Mortality from meningococcal disease by day of the week: English national linked database study

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ABSTRACT

Background There are concerns that quality of medical care may be poorer on weekends than weekdays. Invasive meningococcal disease, comprising septicaemia and meningitis, is often life threatening unless it is immediately and effectively treated regardless of day of the week. We test the hypothesis that numbers of deaths from meningococcal disease outside hospital without admission, and case fatality rates (CFRs) following admission, did not differ between weekends and weekdays.


Results The study comprised 19 729 people. There was no significant difference between days of the week in the number of deaths outside hospital in people who never reached hospital care. Of people who were admitted, CFRs for weekend and weekday admissions were the same: 4.9% (262/5315) on weekends and 4.9% (678/13 798) on weekdays. We undertook sensitivity analyses and analysed multivariate models but, however the data were analysed, the result of no ‘weekend effect’ remained.

Conclusions There are few, if any, other acute diseases in which the difference in mortality outcome between no treatment and effective treatment is so great and unequivocally related to care itself. Meningococcal disease is, therefore, a potentially useful ‘tracer disease’ to use as a clinical example in studies of access to, and quality of, acute care.

Keywords health services, emergency care, communicable diseases

Introduction

There have been concerns in recent years that the quality of medical care may have been suboptimal at weekends. However, studies of ‘weekend effects’ are confounded by issues of case mix, as patients admitted at weekends are typically sicker than the weekday case mix. We decided to study hospital admissions and case fatality rates (CFRs) for meningococcal disease by day of the week of admission in the English National Health Service (NHS). Acute invasive meningococcal disease, comprising meningococcal septicaemia and meningococcal meningitis, is an important life-threatening illness for which prompt medical care may be life-saving. Case fatality rates from meningococcal disease were 70–90% prior to the introduction of antimicrobial chemotherapy in 1937. With early diagnosis and appropriate treatment, the CFR is less than 10%. There are few other diseases, if any, in which the impact of acute medical care on survival is both so considerable and unequivocally related to care itself.
Methods

We used an anonymized data set of English National Hospital Episode Statistics (HES) and mortality records supplied by, respectively, the NHS Information Centre and the Office for National Statistics (population of England: 52 million). All records were linked from 1999 to December 2010, such that successive admissions for each individual, and death if it occurred, are in a composite time-sequenced record for the individual (linkage data set version 13.06). The HES data set includes data on all NHS hospital admissions in England. The mortality data set includes records of all deaths of residents of England. Linkage was effected using encrypted values of the HESID (a unique number for each individual admitted to hospital for NHS care) and of the NHS number (unique for each individual in England) supplemented with encrypted values of the patients’ postcode, date of birth and sex.

Study population

We selected records for all people with a discharge diagnosis in HES of meningococcal disease (code A39 in the 10th revision of the International Classification of Diseases, code 036 in the 9th revision) from 1999 to 30 September 2010. The latter cut-off allowed a follow-up period for registrations of deaths up to 90 days after their date of occurrence. Where a person had more than one admission with a code for meningococcal disease, as is the case for example for inter-hospital transfers, we selected the first as the incident event for analysis for this paper. Deaths of hospitalized patients were identified through linkage to death certificates. Unless otherwise stated, the analyses in this paper exclude people who were admitted to hospital and discharged home alive on the same day (378 people, 6 subsequent deaths within 30 days), the day after admission (835 people, 2 deaths) or on the second day (1697 people, 0 deaths). The reason for excluding them was that the great majority are likely to have been cases admitted with suspected meningitis but then diagnosed and discharged with a less serious illness. Hospital admissions with missing age, sex or date of admission were excluded from the analysis (0.4% of all admission records).

Deaths without hospital admission were defined as those with meningococcal disease as a cause of death on the death registration record, with a place of death outside hospital, and without a corresponding hospital admission.

Case fatality rates

The 30-day hospital CFR was calculated using the total number of hospital admissions with a discharge diagnosis of meningococcal disease as the denominator and all deaths (irrespective of certified cause or place of death) in 0–29 days after the date of hospital admission as the numerator. The total CFR for all cases of meningococcal disease includes the hospitalized cases as defined above, plus all the deaths without hospitalization added to both the denominator and numerator.

