Neonatal Mortality in Weekend vs Weekday Births

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RECENT REPORTS THAT ADULTS with some serious medical conditions are more likely to die if admitted to a hospital during the weekend have raised concerns about the adequacy of complex medical care provided by hospitals on weekends. Several studies of births in Europe and the United States during the 1970s demonstrated a decrease in births during the weekend accompanied by higher mortality rates for weekend births. The findings of far fewer births on weekends than would be expected if birth were a random event was thought to be due to medical practice patterns for elective induction of labor and cesarean delivery. The researchers speculated that 2 possible factors could contribute to the increased mortality of weekend births: (1) decreased quality of care resulting from suboptimal staffing and/or (2) a more adverse weekend case mix. Although obstetric interventions such as cesarean delivery have increased dramatically since the 1970s, and there has been concern that the emergence of cost containment as a major goal for inpatient medicine could affect the quality of perinatal care, there have been no contemporary studies of neonatal mortality by day of birth. Using data from a 1995-1997 linked birth-infant death cohort, the purpose of this analysis was to investigate if California infants born during the weekend had a higher neonatal mortality than infants born on weekdays. To assess the possible roles of quality of care and case mix, we conducted stratified analyses by method of delivery and further controlled for birth weight and congenital anomalies.

METHODS
This analysis is based on 1,615,041 live births (weight ≥ 500 g) in California between 1995-1997. The data were obtained from the California linked birth–infant death cohort files, which includes data from birth and infant death certificates, including method of delivery, birth weight, date of birth, date of death, and cause of death. We determined the average number of births, the neonatal mortality rate (NMR) (i.e., deaths of infants < 28 days of age per 1000 live births), and percentage of

Context Increases in neonatal mortality for infants born on the weekend were last noted several decades ago. Although the current health care environment has raised concern about the adequacy of weekend care, there have been no contemporary evaluations of daily patterns of births, obstetric intervention, and case mix–adjusted neonatal mortality.

Objective To compare the neonatal mortality of infants born on weekdays and weekends.

Design, Setting, and Participants Case series of 1,615,041 live births (weight ≥ 500 g) in California between 1995-1997 to determine patterns of births, cesarean deliveries, and neonatal deaths. Analyses were stratified by birth weight and delivery method. To assess the role of weekend differences in case mix, observed and birth weight–adjusted odds ratios (ORs) for increased weekend mortality were estimated using logistic regression.

Main Outcome Measure Birth weight–adjusted neonatal mortality.

Results There was a 17.5% decrease in births on weekends, accompanied by a decrease in the proportion of cesarean deliveries from 22% on weekdays to 16% on weekends. Weekend decreases in births were least pronounced in smaller infants, resulting in a weekend concentration of high-mortality, very low-birth-weight (< 1500 g) births. Observed neonatal mortality increased from 2.80 per 1000 weekday births to 3.12 per 1000 weekend births (OR, 1.12; 95% confidence interval [CI], 1.05-1.19; P = .001) for all births, and from 4.94 to 6.85 (OR, 1.39; 95% CI, 1.25-1.55; P < .001) for cesarean deliveries. After adjusting for birth weight, the increased odds of death for infants born on the weekend were no longer significant.

Conclusions The provision of optimal care regardless of the day of week is an important goal for perinatal medicine. Comparing the neonatal mortality of infants born on weekdays and weekends provides a straightforward assessment of this goal. After controlling for birth weight, we found no evidence that the quality of perinatal care in California was compromised during the weekend.

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cesarean deliveries for each day of the week. In an effort to compare the observed numbers and rates for each day of the week with the numbers and rates expected under the assumption that birth and death were random events with respect to the day of the week, we calculated an index of occurrence. This index is generated by multiplying by 100 the ratio of the average number of births per day of the week to the overall average number of births per day (ie, 100 \times \text{average number of births per day of week}/\text{average number of births per day}). An index of 110.5, for example, indicates that the daily value was 10.5% higher than the value expected if births or deaths occurred randomly throughout the week. Although the number of births has been noted to be decreased on holidays, holiday status was not included in our analyses. Neonatal mortality was also determined for infants born on the weekend vs on a weekday. Assessment of births and mortality by the day of week were performed for total births and for births stratified by method of delivery (vaginal vs cesarean delivery). To assess the relationship between birth weight and daily variation in births and mortality, analyses were further stratified by 4 birth weight groupings: (1) very low birth weight (VLBW, 500-1499 g); (2) moderately low birth weight (MLBW, 1500-2499 g); (3) normal birth weight (NBW, 2500-4499 g); and (4) high birth weight (HBW, \geq 4500 g).

