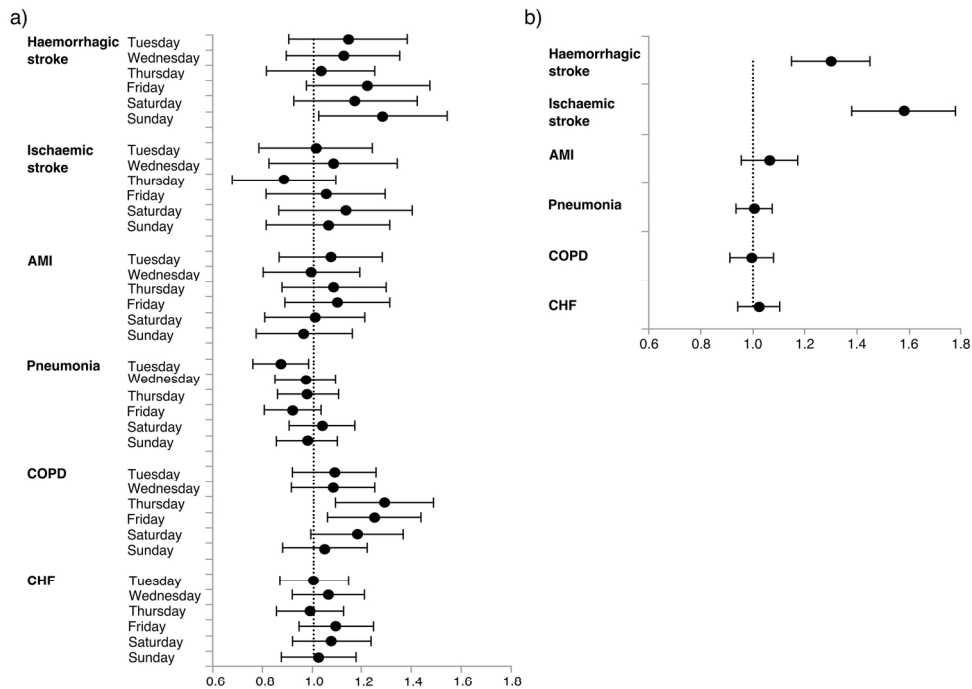


Figure 1. a) Adjusted odds ratios for 30-day mortality for day of week of admission by clinical condition. Reference group is Monday (dotted line). b) adjusted odds ratios for 30-day mortality for admission to hospital at night compared to during the day, by clinical condition. AMI = acute myocardial infarction, COPD = chronic obstructive pulmonary disease, CHF = congestive heart failure.

165x131mm (300 x 300 DPI)

SUPPLEMENTARY MATERIAL

Table S1. Final multivariable model results for 30-day mortality by day of week and time of day of hospital admission or related, preceding ED presentation for ischaemic and haemorrhagic stroke, AMI, pneumonia, COPD and CHF.

Condition Variable	Odds Ratio (95% CI)	p-value	Condition Variable	Odds Ratio (95% CI)	p-value
Ischaemic stroke			Haemorrhagic stroke		
Day of week (ref = Mon)		0.136	Day of week (ref = Mon)		0.404
Tuesday	1.14 (0.95-1.38)	0.167	Tuesday	1.01 (0.82-1.24)	0.926
Wednesday	1.12 (0.93-1.35)	0.242	Wednesday	1.08 (0.88-1.34)	0.451
Thursday	1.03 (0.84-1.25)	0.803	Thursday	0.88 (0.71-1.09)	0.228
Friday	1.22 (1.01-1.47)	0.039	Friday	1.05 (0.85-1.29)	0.653
Saturday	1.17 (0.96-1.42)	0.112	Saturday	1.13 (0.91-1.40)	0.275
Sunday	1.28 (1.06-1.54)	0.012	Sunday	1.06 (0.85-1.31)	0.595
Night	1.30 (1.17-1.45)	<0.001	Night	1.58 (1.40-1.78)	<0.001
Sex (ref = male)	1.32 (1.19-1.47)	<0.001	Sex (ref = male)	1.39 (1.24-1.56)	<0.001
Age (centred)	1.06 (1.06-1.07)	<0.001	Age (centred)	1.04 (1.04-1.05)	<0.001
Age (squared)	1.00 (1.00-1.00)	<0.001	Heart failure	1.47 (1.16-1.87)	0.001
Renal failure	1.70 (1.48-1.97)	<0.001	Malignancy	2.75 (2.20-3.45)	<0.001
Heart failure	1.95 (1.66-2.28)	<0.001	Previous H-stroke	0.61 (0.48-0.77)	<0.001
Malignancy	2.64 (2.15-3.24)	<0.001			
AMI			Pneumonia		
Day of week (ref = Mon)		0.741	Day of week (ref=Mon)		0.136
Tuesday	1.07 (0.90-1.28)	0.451	Tuesday	0.87 (0.77-0.98)	0.023
Wednesday	0.99 (0.83-1.19)	0.936	Wednesday	0.97 (0.86-1.09)	0.606
Thursday	1.08 (0.91-1.29)	0.371	Thursday	0.98 (0.87-1.10)	0.720
Friday	1.10 (0.92-1.31)	0.303	Friday	0.92 (0.81-1.03)	0.156
Saturday	1.01 (0.84-1.21)	0.941	Saturday	1.03 (0.91-1.16)	0.578
Sunday	0.96 (0.80-1.16)	0.681	Sunday	0.97 (0.86-1.10)	0.670
Night	1.07 (0.97-1.17)	0.200	Night	1.00 (0.94-1.07)	0.861
Age (centred)	1.06 (1.05-1.06)	<0.001	Financial year (ref = 2009)		<0.001
Age (squared)	1.00 (1.00-1.00)	<0.001	2010	0.90 (0.83-0.97)	0.004
STEMI	2.71 (2.44-3.01)	<0.001	2011	0.74 (0.68-0.80)	<0.001
Dementia	2.10 (1.77-2.48)	<0.001	Age (centred)	1.05 (1.05-1.05)	<0.001
Hypotension	1.29 (1.14-1.46)	<0.001	Age (squared)	1.00 (1.00-1.00)	<0.001
Shock	9.38 (7.79-11.30)	<0.001	Dementia	2.66 (2.42-2.92)	<0.001
Renal failure	2.32 (2.07-2.60)	<0.001	Hypotension	1.18 (1.08-1.28)	<0.001
Heart failure	1.77 (1.58-1.98)	<0.001	Shock	4.02 (3.34-4.84)	<0.001
Dysrhythmia	1.72 (1.55-1.90)	<0.001	Renal failure	1.84 (1.70-1.99)	<0.001
Malignancy	2.38 (1.94-2.92)	<0.001	Heart failure	1.55 (1.43-1.68)	<0.001
Hypertension	0.67 (0.61-0.74)	<0.001	Dysrhythmia	1.32 (1.22-1.42)	<0.001
Cerebrovascular disease	2.34 (1.95-2.81)	<0.001	Malignancy	5.54 (5.07-6.05)	<0.001
			Cerebrovascular disease	1.82 (1.59-2.08)	<0.001
			Other COPD	1.17 (1.08-1.27)	<0.001
			Liver disease	2.81 (1.75-2.71)	<0.001
			Parkinsons	1.69 (1.35-2.11)	<0.001