Statistical analysis

Statistical analyses were performed in IBM SPSS Statistics version 20 for Windows. We used $\chi^2$ statistics to compare categorical variables and to test their statistical significance. Mantel–Haenszel $\chi^2$ tests for linear associations between two variables were used to examine trends over time. Binary logistic regression analysis using the ‘enter’ method was used to quantify the effects, on the hospital 30-day CFR, of age (grouped <1, 1–4, 5–9 and in 5-year groups to 75–79, then 80+), sex, year of admission, socio-economic deprivation [classified by the Index of Multiple Deprivation (IMD) score for the person’s area of residence] and day of the week of admission. We assessed the fit of the model by using the Hosmer–Lemeshow $\chi^2$ statistic, where a $P$-value of >0.05 indicates satisfactory fit.

Analysis of ‘weekend effects’

We analysed the data for each day of the week individually and then for Saturday and Sunday, combined, versus Monday–Friday combined. We also re-defined a possible ‘weekend effect’ as Friday–Sunday versus Monday–Thursday; and re-defined it again as Saturday–Monday (in the anticipation that weekend delay might result in an excess of moribund admissions on a Monday).

Age

Most of the grouped findings are presented for people <15 years, and 15 and over, because they will have been treated in different specialties: the study of people <15 can be considered a study of care given mainly in paediatrics and the 15s and over as a study of acute adult medical care.

Results

Hospital admission by day of the week

There were 19 113 people admitted to hospital for meningococcal disease (Table 1): 10 136 (53%) were male and 12 697 (66.4%) were under the age of 15 years. There were statistically significant but very small differences between days of the week in numbers of admissions (Table 1). The average was 2730 admissions on each day; the highest
number of admissions was on Friday at 2873 and the lowest was on Saturday at 2569.

**Death without hospital admission: day of the week**

During the same time period, 616 people died from meningococcal disease without hospital admission (Table 2), of whom 328 (53.2%) were male and 279 (45.2%) were under the age of 15 years (39.1% were 5). There were no significant differences between the days of the week in numbers of deaths (Table 2). If the spread of deaths were uniform across the days, there would be 28.6% of deaths expected on any 2 days. Comparing the observed number of deaths on individual days with the expected numbers gave a \( \chi^2 \) value of 4.1, \( P = 0.66 \) (<15s \( P = 0.55 \), >15s \( P = 0.45 \)); and comparing the observed and expected numbers of deaths on Saturday and Sunday with those on Monday–Friday gave a \( \chi^2 \) value of 0.8, \( P = 0.37 \) (<15s \( P = 0.86 \), >15s \( P = 0.29 \)) (Table 2).

**Deaths on the same day as admission or within 1 or 2 days: day of the week admission**

We considered the possibility that seeking variation of death without admission, by day of the week, was too extreme; but that ‘day of the week’ effects might have been manifest in the admission of moribund patients who were admitted to hospital but destined to die. We, therefore, analysed the data for patients who died (after admission) on the same day as admission, or on the day after, or 2 days after. There was no evidence of an adverse ‘weekend effect’ in these respects (Table 2).

**30-day CFRs**

The 30-day CFR for people admitted to hospital was 4.9% and that for all cases, including the out-of-hospital deaths, was 7.9%. The 30-day hospital CFR for people aged <15 years was 2.9% and that for people aged 15 and over was 9.0% (Table 3). The 30-day CFR for the under 15s, by day of the week, ranged from a low of 2.3% on Friday and Sunday to a high of 3.8% on Thursdays (differences between individual days were marginally significant, based on very large numbers, and not interpretable as a systematic effect related to weekend care).

The 30-day CFRs for patients aged 15 and over ranged from a low on Thursdays of 8.5% to a high on Tuesdays of 9.7% (not significant, and no hint of a ‘weekend effect’, Table 3). Grouping days into weekdays and weekends, for those <15, the weekday 30-day CFR was 2.9% compared with 2.8% for weekend admissions (\( P = 0.92 \), Table 3). For those aged 15 and over, the weekday CFR was 9.0% compared with 9.1% for weekend admissions (\( P = 0.85 \), Table 3). Two other combinations of potential ‘weekend effect’ are shown in Table 3, Friday–Sunday versus other days and Saturday–Monday versus other days. Whichever way a ‘weekend effect’ was defined, there was no evidence of a ‘weekend effect’ on 30-day CFRs (Table 3).