To estimate the odds ratios (ORs) and 95% confidence intervals (CIs) for the neonatal mortality of infants born on the weekend, we developed logistic models that controlled for birth weight, an important indicator of neonatal case mix. The models specified day of birth (weekday vs weekend) and 4 categories of birth weight (VLBW, MLBW, NBW, and HBW). If the OR for weekend birth remained significant (P < .05) after controlling for birth weight, we then controlled for lethal congenital abnormalities by eliminating deaths due to congenital anomalies and rerunning the analysis. This stepwise strategy allowed us to assess the relative importance of controlling for birth weight. Deaths due to lethal congenital anomalies were identified by International Classification of Diseases, Ninth Revision (ICD-9) cause of death codes 740 through 748.4 and 748.6 through 759.9.

To estimate the OR for mortality of VLBW infants born on the weekend, we developed a logistic model that controlled for possible weekend differences in birth weight within this group by including 3 birth weight categories (500-749, 750-999, and 1000-1499 g). We controlled for congenital anomalies as described above. Separate logistic models were also developed to evaluate the OR for mortality in weekend births of MLBW, NBW, and HBW infants.

Analyses were performed using SAS for Windows, version 8.1.

RESULTS

Daily Variations in Births, Percentage of Cesarean Deliveries, and Neonatal Mortality

During the period 1995-1997, there were 1615041 live births (weight \geq 500 g) in California. The average number of daily births was 1474 (Table 1). Births were highest on Tuesday (1629), steadily decreased to 1593 on Friday, and then decreased dramatically to 1272 on Saturday (86.3% of expected) and to 1159 on Sunday (78.7% of expected). On average, 20.7% of deliveries were by cesarean intervention. The percentage of cesarean births ranged between 21.5% and 22.1% Monday through Thursday, peaked at 23.1% on Friday, and then dramatically fell to 17.0% and 15.5% on Saturday and Sunday, respectively. The pattern for neonatal mortality was the mirror image. The NMR averaged 2.88 per 1000 live births. Mortality was lowest for infants born on weekdays (between 2.75 and 2.84) and increased to 3.11 for Saturday births and to 3.14 for Sunday births (Table 1, Figure). Higher-than-expected NMRs were seen in weekend births delivered both vaginally (index of occurrence, 108.6 for Saturday and 104.5 for Sunday) and by cesarean (index of occurrence, 120.3 for Saturday and 140.6 for Sunday births) (Table 1).

The NMR was 2.80 for weekday births and 3.12 for weekend births, representing an unadjusted OR of 1.12.
NEONATAL MORTALITY IN WEEKEND VS WEEKDAY BIRTHS

(95% CI, 1.05-1.19; P = .001). However, after adjusting for birth weight, there was no difference in mortality (adjusted OR, 1.01; 95% CI, 0.95-1.08; P = .73). Similarly, the weekend increase observed for vaginally delivered infants (NMR, 2.13 vs 2.32; OR, 1.09; 95% CI, 1.00-1.19; P = .044) was also no longer statistically significant after adjusting for birth weight (adjusted OR, 0.96; 95% CI, 0.88-1.05; P = .40). The NMR for infants delivered by cesarean appeared remarkably higher, 4.94 for weekday and 6.85 for weekend births (OR, 1.39; 95% CI, 1.25-1.55; P < .001). After adjustment for birth weight, the OR decreased to 1.11 (95% CI, 0.99-1.24; P = .08) and remained marginally significant. With an additional adjustment for congenital anomalies, the OR decreased to 1.10 (95% CI, 0.96-1.26; P = .15) and was no longer statistically significant. Thus, the increased mortality observed in weekend births appears to be the result of differences in case mix brought about in large part by a more adverse birth weight distribution.