COPD			CHF		
Day of week (ref = Mon)		0.003	Day of week (ref=Mon)		0.660
Tuesday	1.09 (0.94-1.25)	0.269	Tuesday	1.00 (0.88-1.14)	0.971
Wednesday	1.08 (0.93-1.25)	0.298	Wednesday	1.06 (0.93-1.21)	0.373
Thursday	1.29 (1.12-1.48)	0.001	Thursday	0.99 (0.87-1.12)	0.829
Friday	1.25 (1.08-1.44)	0.002	Friday	1.09 (0.96-1.24)	0.175
Saturday	1.18 (1.02-1.37)	0.030	Saturday	1.07 (0.94-1.23)	0.315
Sunday	1.05 (0.90-1.22)	0.550	Sunday	1.02 (0.89-1.17)	0.784
Night	1.00 (0.92-1.08)	0.905	Night	1.02 (0.95-1.10)	0.525
Financial year (ref = 2009)		<0.001	Financial year (ref = 2009)		<0.001
2010	0.77 (0.70-0.85)	<0.001	2010	0.89 (0.81-0.97)	0.009
2011	0.50 (0.45-0.55)	<0.001	2011	0.67 (0.62-0.74)	<0.001
Prev acute COPD episode (ref = 0) ¹		<0.001	Prev acute CHF episode (ref = 0) ¹		<0.001
1 previous episode	1.67 (1.51-1.85)	<0.001	1 previous episode	1.39 (1.26-1.52)	<0.001
2 previous episodes	2.13 (1.86-2.43)	<0.001	2 previous episodes	1.70 (1.48-1.97)	<0.001
3+ previous episodes	3.04 (2.69-3.44)	<0.001	3+ previous episodes	2.52 (2.14-2.96)	<0.001
Sex (ref=male)	0.82 (0.76-0.89)	<0.001	Sex (ref = male)	0.90 (0.84-0.97)	0.008
Age (centred)	1.03 (1.03-1.04)	<0.001	Age (centred)	1.05 (1.05-1.06)	<0.001
Age (squared)	1.00 (1.00-1.00)	0.013	Age (squared)	1.00 (1.00-1.00)	0.003
CHF	1.47 (1.34-1.61)	<0.001	Pulmonary circ. disord.	1.21 (1.09-1.35)	<0.001
Pulmonary circ. disord.	1.66 (1.46-1.89)	<0.001	Peripheral vascular disord.	1.19 (1.04-1.37)	0.013
Neurological disord.	1.31 (1.05-1.64)	0.016	Hypertension (comp/uncomp)	0.83 (0.77-0.90)	<0.001
Diabetes (comp.)	0.83 (0.73-0.95)	0.005	Paralysis	1.65 (1.34-2.04)	<0.001
Liver disease	1.98 (1.50-2.61)	<0.001	Neurological disorders	1.65 (1.39-1.97)	<0.001
Metastatic cancer	3.06 (2.38-3.95)	<0.001	Chronic pulmonary disease	1.23 (1.13-1.34)	<0.001
Solid tumour w/o metast.	1.42 (1.17-1.72)	<0.001	Renal failure	1.88 (1.73-2.03)	<0.001
Weight loss	1.89 (1.68-2.11)	<0.001	Liver disease	2.78 (2.29-3.38)	<0.001
Fluid/electrolyte dis.	1.81 (1.66-1.98)	<0.001	Lymphoma	2.24 (1.57-3.19)	<0.001
Psychoses	2.10 (1.47-3.00)	<0.001	Metastatic cancer	3.07 (2.44-3.86)	<0.001
			Coagulopathy	1.29 (1.15-1.46)	<0.001
			Weight loss	1.61 (1.43-1.83)	<0.001
			Fluid/electrolyte disorders	1.57 (1.45-1.69)	<0.001
			Deficiency anaemia	0.78 (0.68-0.90)	<0.001

¹lookback to 2004

STROBE Statement—Checklist of items that should be included in reports of *cohort studies*

	Item No	Recommendation	Checked (page #)
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5-6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	6-7
		(b) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-7
Bias	9	Describe any efforts to address potential sources of bias	6-7
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7-8
		(b) Describe any methods used to examine subgroups and interactions	7
		(c) Explain how missing data were addressed	6
		(d) If applicable, explain how loss to follow-up was addressed	NA
		(e) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8, 19
		(b) Indicate number of participants with missing data for each variable of interest	8
		(c) Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	Report numbers of outcome events or summary measures over time	18
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear	20,21

		which confounders were adjusted for and why they were included	
		(b) Report category boundaries when continuous variables were categorized	NA
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	considered
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10,11
Discussion			
Key results	18	Summarise key results with reference to study objectives	9
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	10,11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11,12
Generalisability	21	Discuss the generalisability (external validity) of the study results	11,12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	12

*Give information separately for exposed and unexposed groups.

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

BMJ Open

Is the weekend effect really ubiquitous? Retrospective clinical cohort analyses of 30-day mortality by day of week and time of day using linked population data from New South Wales, Australia

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2017-016943.R3
Article Type:	Research
Date Submitted by the Author:	02-Jan-2018
Complete List of Authors:	Baldwin, Heather; Bureau of Health Information; New South Wales Ministry of Health Marashi-Pour, Sadaf; Bureau of Health Information Chen, Hwei-Yang ; Bureau of Health Information Kaldor, Jill; Bureau of Health Information Sutherland, Kim; Bureau of Health Information Levesque, Jean-Frederic; Bureau of Health Information, ; University of New South Wales, Centre for Primary Health Care and Equity
Primary Subject Heading:	Health services research
Secondary Subject Heading:	Health services research, Health policy, Public health
Keywords:	PUBLIC HEALTH, HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Quality in health care < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT

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Manuscripts

1 Is the weekend effect really ubiquitous? Retrospective clinical cohort
2 analyses of 30-day mortality by day of week and time of day using
3 linked population data from New South Wales, Australia

4
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17

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19 Word count (abstract + body): 3401

20

21

22 ABSTRACT

23 Objective

24 To examine the associations between day of week and time of admission and 30-day
25 mortality for six clinical conditions: ischaemic and haemorrhagic stroke, acute myocardial
26 infarction, pneumonia, chronic obstructive pulmonary disease and congestive heart failure.

27 Design

28 Retrospective population-based cohort analyses. Hospitalisation records were linked to
29 emergency department and deaths data. Random effect logistic regression models were used,
30 adjusting for casemix and taking into account clustering within hospitals.

31 Setting

32 All hospitals in New South Wales, Australia from July 2009 to June 2012.

33 Participants

34 Patients admitted to hospital with a primary diagnosis for one of the six clinical conditions
35 examined.

36 Outcome measures

37 Adjusted odds ratios for all-cause mortality within 30 days of admission, by day of week and
38 time of day.

39 Results

40 A total of 148,722 patients were included in the study, with 17,721 deaths within 30 days of
41 admission. Day of week of admission was not associated with significantly higher likelihood
42 of death for five of the six conditions after adjusting for casemix. There was significant
43 variation in mortality for chronic obstructive pulmonary disease by day of week, however,
44 this was not consistent with a strict weekend effect (Thursday: OR 1.29, 95% CI 1.12–1.48;
45 Friday: OR 1.25, 95%CI 1.08–1.44; Saturday: OR 1.18, 95% CI 1.02–1.37; Sunday OR 1.05,
46 95% CI 0.90–1.22; compared to Monday). There was evidence for a night effect for patients
47 admitted for stroke (ischaemic: OR 1.30, 95% CI 1.17–1.45; haemorrhagic: OR 1.58, 95% CI
48 1.40–1.78).

49 **Conclusions**

50 Mortality outcomes for these conditions, adjusted for casemix, do not vary in accordance
51 with the weekend effect hypothesis. Our findings support a growing body of evidence that
52 questions the ubiquity of the weekend effect.

54 **Keywords**

55 Weekend effect, night effect, out-of-hours effect, stroke, AMI, pneumonia, COPD, CHF

57 **Article summary**

58 *Strengths and limitations of this study*

- 59 • The examined conditions encompass a range of time sensitivity, interventions, acuity
60 and prognosis, providing a gradient to assess potential causality of association.
- 61 • The use of linked hospital admission and emergency department (ED) data allowed
62 complete coverage of hospital admissions for the state, while minimising
63 misclassification bias from time spent in ED and maximising validity and quality of
64 diagnosis and comorbidity data.
- 65 • The use of clinical cohorts of patients allows more precise adjustment for casemix
66 than non-specific admissions.
- 67 • Linkage to the Deaths Register allowed the capture of 30-day all-cause mortality.
68 While mortality is a standard indicator, other outcomes may be more sensitive to
69 variation in patient outcomes.
- 70 • We focussed on the NSW health system as a whole and did not explore the possible
71 weekend effect at hospital level.

72

73 **INTRODUCTION**

74 In recent years, researchers and policy makers have shown growing interest in the
75 ‘weekend effect’, examining whether patients admitted to hospital at the weekend experience
76 worse outcomes compared to patients admitted during the week. This effect has been
77 observed in numerous studies of health systems around the world, for a wide range of
78 conditions and procedures.¹⁻⁶ Studies have also observed a ‘night effect’, suggesting that the
79 phenomenon may extend to out-of-hours presentation more broadly.¹⁻⁴

80 Considerable uncertainty remains as to the cause of the apparent effect of weekend
81 and night-time (hereafter collectively ‘out-of-hours’) presentation on patient outcomes. Two
82 main hypotheses have been proposed to explain the observed variation: these focus on
83 healthcare service quality and on patient characteristics.² The first hypothesis posits that the
84 poorer outcomes seen among patients admitted on the weekend are explained by lower
85 quality of care out-of-hours. More specifically, putative factors include lower staffing levels,
86 fewer senior consultants and specialists, and reduced availability of diagnostic procedures.³
87 This hypothesis gained considerable traction with policy makers and has contributed to the
88 recent, controversial push towards seven day hospital services in the UK.⁷

89 The second hypothesis proposes that the weekend effect is largely attributable to
90 patient characteristics, and at least partly a data artefact resulting from insufficient
91 information on patient characteristics in administrative datasets. There is little clear evidence
92 that higher mortality is a consequence of staffing levels⁷, and a number of studies have found
93 no significant correlation between consultant seniority or specialist availability and
94 mortality.⁸⁻¹¹ There is also an increasing body of evidence to suggest that the weekend effect
95 dissipates after adjustment for casemix¹², arrival by ambulance as a proxy for illness