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**Table 1** Number and percentage of admissions to hospital for meningococcal disease by day of week, England 1999–2010, by age group

<table>
<thead>
<tr>
<th>Age group</th>
<th>Day of week</th>
<th>&lt;15</th>
<th>15–44</th>
<th>45–64</th>
<th>65–74</th>
<th>75+</th>
<th>Total</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
<td>n</td>
<td>%</td>
<td>n</td>
</tr>
<tr>
<td>Monday</td>
<td>1885</td>
<td>14.8</td>
<td>569</td>
<td>13.6</td>
<td>201</td>
<td>14.1</td>
<td>57</td>
</tr>
<tr>
<td>Tuesday</td>
<td>1869</td>
<td>14.7</td>
<td>556</td>
<td>13.3</td>
<td>194</td>
<td>13.6</td>
<td>59</td>
</tr>
<tr>
<td>Wednesday</td>
<td>1796</td>
<td>14.1</td>
<td>609</td>
<td>14.6</td>
<td>190</td>
<td>13.3</td>
<td>60</td>
</tr>
<tr>
<td>Thursday</td>
<td>1749</td>
<td>13.8</td>
<td>621</td>
<td>14.9</td>
<td>203</td>
<td>14.2</td>
<td>57</td>
</tr>
<tr>
<td>Friday</td>
<td>1860</td>
<td>14.6</td>
<td>659</td>
<td>15.8</td>
<td>232</td>
<td>16.3</td>
<td>63</td>
</tr>
<tr>
<td>Saturday</td>
<td>1658</td>
<td>13.1</td>
<td>594</td>
<td>14.2</td>
<td>211</td>
<td>14.8</td>
<td>49</td>
</tr>
<tr>
<td>Sunday</td>
<td>1880</td>
<td>14.8</td>
<td>569</td>
<td>13.6</td>
<td>194</td>
<td>13.6</td>
<td>51</td>
</tr>
<tr>
<td>Total</td>
<td>12697</td>
<td>100</td>
<td>4177</td>
<td>100</td>
<td>1425</td>
<td>100</td>
<td>396</td>
</tr>
</tbody>
</table>

\( \chi^2 \) and \( P \)

- Saturday and Sunday: 24.0, <0.001
- Monday–Friday: 3538, 27.9

\( \chi^2 \) and \( P \) value

- Saturday and Sunday: 13.1, 0.04
- Monday–Friday: 6.1, 0.41

\( \chi^2 \) and \( P \) value

- Saturday and Sunday: 2.6, 0.86
- Monday–Friday: 4.1, 0.67

\( \chi^2 \) and \( P \) value

- Saturday and Sunday: 18.9, 0.004
- Monday–Friday: 18.9, 0.004

\( P \) value

- Saturday and Sunday: 0.016, 0.9
- Monday–Friday: 0.14, 0.26

Assuming an equal spread of admissions across days of the week, there would be 14.3% (1/7) of all admissions on each day and 28.6% (2/7) of all admissions on Saturday and Sunday.
CFRs by age; decline in incidence over time; and differences between calendar years in weekday–weekend comparisons

CFRs increased markedly with increasing age in adulthood (Supplementary data, Appendix 1). Numbers of admissions, and numbers of deaths, declined over time (Supplementary data, Appendix 2); and CFRs declined over time in the older population but not in those aged <15 years (Supplementary data, Appendix 2). Comparing weekend and weekday admissions, the distribution of patients by sex, by 5-year age group and by deprivation score was very similar (data not shown, but see results of modelling below).

We considered the possibility that there may have been systematic ‘weekend effects’ in some years and that an overall analysis may have masked them. Accordingly, we analysed data for individual years (Supplementary data, Appendix 3). There were no significant differences between the 30-day CFR for weekday and weekend admissions in all subgroup analyses except one: in 2006 for people aged 15 years and over, there was a marginally significant high CFR at the weekend (weekday CFR 5.8%, weekend 12.8%, $\chi^2 = 0.028$) but, given the multiple comparisons made, this is consistent with its being a chance finding.