**Daily Variations in Births and Mortality by Birth Weight**

Obstetric intervention strategies differ by birth weight. For example, because of the relationship between survival and increasing gestational age, the overriding goal for an imminent premature VLBW birth is to keep the infant in the womb as long as is safely possible, with little regard for day of delivery. There is greater latitude in intervention for the more physiologically mature, near-to-term MLBW infants and term NBW infants. For these infants, the elective induction of labor or operative delivery during a weekday, when staffing and availability of both obstetric and neonatal services are optimal, emerge as clinical options for the management of high-risk pregnancies. TABLE 2 shows that the greater the birth weight, the greater the decrease in weekend births. For VLBW infants, Saturday and Sunday births were 95.1% and 90.6% of their weekly average. In comparison, the relative decreases in Saturday and Sunday births were 2- to 3-fold greater for MLBW, NBW, and HBW infants. This differential reduction produced a relative increase in the percentage of VLBW infants from 0.95% during the week to 1.11% on weekends. Because of their high mortality, the increase in the proportion of VLBW births appears to be the main contributor to the observed increase in weekend NMR.

When compared with weekday births, VLBW infants born on the week-

### Table 2. Birth Weight–Specific Daily Variation in Births and Neonatal Mortality, California, 1995-1997*

<table>
<thead>
<tr>
<th>Variable†</th>
<th>Monday</th>
<th>Tuesday</th>
<th>Wednesday</th>
<th>Thursday</th>
<th>Friday</th>
<th>Saturday</th>
<th>Sunday</th>
<th>Daily Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Live births</td>
<td>2252</td>
<td>2334</td>
<td>2366</td>
<td>2378</td>
<td>2356</td>
<td>2160</td>
<td>2059</td>
<td>2272</td>
</tr>
<tr>
<td>Index</td>
<td>99.1</td>
<td>102.7</td>
<td>104.1</td>
<td>104.7</td>
<td>103.7</td>
<td>95.1</td>
<td>90.6</td>
<td></td>
</tr>
<tr>
<td>Neonatal mortality rate</td>
<td>145.6</td>
<td>153.4</td>
<td>152.1</td>
<td>151.8</td>
<td>148.1</td>
<td>162.5</td>
<td>163.2</td>
<td>153.6</td>
</tr>
<tr>
<td>Index</td>
<td>94.8</td>
<td>99.9</td>
<td>99.0</td>
<td>98.8</td>
<td>96.4</td>
<td>105.8</td>
<td>106.2</td>
<td></td>
</tr>
<tr>
<td>Live births</td>
<td>11,090</td>
<td>12,272</td>
<td>12,244</td>
<td>12,340</td>
<td>12,692</td>
<td>10,890</td>
<td>9,552</td>
<td>11,582</td>
</tr>
<tr>
<td>Index</td>
<td>95.8</td>
<td>106.0</td>
<td>105.7</td>
<td>106.5</td>
<td>109.6</td>
<td>94.0</td>
<td>82.5</td>
<td></td>
</tr>
<tr>
<td>Neonatal mortality rate</td>
<td>10.73</td>
<td>11.49</td>
<td>10.62</td>
<td>9.64</td>
<td>11.74</td>
<td>10.01</td>
<td>9.21</td>
<td>10.54</td>
</tr>
<tr>
<td>Index</td>
<td>101.8</td>
<td>100.0</td>
<td>100.7</td>
<td>91.5</td>
<td>111.3</td>
<td>94.9</td>
<td>87.4</td>
<td></td>
</tr>
<tr>
<td>Live births</td>
<td>213,344</td>
<td>235,776</td>
<td>231,680</td>
<td>229,536</td>
<td>229,984</td>
<td>182,912</td>
<td>167,360</td>
<td>212,955</td>
</tr>
<tr>
<td>Index</td>
<td>100.2</td>
<td>110.7</td>
<td>108.8</td>
<td>107.8</td>
<td>108.0</td>
<td>85.9</td>
<td>78.6</td>
<td></td>
</tr>
<tr>
<td>Neonatal mortality rate</td>
<td>0.86</td>
<td>0.89</td>
<td>0.94</td>
<td>0.92</td>
<td>0.88</td>
<td>0.84</td>
<td>0.84</td>
<td>0.88</td>
</tr>
<tr>
<td>Index</td>
<td>97.2</td>
<td>100.4</td>
<td>106.1</td>
<td>104.1</td>
<td>99.5</td>
<td>95.4</td>
<td>96.5</td>
<td>94.8</td>
</tr>
<tr>
<td>Live births</td>
<td>3882</td>
<td>4582</td>
<td>4497</td>
<td>4370</td>
<td>4402</td>
<td>3117</td>
<td>2488</td>
<td>3905</td>
</tr>
<tr>
<td>Index</td>
<td>99.4</td>
<td>117.3</td>
<td>115.2</td>
<td>111.9</td>
<td>112.7</td>
<td>79.8</td>
<td>63.7</td>
<td></td>
</tr>
<tr>
<td>Neonatal mortality rate</td>
<td>0.77</td>
<td>0.87</td>
<td>1.11</td>
<td>1.14</td>
<td>0.68</td>
<td>1.92</td>
<td>2.01</td>
<td>1.13</td>
</tr>
<tr>
<td>Index</td>
<td>68.2</td>
<td>77.0</td>
<td>98.1</td>
<td>100.9</td>
<td>60.1</td>
<td>169.8</td>
<td>177.2</td>
<td></td>
</tr>
</tbody>
</table>