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3 96 severity¹³ and a higher severity threshold for admission.¹² This phenomenon may be
4
5 97 influenced by self-selection, whereby patients wait until the weekend to present to hospital
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7 98 and may therefore present with more advanced disease, and less comprehensive note-taking
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9 99 on the weekend limiting the ability to risk-adjust.¹⁴
10

11
12 100 The night effect is less extensively studied than the weekend effect, and reasons for
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14 101 the night effect are usually presumed to be similar to the weekend effect. The few studies that
15
16 102 have examined the effects of out-of-hours presentation on mortality in Australia have had
17
18 103 mixed results.^{3,4,15,16} Previous studies have been limited by using in-hospital mortality only
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20 104 and therefore not capturing deaths that occurred post-discharge¹⁷, reduced ability to
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22 105 adequately risk adjust by focusing on clinically non-specific admissions.^{3,16,18} Further,
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24 106 previous studies have often relied on unlinked emergency department (ED) data⁴, which
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26 107 contain limited or largely incomplete and inaccurate information on principal diagnosis and
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28 108 comorbidity, or unlinked hospitalisation data, which may be affected by misclassification
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30 109 bias due to time spent in waiting in ED prior to admission.^{15,18}
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35 110 Overall, previous studies have shown that the out-of-hours effect does not apply to
36
37 111 all clinical presentations and procedures.^{1-4,8} It is therefore beneficial to investigate conditions
38
39 112 for which we can expect that the weekend is more likely to occur, based on theoretical
40
41 113 grounds, on clinical plausibility or on previous evidence.²
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44 114 We investigated the existence of the weekend effect and the night effect for acute
45
46 115 hospitalisations for various conditions, comprising ischaemic stroke, haemorrhagic stroke,
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48 116 acute myocardial infarction (AMI), pneumonia, chronic obstructive pulmonary disease
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50 117 (COPD), and congestive heart failure (CHF), across all hospitals in New South Wales
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52 118 (NSW). These conditions provide insights into a range of aspects of healthcare, including
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54 119 timely delivery of interventions, surgical services, differences in acuity and prognosis, and
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3 120 provide a gradient to assess potential causality of association as they vary in the importance
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5 121 of immediate care. We predicted that if day and time effects exist, they would show strongest
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7 122 effects for the most urgent conditions (stroke and AMI), and be weakest for patients with the
8
9 123 least urgent conditions (pneumonia and COPD). We hypothesized that presentations on
10
11 124 Saturdays and Sundays would show higher 30-day mortality for the six conditions than
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13 125 presentations that occurred during the week, and that night-time presentations would show
14
15 126 higher mortality than presentations that occurred during the day.
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22 128 **METHODS**

23
24 129 Retrospective cohort analyses were performed for the six indicator conditions. Cohorts were
25
26 130 identified from all admissions to NSW public and private hospitals for the period of 1 July
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28 131 2009 to 30 June 2012, extracted from the NSW Admitted Patient Data Collection, which is a
29
30 132 census of all hospital admissions in NSW. These data were linked to emergency department
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32 133 (ED) attendances in all NSW public hospitals recorded in the Emergency Department Data
33
34 134 Collection, representing approximately 85% of all emergency presentations in NSW.^{19,20}
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36 135 Emergency department data were linked to allow the capture of the start day and time of the
37
38 136 patients' contact with the hospital system for the episode of illness, minimising any bias
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40 137 imposed by time spent in the ED that may affect the day and time of hospitalisation, since
41
42 138 patients may spend longer in the ED before admission at night or at weekends. Mortality data
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44 139 were obtained from the NSW Deaths Register. Data were linked by the NSW Centre for
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46 140 Health Record Linkage using probabilistic methods based on personal identifiers. The
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48 141 estimated false positive rate for the current version of the Master Linkage Key is 5 per
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50 142 1000.²¹
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3 143 The principal diagnosis in the patient record, coded using International Classification
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5 144 of Diseases 10th revision Australian modification, was used to identify each clinical cohort.
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7 145 Only complete records of admissions coded as acute and emergency were included. The
8
9 146 proportion of records excluded for missing values on key variables such as age, sex, date of
10
11 147 admission and separation, type of care and emergency status was less than 0.1%. Patients
12
13 148 aged less than 15 years (ischaemic stroke, haemorrhagic stroke, AMI), 18 years (pneumonia)
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15 149 or 45 years (COPD, CHF) were excluded, consistent with existing mortality indicator
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17 150 definitions for these conditions, due to low mortality rates among these groups.^{22,23} AMI can
18
19 151 be classified as ST-elevated myocardial infarction (STEMI) or non-ST elevated myocardial
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21 152 infarction (non-STEMI) based on the electrocardiogram reading, or unspecified AMI when
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23 153 diagnostic records are unavailable. STEMI is associated with higher mortality at 30 days
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25 154 compared to non-STEMI, and the unspecified group is a heterogeneous mix of critically
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27 155 unwell patients who died before their AMI could be specified and patients for whom
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29 156 diagnostic records were less precise, so AMI patients with a non-specific infarction were
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31 157 excluded to allow adjustment for STEMI.^{22,23} Transfers and multiple contiguous
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33 158 hospitalisations were considered as a single period of care. For patients with multiple periods
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35 159 of care during the study period, only the last period of care was included in the analyses.
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40 160 Mortality was defined as death (in or out of hospital) occurring within 30 days of the
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42 161 start of the period of care. The day of week of presentation was defined as the first day of
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44 162 contact with the hospital system for the period of care (either hospital admission or ED
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46 163 presentation). Patients dead on arrival to ED and not admitted to hospital were excluded. An
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48 164 ED presentation was considered relevant for the hospital admission if it occurred on the same
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50 165 day, or previous day, as the hospital admission. Same day ED presentations were only
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52 166 included if the time was recorded as before the hospital admission time. In this study, the
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54 167 weekend comprises Saturday and Sunday, while weekdays are defined as Monday through
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3 168 Friday. Night time presentation was defined as first presentation between 18:00 and 07:59,
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5 169 using hospital admission time or ED presentation time as described.
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8 170 Random effects logistic regression models were used to investigate associations
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10 171 between day of week, or time of presentation, with mortality. To account for clustering of
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12 172 patients within hospitals, hospitals were considered as random effects in the regression
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14 173 models. Risk adjustment was performed to account for casemix factors including age
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16 174 (continuous, tested for curvilinearity), sex, year and comorbidities. Condition-specific
17
18 175 comorbidity sets defined by the Australian Commission for Safety and Quality in Health Care
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20 176 were used as the basis for building risk adjustment models for each condition, where
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22 177 available (ischaemic stroke, haemorrhagic stroke, AMI, pneumonia), while COPD and CHF
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24 178 used Elixhauser comorbidities.²² Availability of thrombolysis treatment was also considered
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26 179 as a predictive variable for ischaemic stroke, and STEMI status was considered for AMI.
27
28 180 Comorbidities were captured across all hospital admissions over a one year period prior to the
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30 181 index admission. Interactions between day of the week and night time presentations were also
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32 182 explored in the final models using likelihood ratio tests.
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36 183 Models were selected using backwards selection.²⁴ Factors with a *p*-value of less than
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38 184 0.2 in the univariate analyses were included in the initial full models. Variables with a *p*-
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40 185 value of less than 0.05 were retained in the model. Variables that were not significant at the
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42 186 20% level in the univariate models were then checked for significance in the backwards-
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44 187 selected model, and retained in the final model where $p < 0.05$. Overall performance of the
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46 188 models was assessed using c-statistics. In order to capture daily variation, 30-day mortality
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48 189 risks for each day of the week were compared against a reference weekday (Monday). We
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50 190 define observation of a weekend effect as significantly higher odds of 30-day mortality on
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52 191 weekend days (Saturday and Sunday) compared to Monday. To validate our findings,
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54 192 additional analyses were performed comparing weekend days against weekdays. Statistical
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3 193 analyses were performed using SAS v9.4 (SAS Institute Inc., Cary, NC, USA) and STATA
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5 194 v12.1 (StataCorp LP, Texas, USA).
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12 196 **RESULTS**