Potential confounders and multivariate modelling

We considered the effects on CFRs of sex, age (in 5-year groups), year of admission, IMD score (in quintiles) and day of the week of admission, adjusting each factor for the effects of all others. Table 4 shows results for the all-ages analysis. The odds ratio (OR) for death within 30 days of admission was higher for males than females, differed substantially by age, declined over time and generally did not differ according to deprivation (it was slightly but non-significantly higher in the lowest deprivation quintile, OR 1.21 [95% confidence interval (CI) 0.97–1.51]).

We compared weekends with weekdays (using the latter as the reference category) for the unadjusted ORs first. For weekends defined as Saturday and Sunday, the unadjusted OR was 1.0 (95% CI 0.87–1.16); for weekends defined as Friday–Sunday, it was 0.95 (95% CI 0.83–1.09) and for weekends defined as Saturday–Monday, it was 0.96 (95% CI 0.89–1.10). Adjustment for all other factors shown in

<table>
<thead>
<tr>
<th>Day of week</th>
<th>Deaths outside hospital$^b$</th>
<th>Death in hospital in days after admission</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Monday</td>
<td>75</td>
<td>12.2</td>
</tr>
<tr>
<td>Tuesday</td>
<td>80</td>
<td>13.0</td>
</tr>
<tr>
<td>Wednesday</td>
<td>91</td>
<td>14.8</td>
</tr>
<tr>
<td>Thursday</td>
<td>96</td>
<td>15.6</td>
</tr>
<tr>
<td>Friday</td>
<td>88</td>
<td>14.3</td>
</tr>
<tr>
<td>Saturday</td>
<td>95</td>
<td>15.4</td>
</tr>
<tr>
<td>Sunday</td>
<td>91</td>
<td>14.8</td>
</tr>
<tr>
<td>Saturday and Sunday</td>
<td>186</td>
<td>30.2</td>
</tr>
<tr>
<td>Monday–Friday</td>
<td>430</td>
<td>69.8</td>
</tr>
<tr>
<td>Total</td>
<td>616</td>
<td>100</td>
</tr>
</tbody>
</table>

$^a$Assuming an equal spread of deaths occurring outside hospital across days of the week, there would be an expected 14.3% (1/7) of all deaths on each day.

$^b$Comparing individual days $\chi^2 = 4.1$, $P$-value = 0.66. Comparing weekend and weekday (Saturday and Sunday compared with Monday–Friday) $\chi^2 = 0.8$, $P$-value = 0.37.

$^c$Comparing individual days $\chi^2 = 9.7$, $P$-value = 0.14. Comparing weekend and weekday (Saturday and Sunday compared with Monday–Friday) $\chi^2 = 0.55$, $P$-value = 0.46.

$^d$Comparing individual days $\chi^2 = 2.4$, $P$-value = 0.88. Comparing weekend and weekday (Saturday and Sunday compared with Monday–Friday) $\chi^2 = 0.073$, $P$-value = 0.79.

$^e$Comparing individual days $\chi^2 = 2.7$, $P$-value = 0.84. Comparing weekend and weekday (Saturday and Sunday compared with Monday–Friday) $\chi^2 = 0.02$, $P$-value = 0.88.
Table 4 made little difference: for the above definitions of ‘weekend effect’, the OR for weekend compared with weekday admissions were, respectively, 1.02 (95% CI 0.88–1.19), 0.96 (0.84–1.10) and 0.97 (0.85–1.12, Table 4). As noted above, the distribution of the factors for which we adjusted were, in fact, very similar when weekends and weekdays were compared in univariate analysis and so we did not anticipate and did not find any appreciable differences between the unadjusted and adjusted rate ratios.

We repeated the analyses confined to people aged <15 and obtained similar results except that, in this age group, there was no significant decline in CFRs by year (Table 4). As noted above, the distribution of the factors for which we adjusted were, in fact, very similar when weekends and weekdays were compared in univariate analysis and so we did not anticipate and did not find any appreciable differences between the unadjusted and adjusted rate ratios.

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We considered those cases of bacterial meningitis that do not have an organism identified as some of them will have been meningococcal. We repeated our analysis by adding cases of ‘bacterial meningitis, unspecified’ (ICD 10 G00.9) to the cases of meningococcal disease. Our findings remained similar with the inclusion of G00.9 (Table 4).