*Fetal deaths, infants with unknown birth weights, and infants weighing less than 500 g were excluded. Data from Tashiro.†Live births is the average daily number for the specified birth weight group. Index is calculated as 100 × the ratio of daily value to the average daily value (100 is reference). Neonatal mortality rate is defined as the number of neonatal deaths per 1000 live births for the specified birth weight.
end had a marginally significant increased NMR (162.8 vs 150.3; OR, 1.10; 95% CI, 1.00-1.21; P = .05) (Table 3). However, when we controlled for the possibility of a more adverse case mix among the VLBW infants by further adjusting for birth weight, being born on the weekend no longer incurred a statistically significant increase in risk (OR, 1.07; 95% CI, 0.96-1.21; P = .24). Because of their size. An increase in weekend mortality for such HBW births (1.96 vs 0.92; OR, 2.14; 95% CI, 1.02-4.46; P = .04) was also observed. After controlling for deaths due to congenital abnormalities, this increased risk was no longer significant (OR, 1.70; P = .24). Because of their small numbers, weekday/weekend neonatal mortality analysis for VLBW and HBW infants should be interpreted cautiously.

Unlike the high-risk VLBW and HBW infants, the NMRs for MLBW infants born on Saturday and Sunday were 5.1% and 12.6% lower than expected, and the mortality for NBW infants was 4.6% and 5.2% lower than expected, respectively (Table 2). These decreased mortalities, while not statistically significant (Table 3), suggest that the birth of some high-risk infants in these birth weight categories may have been shifted from the weekend to a weekday, resulting in a lower-than-anticipated weekend mortality.

**COMMENT**

Several decades ago, studies of births in Europe and the United States described a decrease in births on holidays and weekends. As there is no reason to suspect that births should not occur randomly throughout the week, these patterns were believed to reflect obstetric interventions. The decrease in births on weekends was accompanied by an increase in neonatal mortality for infants born on the weekend. Although the etiology of this increase was not formally investigated in previous studies, 2 possibilities were suggested: (1) a more severe weekend case mix and/or (2) a decrease in the quality of care provided on the weekend.

Promoted by the recent observation that adult patients with some serious medical conditions are more likely to die if admitted to the hospital during the weekend, our evaluation of California births demonstrates a continuation of the observed pattern of decreased births and increased mortality on weekends. The 17.5% decrease in 1995-1997 weekend births, while less than the 24% decrease reported nationally for 2000, was almost twice that seen in the 1970s, most probably reflecting the rise in the use of cesarean delivery and other obstetric interventions. However, these interventions are not applied uniformly. A major goal when a woman goes into preterm labor is to extend gestation and gain maturity by attempting to prolong pregnancy as long as is safely possible. Relative to larger infants, elective delivery of a VLBW infant is less desirable and far less subject to control. Although the number of VLBW infants delivered on the weekend is decreased (Table 2), the greater weekend decrease in the birth of larger infants resulted in a concentration of fragile, high-mortality VLBW infants in the weekend population. After adjusting for this more adverse birth weight distribution, the increases in weekend mortality for all infants and for vaginal deliveries of VLBW infants were no longer significant.