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14 197 There were a total of 213,834 acute, emergency hospital admissions for the conditions of
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16 198 interest during the study period. There were 10,658 admissions excluded as they did not meet
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18 199 the eligibility criteria for age, and 2161 patients were excluded who had a non-specified AMI.
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20 200 After accounting for transfers and multiple admissions, there were 148,722 patients were
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22 201 included in the study (table 1). There were 17,721 deaths within 30 days of admission
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24 202 (11.9%). A total of 127,268 admissions were linked to an ED presentation (85.6%). The
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26 203 clinical cohorts comprised between 5,740 (haemorrhagic stroke) and 44,508 (pneumonia)
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28 204 patients that were admitted or presented to between 133 and 183 hospitals. Characteristics of
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30 205 patients are provided by day of week and time of day of arrival in table 2.
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34 206 The most frequent day of presentation was Monday, while Saturdays and Sundays had
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36 207 fewer presentations than weekdays for all conditions. More patients were admitted during
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38 208 daytime than at night, regardless of condition.
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41 209 There were no significant associations in the univariate analyses between mortality
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43 210 and day of week, for haemorrhagic stroke, AMI, pneumonia, or CHF (table 3). There was
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45 211 significant variation in unadjusted 30-day mortality by day of week for ischaemic stroke and
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47 212 COPD, however this did not show a strict 'weekend effect' (ischaemic stroke: Friday,
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49 213 Saturday and Sunday significantly higher than Monday; COPD: Thursday, Friday and
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51 214 Saturday significantly higher than Monday).
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3 215 There was no significant difference in 30-day mortality by day of week after
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5 216 adjustment for casemix and other factors for five of the six conditions (table 4, figure 1).
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7 217 While Friday and Sunday presentations had significantly higher mortality than Monday for
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9 218 ischaemic stroke, overall day of the week was not significant in the model. Significant
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11 219 variation in mortality by day of week for COPD was not consistent with a weekend effect
12
13 220 (with Thursday, Friday and Saturday being associated with higher mortality compared with
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15 221 Monday).

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18 222 There was evidence for higher mortality among ischaemic and haemorrhagic stroke
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20 223 patients who presented to hospital overnight. This night effect was observed in both the
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22 224 unadjusted and adjusted analyses (table 3, table 4). There was no evidence of increased
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24 225 mortality among night admissions for the other conditions. There were no significant
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26 226 interactions between day of week and time of day, after adjustment for confounding factors,
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28 227 for any of the conditions.

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32 228 The models performed moderately well, with c-statistics ranging from 0.68 to 0.82
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34 229 (ischaemic stroke: 0.73, haemorrhagic stroke: 0.68, AMI: 0.81, pneumonia: 0.82, COPD:
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36 230 0.74, CHF: 0.72).

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39 231 Results from the analyses comparing 30-day mortality on pooled weekend versus
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41 232 weekdays showed that the weekend was associated with a higher unadjusted likelihood of 30-
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43 233 day mortality compared with weekday for ischaemic stroke and pneumonia (table 5).
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45 234 However, after taking into account other risk factors, no significant differences were
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47 235 observed in 30-day mortality between weekdays and weekend for any of the conditions
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49 236 studied.

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3 238 **DISCUSSION**

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6 239 *Main findings*

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8 240 Mortality outcomes do not vary in accordance with the weekend effect, after adjusting for
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10 241 casemix, for patients admitted to hospital with stroke, AMI, pneumonia, COPD, or CHF in
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12 242 NSW. We found increased mortality for stroke patients presenting to hospital at night, with
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15 243 no evidence for the night effect for the remaining conditions.

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18 244 Our findings support a growing body of evidence that disputes the ubiquity of the
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20 245 weekend effect.^{7,12,14,15,25,26} Of the six conditions investigated in this study, only ischaemic
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22 246 stroke and COPD showed significant variation in crude mortality risk by day of week of
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24 247 presentation. Significant variation remained after risk adjustment for COPD only, and this
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26 248 was not consistent with predictions for the weekend effect, with the highest odds of death
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28 249 within 30 days was found for those who presented on Thursday and Friday. When weekend
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30 250 and week days were pooled, there were no significant differences in odds of death after
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32 251 adjusting for other risk factors. This is consistent with studies which have shown more
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34 252 complex patterns of temporal variation in that there are some days/times that are different but
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36 253 not specifically 'the weekend'.^{4,17,26,27}

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40 254 While findings from previous studies for stroke^{11,14,28,29}, AMI^{15,30} and COPD^{15,31} have
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42 255 been conflicting, our results are consistent with those that found no weekend effect
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44 256 (stroke^{1,14,26,32}, AMI^{1,33}, COPD¹⁵). A recent meta-analysis found no weekend effect for COPD
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46 257 and pneumonia, although it did find significant effects for intracerebral haemorrhage,
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48 258 ischaemic stroke and myocardial infarction³⁴. However, on comparing effects between
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50 259 continents, Oceania was found to have the lowest overall increase in odds of death (OR =
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52 260 1.04; compared to South America, OR = 1.47), suggesting that the weekend effect may be

261 highly heterogenous and dependent not only on clinical conditions but also on hospital
262 contexts, regional policy and other factors that may vary widely by geographic setting.

263 We observed that the numbers of admissions were lower at weekends in New South
264 Wales, and that the number of deaths within 30 days are generally proportionate to the
265 number of admissions. This is in contrast to the findings of previous studies.^{1,6,12,35} There are
266 a number of differences between our study and some of the previously published work which
267 may explain these differences. The use of 30-day mortality through linkage to the Deaths
268 Register as opposed to in-hospital death^{1,3,6,12,13,35} allows the capture not only of patients who
269 died in hospital, but also those died in community due to variation in care or early discharge.
270 This provides a more complete picture of mortality.

271 Further, our study has examined six specific clinical conditions, as opposed to all
272 emergency conditions.^{3,4,12,35} Not all emergency admissions have the same urgency or acuity
273 for treatment, and the conditions we have examined are useful indicators that encompass a
274 range of time sensitivity, interventions, acuity and prognosis. The use of clinical cohorts of
275 patients allows more precise adjustment for case-mix than considering non-specific
276 admissions. We found no effect on mortality of weekend presentation either in conditions
277 expected to be less sensitive to reduced staffing and services, nor among the more severe,
278 acute conditions, which confers confidence in the validity of our findings. Our analyses
279 comprised three years' complete population data for NSW with cohorts ranging from over
280 5000 to 44,000, which should provide sufficient power to detect statistically significant
281 differences.

282 In contrast to other studies, the use of linked hospitalisation and emergency
283 department data provides complete coverage of hospital admissions for the conditions of
284 interest in NSW, and minimises several potential biases. While most studies use either

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3 285 hospital admission data^{1,6,35} or ED data^{3,4}, the use of linked data in this study minimises
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5 286 misclassification bias in day and time of presentation caused by time spent in ED prior to
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7 287 admission. Additionally, the use of hospitalisation data from the index and historical
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9 288 admissions of the patients allowed us to maximise the detail and quality of diagnoses and
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11 289 comorbidities. This increases our confidence in our finding of no evidence for increased
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13 290 mortality associated with weekend presentation.

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16 291 We found significantly higher adjusted risk of death for ischaemic and haemorrhagic
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18 292 stroke patients who presented at night compared to those who presented during the day. This
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20 293 is consistent with other studies of stroke.^{26,28} This finding may reflect factors specific to
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22 294 stroke, such as that strokes occurring at night may take longer to recognise due to reduced
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24 295 activity, and may result in delayed seeking of treatment and therefore higher mortality. That
25
26 296 we only observed the night effect for stroke patients suggests that this variation is probably
27
28 297 not attributable to system-wide deficiencies. However, further research to explore reasons for
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30 298 the increase in mortality for stroke patients admitted at night, and the observed variation in
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32 299 mortality for COPD by day of presentation, including potential contributions from poorer
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34 300 community care, will help to understand whether these excess deaths are preventable.

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38 301 Our study is limited by a lack contextual information in our data about the differences
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40 302 in weekend and weekday or night time and day time practice, such as the availability of
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42 303 clinical or laboratory staff. It would be interesting to consider the results on the level of
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44 304 individual hospitals, as hospital variation in quality of care on weekends may be masked in
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46 305 this type of global analysis.

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50 306 Mortality is a useful indicator for health system performance and for evaluating
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52 307 unwarranted variation. However, it is an extreme outcome, and it may be a blunt tool that
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54 308 could mask some variation in patient outcomes. Further research is needed to determine

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3 309 whether lower staffing levels and resource access on weekends and out-of-hours may exhibit
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5 310 effects on other outcomes or processes, such as adverse events, delays in test results or care,
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7 311 or other quality indicators. Across healthcare systems, different models of care or availability
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9 312 of out-of-hours specialist services may affect any weekend effect seen locally.
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12 313 Unlike many other studies, our findings do not suggest a threshold effect or differing
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14 314 propensity to admit patients across days of the week. This may be a reflection of the
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16 315 particular conditions that our study focused upon or it may be the case that there is no
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18 316 weekend effect in NSW public hospitals. While our study does address both weekend effect
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20 317 and night time effect, it is possible that more complex patterns of temporal variation exist that
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22 318 could not be observed using our models.”
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27 28 29 320 **CONCLUSION**

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32 321 By identifying patients admitted through ED, and taking out-of-hospital deaths into account,
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34 322 this study was able to investigate the weekend effect by following the patient journey from
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36 323 prior to admission to after discharge. We found no evidence for a strict weekend effect in 30-
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38 324 day mortality for patients admitted with ischaemic or haemorrhagic stroke, AMI, pneumonia,
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40 325 COPD, or CHF. The finding of a night effect for stroke, and some variation between days for
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42 326 COPD, highlights that temporal variation in patient outcomes is complex and may have a
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44 327 variety of causes. Our findings increase the weight of evidence challenging the existence of
45
46 328 the weekend effect.
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50 329 **Acknowledgements**

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53 330 We thank the NSW Ministry of Health for access to population health data and the NSW
54
55 331 Centre for Health Record Linkage for linking the data sets. We thank Lisa Corscadden for
56
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332 helpful comments on the manuscript. HJB is supported by the NSW Biostatistics Training
333 Program.