Next, we re-introduced into the study the 2910 people who were admitted to hospital but discharged home alive after 2 days or less (Table 4). Finally, we undertook further analyses that are shown in Supplementary data, Appendix 4. None of these analyses changed the conclusions about lack of weekend effects.

Discussion

Main findings of this study

None of the analyses of CFRs comparing admissions by day of the week showed significant differences, whether compared across 7 days or compared as weekends versus weekdays. Specifically, there was no evidence of a systematic adverse ‘weekend effect’. Similarly, the analysis of deaths outside hospital showed no evidence that deaths of people who never reached hospital care were more common at weekends. The great majority of patients with acute meningococcal disease in England will have been treated in NHS hospitals and, if referred by general practitioners (GPs), will have been referred by NHS GPs. Accordingly, this is a study of what was predominantly NHS care. Our 30-day CFR was 4.9%, similar to that published for laboratory-confirmed
Table 4 Determinants of 30-day CFR for meningococcal disease, 1999–2010, odds ratios with their 95% confidence intervals obtained from logistic regression with variations of weekend definition and patient subgroups

<table>
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<tr>
<th>Determinants</th>
<th>Odds ratio</th>
<th>95% CI</th>
<th>N</th>
<th>n</th>
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<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>1.13</td>
<td>0.98–1.29</td>
<td>10,136</td>
<td>474</td>
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<tr>
<td>Femaleb</td>
<td></td>
<td></td>
<td>8,977</td>
<td>466</td>
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<td>Age group</td>
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<td>&lt;1b</td>
<td>0.93</td>
<td>0.74–1.17</td>
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<td>1–4</td>
<td>0.52**</td>
<td>0.34–0.80</td>
<td>5,516</td>
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<td>5–9</td>
<td>1.21</td>
<td>0.85–1.72</td>
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<td>10–14</td>
<td>1.72***</td>
<td>1.31–2.25</td>
<td>1,884</td>
<td>95</td>
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<tr>
<td>15–19</td>
<td>1.38</td>
<td>0.93–2.04</td>
<td>798</td>
<td>33</td>
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<td>20–24</td>
<td>1.85**</td>
<td>1.19–2.90</td>
<td>434</td>
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<tr>
<td>25–29</td>
<td>2.44***</td>
<td>1.58–3.77</td>
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<td>30–34</td>
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<td>1.84–4.29</td>
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<td>1.77–4.00</td>
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<td>5.66***</td>
<td>3.99–8.03</td>
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<td>8.98***</td>
<td>6.21–12.97</td>
<td>226</td>
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<td>7.25***</td>
<td>4.33–10.52</td>
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<td>5.25–12.44</td>
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<td>75–79</td>
<td>16.92***</td>
<td>12.27–23.33</td>
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<td>0.93</td>
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<td>0.87–1.42</td>
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<tr>
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<td>0.95</td>
<td>0.72–1.25</td>
<td>1,714</td>
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<td>1.03</td>
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<td>1,663</td>
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<td>0.68*</td>
<td>0.49–0.95</td>
<td>1,304</td>
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<td>0.61**</td>
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<td>0.66–1.24</td>
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<td>0.41–0.88</td>
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<td>0.68</td>
<td>0.44–1.05</td>
<td>651</td>
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<td>Least deprived 1b</td>
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<td>0.84–1.27</td>
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<td>1.11</td>
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<td>0.99</td>
<td>0.79–1.24</td>
<td>3,831</td>
<td>159</td>
</tr>
<tr>
<td>Most deprived 5</td>
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<td></td>
<td>3,824</td>
<td>172</td>
</tr>
<tr>
<td>Day of admission</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saturday–Sunday</td>
<td>1.02</td>
<td>0.88–1.19</td>
<td>5,315</td>
<td>262</td>
</tr>
<tr>
<td>Monday–Fridayb</td>
<td>1.3798</td>
<td></td>
<td>392</td>
<td></td>
</tr>
<tr>
<td>Friday–Sunday</td>
<td>0.96</td>
<td>0.84–1.10</td>
<td>8,188</td>
<td>392</td>
</tr>
<tr>
<td>Monday–Thursdayb</td>
<td>1.0925</td>
<td></td>
<td>548</td>
<td></td>
</tr>
<tr>
<td>Saturday–Monday</td>
<td>0.97</td>
<td>0.85–1.12</td>
<td>389</td>
<td>8095</td>
</tr>
</tbody>
</table>

Continued
meningococcal disease in England and Wales in recent years.\textsuperscript{14,15} During the period of the study population-based admission rates for meningococcal disease declined, as expected, following increased use of vaccination against serogroup C meningococcus.\textsuperscript{16}

\textbf{What is already known on this topic}

In recent years, there has been interest in studying and interpreting ‘weekend effects’ in the quality of medical care. The literature shows inconsistencies. This is not surprising because ‘weekend effects’, or lack of them, may differ between clinical conditions, health-care systems and periods of time.\textsuperscript{3,6,17,18} Other studies from the UK have reported excess mortality associated with weekend care for a range of conditions combined.\textsuperscript{1,2,19} Studies of mortality by day of the week are likely to encounter problems with taking account of case mix, even in the study of one disease;\textsuperscript{20} and such problems are likely to be compounded in studies that include several diseases in combination.\textsuperscript{21} However, studies of one disease raise questions of generalizability.

\begin{table}
\centering
\caption{Continued}
\begin{tabular}{lccccc}
\hline
\textbf{Determinants} & \multicolumn{2}{c}{\textbf{Odds ratio}} & \multicolumn{2}{c}{\textbf{95\% CI}} & \textbf{N} & \textbf{n} \\
\hline
	Tuesday–Friday\textsuperscript{b} & & & & & 551 & 11018 \\
\textbf{Patient subgroups: sensitivity analysis\textsuperscript{c}} & & & & & & \\
<15 years old & & & & & & \\
	Saturday and Sunday & 0.98 & 0.78–1.24 & 3538 & 100 \\
	Monday–Friday\textsuperscript{b} & & & & & 9159 & 262 \\
	Friday–Sunday & 0.87 & 0.71–1.08 & 5398 & 142 \\
	Monday–Thursday\textsuperscript{b} & & & & & 7299 & 220 \\
	Saturday–Monday & 0.91 & 0.74–1.13 & 5423 & 147 \\
	Tuesday–Friday\textsuperscript{b} & & & & & 7274 & 215 \\
\geq15 years old & & & & & & \\
	Saturday and Sunday & 1.05 & 0.86–1.28 & 1777 & 162 \\
	Monday–Friday\textsuperscript{b} & & & & & 4639 & 416 \\
	Friday–Sunday & 1.02 & 0.86–1.22 & 2790 & 250 \\
	Monday–Thursday\textsuperscript{b} & & & & & 3626 & 328 \\
	Saturday–Monday & 1.01 & 0.85–1.21 & 2672 & 242 \\
	Tuesday–Friday\textsuperscript{b} & & & & & 3744 & 336 \\
\hline
\textbf{Including diagnosis of bacterial meningitis unspecified (G00.9)} & & & & & & \\
	Saturday and Sunday & 1.10 & 0.96–1.25 & 6601 & 352 \\
	Monday–Friday\textsuperscript{b} & & & & & 17349 & 882 \\
	Friday–Sunday & 1.01 & 0.9–1.14 & 10225 & 525 \\
	Monday–Thursday\textsuperscript{b} & & & & & 13725 & 709 \\
	Saturday–Monday & 1.04 & 0.93–1.18 & 10115 & 525 \\
	Tuesday–Friday\textsuperscript{b} & & & & & 13835 & 709 \\
\hline
\textbf{Including patients discharged home with a \leq2-day stay} & & & & & & \\
	Saturday and Sunday & 1.04 & 0.90–1.21 & 5797 & 265 \\
	Monday–Friday\textsuperscript{b} & & & & & 15278 & 683 \\
	Friday–Sunday & 0.98 & 0.86–1.12 & 8926 & 396 \\
	Monday–Thursday\textsuperscript{b} & & & & & 12149 & 552 \\
	Saturday–Monday & 0.97 & 0.85–1.12 & 8925 & 392 \\
	Tuesday–Friday\textsuperscript{b} & & & & & 12150 & 556 \\
\hline
\end{tabular}
\end{table}

\textsuperscript{a}The results for the three variations of ‘weekend’ were obtained by running each variation separately. The results for all other determinants (sex, age group, year of admission and IMD score) were obtained by excluding the day of admission grouped.