334 **Contributors**

335 HJB, SMP, HYC, JK, KS and JFL contributed to the study design. HJB and SMP cleaned and
336 analysed the data and HJB produced the figure and tables. All authors contributed to the
337 interpretation of the results. HJB drafted the manuscript, and all authors contributed to
338 revising the manuscript. All authors approved the final version of the manuscript.

339 **Funding statement**

340 This research received no specific grant from any funding agency in the public, commercial
341 or not-for-profit sectors.

342 **Competing interests**

343 We declare no competing interests.

344 **Data sharing statement**

345 Privacy restrictions for the datasets used in this study prohibit free online availability. Access
346 to these data may be sought from the data custodians, the New South Wales Ministry of
347 Health.

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350 **REFERENCES**

- 351 1. Bell CM, Redelmeier DA. Mortality among patients admitted to hospitals on
352 weekends as compared with weekdays. *N Engl J Med*. 2001;345(9):663-8.
- 353 2. Lilford RJ, Chen Y-F. The ubiquitous weekend effect: moving past proving it exists
354 to clarifying what causes it. *BMJ Qual Saf*. 2015:bmjqs-2015-004360.
- 355 3. Ruiz M, Bottle A, Aylin PP. The Global Comparators project: international
356 comparison of 30-day in-hospital mortality by day of the week. *BMJ Qual Saf*. 2015:bmjqs-
357 2014-003467.
- 358 4. Concha OP, Gallego B, Hillman K, Delaney GP, Coiera E. Do variations in hospital
359 mortality patterns after weekend admission reflect reduced quality of care or different patient
360 cohorts? A population-based study. *BMJ Qual Saf*. 2014;23(3):215-22.
- 361 5. Vest-Hansen B, Riis AH, Sørensen HT, Christiansen CF. Out-of-hours and weekend
362 admissions to Danish medical departments: admission rates and 30-day mortality for 20
363 common medical conditions. *BMJ Open*. 2015;5(3):e006731.
- 364 6. Freemantle N, Richardson M, Wood J, Ray D, Khosla S, Shahian D, et al. Weekend
365 hospitalization and additional risk of death: an analysis of inpatient data. *J R Soc Med*.
366 2012;105(2):74-84.
- 367 7. McKee M. The weekend effect: now you see it, now you don't. *BMJ*. 2016;353:i2750.
- 368 8. Wise J. The weekend effect—how strong is the evidence? *BMJ*. 2016;353.
- 369 9. Ruiz M, Bottle A, Aylin PP. Exploring the impact of consultants' experience on
370 hospital mortality by day of the week: a retrospective analysis of hospital episode statistics.
371 *BMJ Qual Saf*. 2015:bmjqs-2015-004105.
- 372 10. Aldridge C, Bion J, Boyal A, Chen Y-F, Clancy M, Evans T, et al. Weekend specialist
373 intensity and admission mortality in acute hospital trusts in England: a cross-sectional study.
374 *The Lancet*. 2016.

- 1
2
3 375 11. Bray BD, Ayis S, Campbell J, Cloud GC, James M, Hoffman A, et al. Associations
4 376 between stroke mortality and weekend working by stroke specialist physicians and registered
5 377 nurses: prospective multicentre cohort study. *PLoS Med.* 2014;11(8):e1001705.
6
7
8
9 378 12. Meacock R, Anselmi L, Kristensen SR, Doran T, Sutton M. Higher mortality rates
10 379 amongst emergency patients admitted to hospital at weekends reflect a lower probability of
11 380 admission. *J Health Serv Res Policy.* 2016;0(0):1-8.
12
13
14
15 381 13. Anselmi L, Meacock R, Kristensen SR, Doran T, Sutton M. Arrival by ambulance
16 382 explains variation in mortality by time of admission: retrospective study of admissions to
17 383 hospital following emergency department attendance in England. *BMJ Qual Saf.* 2016:bmjqs-
18 384 2016-005680.
19
20
21
22
23 385 14. Li L, Rothwell PM. Biases in detection of apparent “weekend effect” on outcome
24 386 with administrative coding data: population based study of stroke. *BMJ.* 2016;353.
25
26
27
28 387 15. Clarke M, Wills RA, Bowman R, Zimmerman P, Fong K, Coory M, et al. Exploratory
29 388 study of the ‘weekend effect’ for acute medical admissions to public hospitals in Queensland,
30 389 Australia. *Intern Med J.* 2010;40(11):777-83.
31
32
33
34 390 16. Singla AA, Guy GS, Field JB, Ma N, Babidge WJ, Maddern GJ. No weak days?
35 391 Impact of day in the week on surgical mortality. *ANZ J Surg.* 2015.
36
37
38
39 392 17. Coiera E, Wang Y, Magrabi F, Concha OP, Gallego B, Runciman W. Predicting the
40 393 cumulative risk of death during hospitalization by modeling weekend, weekday and diurnal
41 394 mortality risks. *BMC Health Serv Res.* 2014;14(1):1.
42
43
44
45 395 18. Bhonagiri D, Pilcher DV, Bailey MJ. Increased mortality associated with after-hours
46 396 and weekend admission to the intensive care unit: a retrospective analysis. *Med J Aust.*
47 397 2011;194(6):287-92.
48
49
50
51 398 19. Bureau of Health Information. Hospital Quarterly Technical supplement: Measures of
52 399 emergency department performance and activity. April to June 2010. Sydney (NSW); 2010.
53
54
55
56
57
58
59
60

- 1
2
3 400 20. Bureau of Health Information. Hospital Quarterly Technical Supplement: Measures of
4 401 emergency department performance, January to March 2012. Sydney (NSW); 2012.
- 5
6
7 402 21. Centre for Health Record Linkage. CHeReL—quality assurance. 2017. Available at:
8 403 <http://www.cherel.org.au/quality-assurance>. Retrieved May 30, 2017.
- 9
10
11
12 404 22. Bureau of Health Information. Spotlight on measurement: 30-day mortality following
13 405 hospitalisation, five clinical conditions, NSW, July 2009 - June 2012. Sydney (NSW), 2013.
- 14
15
16
17 406 23. Australian Commission of Safety and Quality in Health Care. National core, hospital-
18 407 based outcome indicator specification. Consultation Draft. Sydney: ACSQHC; 2012.
- 19
20
21 408 24. Hosmer D, Lemeshow S, May S. Applied survival analysis. Hoboken. NJ: John Wiley
22 409 & Sons; 2008.
- 23
24
25
26 410 25. Mikulich O, Callaly E, Bennett K, O'Riordan D, Silke B. The increased mortality
27 411 associated with a weekend emergency admission is due to increased illness severity and
28 412 altered case-mix. *Acute Medicine*. 2010;10(4):182-7.
- 29
30
31
32 413 26. Bray BD, Cloud GC, James MA, Hemingway H, Paley L, Stewart K, et al. Weekly
33 414 variation in health-care quality by day and time of admission: a nationwide, registry-based,
34 415 prospective cohort study of acute stroke care. *The Lancet*. 2016.
- 35
36
37
38 416 27. Lyndon A, Lee HC, Gay C, Gilbert WM, Gould JB, Lee KA. Effect of time of birth
39 417 on maternal morbidity during childbirth hospitalization in California. *Am J Obstet Gynecol*.
40 418 2015;213(5):705. e1-. e11.
- 41
42
43
44
45 419 28. Sorita A, Ahmed A, Starr SR, Thompson KM, Reed DA, Dabrh AMA, et al. Off-hour
46 420 presentation and outcomes in patients with acute ischemic stroke: a systematic review and
47 421 meta-analysis. *Eur J Intern Med*. 2014;25(4):394-400.
- 48
49
50
51 422 29. Roberts SE, Thorne K, Akbari A, Samuel DG, Williams JG. Mortality following
52 423 stroke, the weekend effect and related factors: record linkage study. *PLoS ONE*.
53 424 2015;10(6):e0131836.