\textsuperscript{b}Reference group.

\textsuperscript{c}Logistic regression was performed separately for each patient subgroup and adjusted for the following variables: sex, age group, year of admission and IMD score in quintiles.

\textsuperscript{*P-value <0.05,}

\textsuperscript{**P-value <0.01, ***P-value <0.001.}
What this study adds
We undertook a population-based study of survival of people with meningococcal disease, because survival is often critically dependent on effective medical care. In addition, the case mix and clinical severity of weekday and weekend admissions for meningococcal disease is likely to be more homogeneous than that for many other conditions. This is important in the choice of the disease for study because a crucial issue in studies that find an excess of deaths in weekend admissions is whether the explanation is quality of care or case mix (i.e., that, typically, people admitted at weekends are likely to be more severely ill than those admitted on weekdays).22

There was no evidence that ‘weekend effects’ resulted in excess deaths from meningococcal disease. The findings show what the NHS has achieved in this respect in the past. However, it cannot be assumed that this will inevitably continue; and our finding cannot be assumed to be generalizable to other diseases in the NHS or to meningococcal disease in other countries. There should be no complacency about the need to assure the highest possible standards of care at all times.23,24 Meningococcal disease should be a good ‘tracer’ disease to study to ensure that high standards continue in respect of weekend care for the severely ill. It should also be a good disease to study in comparisons of performance in quality of acute care across countries and across health-care systems.

Limitations of this study
A potential weakness is that our study design is based on the assumption, very likely but perhaps not certain, that the incidence and severity of the disease did not vary in any important ways by day of the week. We have no way of testing this directly, though other studies have shown that incidence of meningococcal disease, measured as hospital admissions, was evenly distributed by day of the week.25,26 We also acknowledge that there exist less severe clinical variations of meningococcal disease than septicaemia and meningitis27 and that many cases of meningococcal septicaemia and meningitis will recover with no more intensive treatment than intravenous antibiotics.

The slight deficit in numbers of admissions on Saturday and Sunday might, in principle, indicate missed diagnosis at weekends. However, the fact that there is no significant weekend excess in deaths outside hospital, assuming that outside hospital deaths would be subject to post-mortem and accurate post-mortem diagnosis, means that this explanation is unlikely.

Other potential weaknesses are that we are reliant on data in routine data sets and, because of privacy regulations, it is not possible to check their reliability by studying case notes. Accordingly, we have no data on the diagnostic criteria used for making the diagnosis of meningococcal disease. However, we have data from the Health Protection Agency (HPA) in a comparable period for most of our study (2000–2009), and our HES cases (15 475 in this period) compare with 15 037 laboratory confirmed cases in the HPA data.28 We have no data on post-infection morbidity, as distinct from mortality, by day of the week of admission. Our data set does not include information on the hour of hospital admission and so we were not able to examine case fatality by time of admission.

We have no data to explain, directly, the fact that CFRs in adults fell during the study period, while CFRs in children remained constant. One explanation may be that, because CFRs are higher in serogroup C disease than in serogroup B15 and because most childhood infection is group B, reducing group C disease by vaccine (since 1999) would have a greater impact on adult than childhood mortality.

Conclusion
There was no evidence of excess deaths from meningococcal disease associated with weekend care.

Supplementary data
Supplementary data are available at PUBMED online.

Authorship
M.J.G. proposed and designed the study. J.J.M. undertook the analyses with input from M.J.G. J.J.M. wrote the first draft, both authors contributed to further drafts and both agreed the final draft. M.J.G. and J.J.M. are guarantors for the study.

Ethical approval
The Unit of Health-Care Epidemiology has ethical approval from the Central and South Bristol Multi-Centre Research Ethics Committee (04/Q2006/176) for a programme of work analysing anonymized record-linked data sets.

Acknowledgements
Over many years, the linked data files were built by Leicester Gill, Matt Davidson and Myfanwy Griffith, Unit of Health-Care Epidemiology, University of Oxford.
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Conflict of interest

M.J.G. and J.J.M. declare no conflicts of interest. M.J.G. and J.J.M. declare no financial relationships with any organizations that might have an interest in the submitted work and no other relationships or activities that could appear to have influenced the submitted work.

References