- 1
2
3 425 30. Sorita A, Ahmed A, Starr SR, Thompson KM, Reed DA, Prokop L, et al. Off-hour
4 426 presentation and outcomes in patients with acute myocardial infarction: systematic review
5 427 and meta-analysis. *BMJ*. 2014;348:f7393.
6
7
8
9 428 31. Barba R, Zapatero A, Losa JE, Marco J, Plaza S, Rosado C, et al. The impact of
10 429 weekends on outcome for acute exacerbations of COPD. *Eur Respir J*. 2012;39(1):46-50.
11
12
13 430 32. Turin TC, Kita Y, Rumana N, Ichikawa M, Sugihara H, Morita Y, et al. Case fatality
14 431 of stroke and day of the week: is the weekend effect an artifact? *Cerebrovasc Dis*.
15 432 2008;26(6):606-11.
16
17
18
19
20 433 33. Hansen KW, Hvelplund A, Abildstrøm SZ, Prescott E, Madsen M, Madsen JK, et al.
21 434 Prognosis and treatment in patients admitted with acute myocardial infarction on weekends
22 435 and weekdays from 1997 to 2009. *Int J Cardiol*. 2013;168(2):1167-73.
23
24
25
26 436 34. Hoshijima H, Takeuchi R, Mihara T, Kuratani N, Mizuta K, Wajima Zi, et al.
27 437 Weekend versus weekday admission and short-term mortality: A meta-analysis of 88 cohort
28 438 studies including 56,934,649 participants. *Medicine*. 2017;96(17).
29
30
31
32 439 35. Aylin P, Yunus A, Bottle A, Majeed A, Bell D. Weekend mortality for emergency
33 440 admissions. A large, multicentre study. *Qual Saf Health Care*. 2010;19(3):213-7.
34
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442 **Table 1.** Numbers of patients admitted to hospital in NSW between July 2009 and June 2012 for the conditions
 443 examined, number and percentage of deaths within 30 days, by day and time of presentation¹.

Condition	Day of week							Time of Day		Total
	Mon	Tues	Wed	Thurs	Fri	Sat	Sun	Day	Night	
Ischaemic stroke (145 hospitals)										
Admissions ¹	2240	2168	2082	2070	2010	1868	1916	9858	4496	14354
Deaths	257	281	281	247	291	267	287	1241	670	1911
30-day mortality (%)	11.5	13.0	13.5	11.9	14.5	14.3	15.0	12.6	14.9	13.3
Haemorrhagic stroke (133 hospitals)										
Admissions ¹	905	894	818	830	853	703	737	3676	2064	5740
Deaths	303	296	288	255	286	254	264	1127	819	1946
30-day mortality (%)	33.5	33.1	35.2	30.7	33.5	36.1	35.8	30.7	39.7	33.9
Acute myocardial infarction (172 hospitals)										
Admissions ¹	4493	4332	4248	4241	4388	4004	3869	16309	13266	29575
Deaths	331	321	320	337	347	292	290	1233	1005	2238
30-day mortality (%)	7.4	7.4	7.5	8.0	7.9	7.3	7.5	7.6	7.6	7.6
Pneumonia (183 hospitals)										
Admissions ¹	7097	6354	6419	6366	6489	5754	6029	27382	17126	44508
Deaths	775	627	703	677	679	667	656	2929	1855	4784
30-day mortality (%)	10.9	9.9	11.0	10.6	10.5	11.6	10.9	10.7	10.8	10.8
Chronic obstructive pulmonary disease (177 hospitals)										
Admissions ¹	4794	4272	4193	4114	4116	3664	3786	17674	11265	28939
Deaths	459	436	426	476	479	408	367	1891	1160	3051
30-day mortality (%)	9.6	10.2	10.2	11.6	11.6	11.1	9.7	10.7	10.3	10.5
Congestive heart failure (177 hospitals)										
Admissions ¹	4325	3935	3828	3799	3780	2962	2977	16046	9560	25606
Deaths	628	568	577	549	566	462	441	2369	1422	3791
30-day mortality (%)	14.5	14.4	15.1	14.5	15.0	15.6	14.8	14.8	14.9	14.8

444 ¹Day of hospital admission or associated preceding emergency department presentation

445

446 **Table 2.** Demographic and clinical characteristics of patients with acute, emergency hospital admissions for the
 447 conditions of interest by day of week and time of day of presentation¹, NSW, July 2009 - June 2012.

448

Characteristic	Day of week		Time of day	
	Weekday N = 110,453 (%)	Weekend N = 38,269 (%)	Day N = 90,945 (%)	Night N = 57,777 (%)
Age groups				
15-39	4,361 (4.0)	1,580 (4.1)	3,501 (3.9)	2,440 (4.2)
40-59	16,623 (15.1)	5,804 (15.2)	13,044 (14.3)	9,383 (16.2)
60-79	46,943 (42.5)	16,178 (42.3)	38,593 (42.4)	24,528 (42.5)
80+	42,526 (38.5)	14,707 (38.4)	35,807 (39.4)	21,426 (37.1)
Age (years; median (IQR))	75.8 (63.9-84.1)	75.8 (63.7-84.2)	76.2 (64.5-84.3)	75.1 (62.9-83.9)
Gender				
Female	50,318 (45.6)	17,407 (45.5)	42,300 (46.5)	25,425 (44.0)
Male	60,135 (54.4)	20,862 (54.5)	48,645 (53.5)	32,352 (56.0)
Charlson comorbidity index				
0	74,780 (67.7)	25,954 (67.8)	61,248 (67.4)	39,486 (68.3)
1-2	28,678 (26.0)	9,859 (25.8)	23,930 (26.3)	14,607 (25.3)
3+	6,995 (6.3)	2,456 (6.4)	5,767 (6.3)	3,684 (6.4)
Admitted via ED	93,799 (84.9)	33,469 (87.5)	76,835 (84.5)	50,433 (87.3)

449 ¹Day of hospital admission or associated preceding emergency department presentation

450 Conditions included are ischaemic stroke, haemorrhagic stroke, acute myocardial infarction, pneumonia, chronic
 451 obstructive pulmonary disease, and congestive heart failure.

452

453 **Table 3.** Unadjusted odds ratios for 30-day mortality for day of week and time of day of presentation¹.

Variable	Ischaemic stroke		Haemorrhagic stroke		AMI		Pneumonia		COPD		CHF	
	Unadjusted Odds Ratio	P-value	Unadjusted Odds Ratio	P-value	Unadjusted Odds Ratio	P-value	Unadjusted Odds Ratio	P-value	Unadjusted Odds Ratio	P-value	Unadjusted Odds Ratio	P-value
Day of week		0.006		0.271		0.879		0.092		0.003		0.813
Monday	Reference		Reference		Reference		Reference		Reference		Reference	
Tuesday	1.14 (0.95-1.37)	0.152	0.97 (0.80-1.19)	0.789	1.00 (0.86-1.18)	0.964	0.90 (0.80-1.00)	0.052	1.07 (0.93-1.23)	0.332	0.99 (0.88-1.12)	0.927
Wednesday	1.20 (1.00-1.44)	0.051	1.07 (0.88-1.31)	0.493	1.02 (0.87-1.20)	0.787	1.01 (0.90-1.12)	0.916	1.07 (0.93-1.23)	0.354	1.05 (0.93-1.18)	0.462
Thursday	1.04 (0.86-1.25)	0.668	0.87 (0.71-1.07)	0.194	1.08 (0.92-1.27)	0.321	0.97 (0.87-1.08)	0.600	1.24 (1.08-1.42)	0.002	0.99 (0.88-1.13)	0.929
Friday	1.30 (1.09-1.56)	0.004	1.00 (0.82-1.23)	0.969	1.08 (0.92-1.26)	0.355	0.95 (0.85-1.06)	0.346	1.24 (1.08-1.42)	0.002	1.04 (0.92-1.17)	0.566
Saturday	1.28 (1.07-1.54)	0.008	1.12 (0.91-1.38)	0.288	0.99 (0.84-1.16)	0.887	1.07 (0.96-1.20)	0.211	1.18 (1.02-1.36)	0.023	1.09 (0.96-1.24)	0.195
Sunday	1.35 (1.12-1.61)	0.001	1.10 (0.90-1.36)	0.352	1.02 (0.86-1.20)	0.843	1.00 (0.89-1.12)	0.981	1.01 (0.88-1.17)	0.866	1.03 (0.90-1.17)	0.712
Time of day		0.001		<0.001		0.967		0.750		0.231		0.794
Day	Reference		Reference		Reference		Reference		Reference		Reference	
Night	1.22 (1.10-1.35)		1.49 (1.33-1.67)		1.00 (0.92-1.09)		1.01 (0.95-1.07)		0.95 (0.88-1.03)		1.01 (0.94-1.08)	

¹Day of hospital admission or associated preceding emergency department presentation

Hospital is included as a random effect.

454

455 **Table 4.** Adjusted odds-ratios for 30-day mortality by day of week and time of day of presentation¹.

Variable	Ischaemic stroke		Haemorrhagic stroke		AMI		Pneumonia		COPD		CHF	
	Adjusted Odds Ratio	P-value	Adjusted Odds Ratio	P-value	Adjusted Odds Ratio	P-value	Adjusted Odds Ratio	P-value	Adjusted Odds Ratio	P-value	Adjusted Odds Ratio	P-value
Day of week		0.136		0.404		0.741		0.136		0.003		0.660
Monday	Reference		Reference		Reference		Reference		Reference		Reference	
Tuesday	1.14 (0.95-1.38)	0.167	1.01 (0.82-1.24)	0.926	1.07 (0.90-1.28)	0.451	0.87 (0.77-0.98)	0.023	1.09 (0.94-1.25)	0.269	1.00 (0.88-1.14)	0.971
Wednesday	1.12 (0.93-1.35)	0.242	1.08 (0.88-1.34)	0.451	0.99 (0.83-1.19)	0.936	0.97 (0.86-1.09)	0.606	1.08 (0.93-1.25)	0.298	1.06 (0.93-1.21)	0.373
Thursday	1.03 (0.84-1.25)	0.803	0.88 (0.71-1.09)	0.228	1.08 (0.91-1.29)	0.371	0.98 (0.87-1.10)	0.720	1.29 (1.12-1.48)	0.001	0.99 (0.87-1.12)	0.829
Friday	1.22 (1.01-1.47)	0.039	1.05 (0.85-1.29)	0.653	1.10 (0.92-1.31)	0.303	0.92 (0.81-1.03)	0.156	1.25 (1.08-1.44)	0.002	1.09 (0.96-1.24)	0.175
Saturday	1.17 (0.96-1.42)	0.112	1.13 (0.91-1.40)	0.275	1.01 (0.84-1.21)	0.941	1.03 (0.92-1.17)	0.578	1.18 (1.02-1.37)	0.030	1.07 (0.94-1.23)	0.315
Sunday	1.28 (1.06-1.54)	0.012	1.06 (0.85-1.31)	0.595	0.96 (0.80-1.16)	0.681	0.97 (0.86-1.10)	0.670	1.05 (0.90-1.22)	0.550	1.02 (0.89-1.17)	0.784
Time of day		<0.001		<0.001		0.200		0.861		0.905		0.525
Day	Reference		Reference		Reference		Reference		Reference		Reference	
Night	1.30 (1.17-1.45)		1.58 (1.40-1.78)		1.07 (0.97-1.17)		1.01 (0.94-1.08)		1.00 (0.92-1.08)		1.02 (0.95-1.10)	

456 ¹Day of hospital admission or associated preceding emergency department presentation

457 Models were adjusted for age, sex, and comorbidities (final model results for all variables are provided in supplementary table S1). Hospital is included as a random effect.

458

459 **Table 5.** Unadjusted and adjusted odds ratios for 30-day mortality for day of week, categorized as weekend versus weekday, of hospital presentation¹ using random effect
 460 logistic regression models

Variable	Ischaemic stroke		Haemorrhagic stroke		AMI		Pneumonia		COPD		CHF	
	Odds ratio	P-value	Odds ratio	P-value	Odds ratio	P-value	Odds ratio	P-value	Odds ratio	P-value	Odds ratio	P-value
Unadjusted												
Day of week		0.006		0.057		0.498		0.042		0.617		0.310
Weekday	Reference		Reference		Reference		Reference		Reference		Reference	
Weekend	1.16 (1.04-1.29)		1.13 (1.00-1.28)		0.97 (0.88-1.07)		1.07 (1.00-1.15)		0.98 (0.90-1.07)		1.04 (0.96-1.13)	
Adjusted												
Day of week		0.067		0.197		0.261		0.135		0.686		0.686
Weekday	Reference		Reference		Reference		Reference		Reference		Reference	
Weekend	1.11 (0.99-1.24)		1.09 (0.96-1.24)		0.94 (0.84-1.05)		1.06 (0.98-1.14)		0.98 (0.90-1.07)		1.02 (0.93-1.11)	
Time of day		<0.001		<0.001		0.210		0.939		0.930		0.930
Day	Reference		Reference		Reference		Reference		Reference		Reference	
Night	1.30 (1.17-1.45)		1.57 (1.40-1.77)		1.06 (0.97-1.17)		1.00 (0.94-1.07)		1.00 (0.92-1.08)		1.02 (0.95-1.10)	0.930

461 ¹Day of hospital admission or associated preceding emergency department presentation

462 Adjusted models included age, sex and comorbidities. All models included hospital as a random effect.

1
2
3 463 **Figure 1.** a) Adjusted odds ratios for 30-day mortality for day of week of presentation by
4 464 clinical condition. Reference group is Monday (dotted line). b) adjusted odds ratios for 30-
5 465 day mortality for presentation to hospital at night compared to during the day, by clinical
6 466 condition. AMI = acute myocardial infarction, COPD = chronic obstructive pulmonary
7 467 disease, CHF = congestive heart failure.
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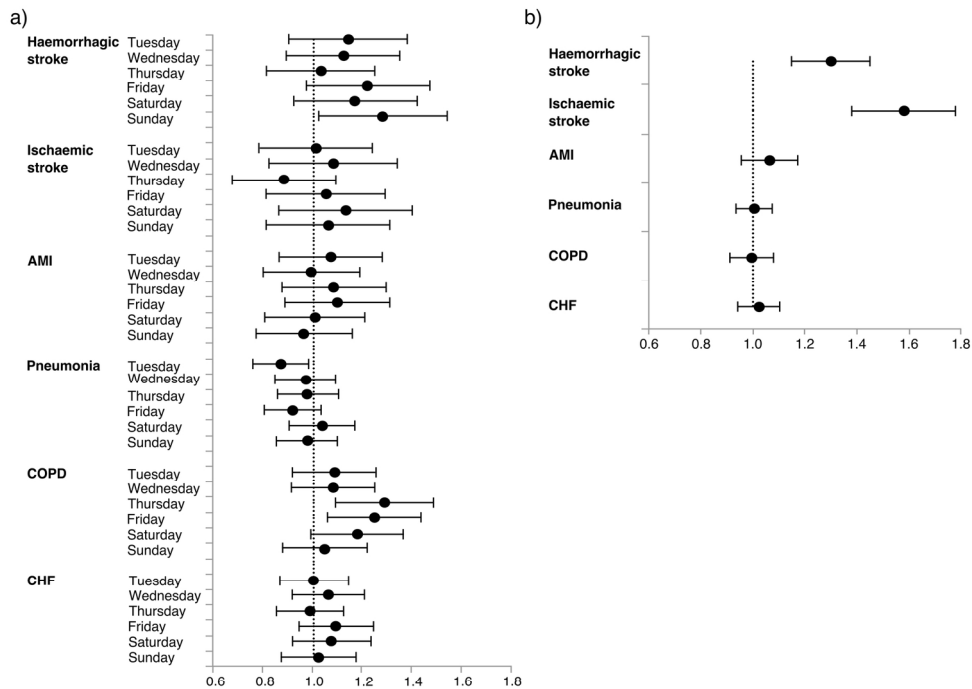


Figure 1. a) Adjusted odds ratios for 30-day mortality for day of week of admission by clinical condition. Reference group is Monday (dotted line). b) adjusted odds ratios for 30-day mortality for admission to hospital at night compared to during the day, by clinical condition. AMI = acute myocardial infarction, COPD = chronic obstructive pulmonary disease, CHF = congestive heart failure.

165x131mm (300 x 300 DPI)

SUPPLEMENTARY MATERIAL

Table S1. Final multivariable model results for 30-day mortality by day of week and time of day of hospital admission or related, preceding ED presentation for ischaemic and haemorrhagic stroke, AMI, pneumonia, COPD and CHF.

Condition Variable	Odds Ratio (95% CI)	p-value	Condition Variable	Odds Ratio (95% CI)	p-value
Ischaemic stroke			Haemorrhagic stroke		
Day of week (ref = Mon)		0.136	Day of week (ref = Mon)		0.404
Tuesday	1.14 (0.95-1.38)	0.167	Tuesday	1.01 (0.82-1.24)	0.926
Wednesday	1.12 (0.93-1.35)	0.242	Wednesday	1.08 (0.88-1.34)	0.451
Thursday	1.03 (0.84-1.25)	0.803	Thursday	0.88 (0.71-1.09)	0.228
Friday	1.22 (1.01-1.47)	0.039	Friday	1.05 (0.85-1.29)	0.653
Saturday	1.17 (0.96-1.42)	0.112	Saturday	1.13 (0.91-1.40)	0.275
Sunday	1.28 (1.06-1.54)	0.012	Sunday	1.06 (0.85-1.31)	0.595
Night	1.30 (1.17-1.45)	<0.001	Night	1.58 (1.40-1.78)	<0.001
Sex (ref = male)	1.32 (1.19-1.47)	<0.001	Sex (ref = male)	1.39 (1.24-1.56)	<0.001
Age (centred)	1.06 (1.06-1.07)	<0.001	Age (centred)	1.04 (1.04-1.05)	<0.001
Age (squared)	1.00 (1.00-1.00)	<0.001	Heart failure	1.47 (1.16-1.87)	0.001
Renal failure	1.70 (1.48-1.97)	<0.001	Malignancy	2.75 (2.20-3.45)	<0.001
Heart failure	1.95 (1.66-2.28)	<0.001	Previous H-stroke	0.61 (0.48-0.77)	<0.001
Malignancy	2.64 (2.15-3.24)	<0.001			
AMI			Pneumonia		
Day of week (ref = Mon)		0.741	Day of week (ref=Mon)		0.136
Tuesday	1.07 (0.90-1.28)	0.451	Tuesday	0.87 (0.77-0.98)	0.023
Wednesday	0.99 (0.83-1.19)	0.936	Wednesday	0.97 (0.86-1.09)	0.606
Thursday	1.08 (0.91-1.29)	0.371	Thursday	0.98 (0.87-1.10)	0.720
Friday	1.10 (0.92-1.31)	0.303	Friday	0.92 (0.81-1.03)	0.156
Saturday	1.01 (0.84-1.21)	0.941	Saturday	1.03 (0.91-1.16)	0.578
Sunday	0.96 (0.80-1.16)	0.681	Sunday	0.97 (0.86-1.10)	0.670
Night	1.07 (0.97-1.17)	0.200	Night	1.00 (0.94-1.07)	0.861
Age (centred)	1.06 (1.05-1.06)	<0.001	Financial year (ref = 2009)		<0.001
Age (squared)	1.00 (1.00-1.00)	<0.001	2010	0.90 (0.83-0.97)	0.004
STEMI	2.71 (2.44-3.01)	<0.001	2011	0.74 (0.68-0.80)	<0.001
Dementia	2.10 (1.77-2.48)	<0.001	Age (centred)	1.05 (1.05-1.05)	<0.001
Hypotension	1.29 (1.14-1.46)	<0.001	Age (squared)	1.00 (1.00-1.00)	<0.001
Shock	9.38 (7.79-11.30)	<0.001	Dementia	2.66 (2.42-2.92)	<0.001
Renal failure	2.32 (2.07-2.60)	<0.001	Hypotension	1.18 (1.08-1.28)	<0.001
Heart failure	1.77 (1.58-1.98)	<0.001	Shock	4.02 (3.34-4.84)	<0.001
Dysrhythmia	1.72 (1.55-1.90)	<0.001	Renal failure	1.84 (1.70-1.99)	<0.001
Malignancy	2.38 (1.94-2.92)	<0.001	Heart failure	1.55 (1.43-1.68)	<0.001
Hypertension	0.67 (0.61-0.74)	<0.001	Dysrhythmia	1.32 (1.22-1.42)	<0.001
Cerebrovascular disease	2.34 (1.95-2.81)	<0.001	Malignancy	5.54 (5.07-6.05)	<0.001
			Cerebrovascular disease	1.82 (1.59-2.08)	<0.001
			Other COPD	1.17 (1.08-1.27)	<0.001
			Liver disease	2.81 (1.75-2.71)	<0.001
			Parkinsons	1.69 (1.35-2.11)	<0.001

COPD			CHF		
Day of week (ref = Mon)		0.003	Day of week (ref=Mon)		0.660
Tuesday	1.09 (0.94-1.25)	0.269	Tuesday	1.00 (0.88-1.14)	0.971
Wednesday	1.08 (0.93-1.25)	0.298	Wednesday	1.06 (0.93-1.21)	0.373
Thursday	1.29 (1.12-1.48)	0.001	Thursday	0.99 (0.87-1.12)	0.829
Friday	1.25 (1.08-1.44)	0.002	Friday	1.09 (0.96-1.24)	0.175
Saturday	1.18 (1.02-1.37)	0.030	Saturday	1.07 (0.94-1.23)	0.315
Sunday	1.05 (0.90-1.22)	0.550	Sunday	1.02 (0.89-1.17)	0.784
Night	1.00 (0.92-1.08)	0.905	Night	1.02 (0.95-1.10)	0.525
Financial year (ref = 2009)		<0.001	Financial year (ref = 2009)		<0.001
2010	0.77 (0.70-0.85)	<0.001	2010	0.89 (0.81-0.97)	0.009
2011	0.50 (0.45-0.55)	<0.001	2011	0.67 (0.62-0.74)	<0.001
Prev acute COPD episode (ref = 0) ¹		<0.001	Prev acute CHF episode (ref = 0) ¹		<0.001
1 previous episode	1.67 (1.51-1.85)	<0.001	1 previous episode	1.39 (1.26-1.52)	<0.001
2 previous episodes	2.13 (1.86-2.43)	<0.001	2 previous episodes	1.70 (1.48-1.97)	<0.001
3+ previous episodes	3.04 (2.69-3.44)	<0.001	3+ previous episodes	2.52 (2.14-2.96)	<0.001
Sex (ref=male)	0.82 (0.76-0.89)	<0.001	Sex (ref = male)	0.90 (0.84-0.97)	0.008
Age (centred)	1.03 (1.03-1.04)	<0.001	Age (centred)	1.05 (1.05-1.06)	<0.001
Age (squared)	1.00 (1.00-1.00)	0.013	Age (squared)	1.00 (1.00-1.00)	0.003
CHF	1.47 (1.34-1.61)	<0.001	Pulmonary circ. disord.	1.21 (1.09-1.35)	<0.001
Pulmonary circ. disord.	1.66 (1.46-1.89)	<0.001	Peripheral vascular disord.	1.19 (1.04-1.37)	0.013
Neurological disord.	1.31 (1.05-1.64)	0.016	Hypertension (comp/uncomp)	0.83 (0.77-0.90)	<0.001
Diabetes (comp.)	0.83 (0.73-0.95)	0.005	Paralysis	1.65 (1.34-2.04)	<0.001
Liver disease	1.98 (1.50-2.61)	<0.001	Neurological disorders	1.65 (1.39-1.97)	<0.001
Metastatic cancer	3.06 (2.38-3.95)	<0.001	Chronic pulmonary disease	1.23 (1.13-1.34)	<0.001
Solid tumour w/o metast.	1.42 (1.17-1.72)	<0.001	Renal failure	1.88 (1.73-2.03)	<0.001
Weight loss	1.89 (1.68-2.11)	<0.001	Liver disease	2.78 (2.29-3.38)	<0.001
Fluid/electrolyte dis.	1.81 (1.66-1.98)	<0.001	Lymphoma	2.24 (1.57-3.19)	<0.001
Psychoses	2.10 (1.47-3.00)	<0.001	Metastatic cancer	3.07 (2.44-3.86)	<0.001
			Coagulopathy	1.29 (1.15-1.46)	<0.001
			Weight loss	1.61 (1.43-1.83)	<0.001
			Fluid/electrolyte disorders	1.57 (1.45-1.69)	<0.001
			Deficiency anaemia	0.78 (0.68-0.90)	<0.001

¹lookback to 2004

STROBE Statement—Checklist of items that should be included in reports of *cohort studies*

	Item No	Recommendation	Checked (page #)
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5-6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	6-7
		(b) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-7
Bias	9	Describe any efforts to address potential sources of bias	6-7
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	7-8
		(b) Describe any methods used to examine subgroups and interactions	7
		(c) Explain how missing data were addressed	6
		(d) If applicable, explain how loss to follow-up was addressed	NA
		(e) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8, 19
		(b) Indicate number of participants with missing data for each variable of interest	8
		(c) Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	Report numbers of outcome events or summary measures over time	18
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear	20,21

		which confounders were adjusted for and why they were included	
		(b) Report category boundaries when continuous variables were categorized	NA
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	considered
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10,11
Discussion			
Key results	18	Summarise key results with reference to study objectives	9
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	10,11
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11,12
Generalisability	21	Discuss the generalisability (external validity) of the study results	11,12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	12

*Give information separately for exposed and unexposed groups.

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

Correction: *Is the weekend effect really ubiquitous? A retrospective clinical cohort analysis of 30-day mortality by day of week and time of day using linked population data from New South Wales, Australia*

Baldwin HJ, Marashi-Pour S, Chen H, *et al.* Is the weekend effect really ubiquitous? A retrospective clinical cohort analysis of 30-day mortality by day of week and time of day using linked population data from New South Wales, Australia. *BMJ Open* 2018;8:e016943. doi: 10.1136/bmjopen-2017-016943

This article has been corrected since it first published. In the article title ‘A retrospective clinical analyses’ was corrected to ‘A retrospective clinical analysis’.

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BMJ Open 2018;8:e016943corr1. doi:10.1136/bmjopen-2017-016943corr1