**Table 3. Results From Logistic Regression: Odds Ratios of Neonatal Death for Weekend vs Weekday Deliveries, by Birth Weight Group, California, 1995-1997**

<table>
<thead>
<tr>
<th>Birth Weight Group</th>
<th>Weekday Neonatal Mortality Rate</th>
<th>Weekday Neonatal Mortality Rate</th>
<th>Odds Ratio (95% Confidence Interval)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Low Birth Weight (500-1499 g)‡</td>
<td>150.3</td>
<td>162.8</td>
<td>1.10 (1.00-1.21)</td>
<td>.05</td>
</tr>
<tr>
<td>Excluding congenital anomalies§</td>
<td></td>
<td></td>
<td>1.07 (0.96-1.19)</td>
<td>.24</td>
</tr>
<tr>
<td>Moderately Low Birth Weight (1500-2499 g)</td>
<td></td>
<td></td>
<td>0.89 (0.76-1.04)</td>
<td>.14</td>
</tr>
<tr>
<td>Excluding congenital anomalies§</td>
<td>10.85</td>
<td>9.63</td>
<td>1.10 (0.83-1.31)</td>
<td>.70</td>
</tr>
<tr>
<td>Normal Birth Weight (2500-4499 g)</td>
<td>0.90</td>
<td>0.84</td>
<td>0.94 (0.82-1.07)</td>
<td>.32</td>
</tr>
<tr>
<td>Excluding congenital anomalies§</td>
<td></td>
<td></td>
<td>0.88 (0.74-1.06)</td>
<td>.17</td>
</tr>
<tr>
<td>High Birth Weight (≥4500 g)</td>
<td>0.92</td>
<td>1.96</td>
<td>2.14 (1.02-4.46)</td>
<td>.04</td>
</tr>
<tr>
<td>Excluding congenital anomalies§</td>
<td></td>
<td></td>
<td>1.70 (0.70-4.13)</td>
<td>.24</td>
</tr>
</tbody>
</table>

*Fetal deaths, infants with unknown birth weights, and infants weighing less than 500 g were excluded. Data from Tashiro.11
†Neonatal mortality rate is defined as the number of deaths before age 28 days per 1000 live births.
‡Very low birth weight adjusted for birth weight subgroups: 500-749 g, 750-999 g, and 1000-1499 g (reference).
§Congenital anomalies are defined as International Classification of Diseases, 9th Revision (ICD-9) cause of death codes 740 through 748.4 and 748.6 through 759.9.

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when we controlled for case mix (birth weight and congenital abnormalities), the increase in NMR was no longer statistically significant ($P = 0.15$). The national Healthy People 2010 objectives call for a primary cesarean delivery rate of 15% and a repeat rate of 63%. Our findings suggest that it may be possible to achieve statewide, overall cesarean delivery rates in the range of 15.5% to 17% without compromising NMRs.

We conclude that the weekend is not a dangerous time to be born in California. However, this conclusion has several caveats. The first caveat is that death is both an uncommon and extreme outcome. Assessing weekend differences in neonatal condition following birth and subsequent neonatal morbidity could provide a more sensitive estimate of suboptimal care than the NMR. Although the Score for Neonatal Acute Physiology (SNAP) and Clinical Risk Index for Babies (CRIB) scores have been used to characterize the condition of infants at birth, and both the SNAP and Clinical Risk Index for Babies (CRIB) scores have been used to control for differences in case-mix severity in studies evaluating neonatal outcomes, the information required to construct these scores was not available on the California birth certificate. The second caveat is that although there is no indication of compromised weekend care for California as a whole, deficiencies could exist at the institutional level. We are now in the process of conducting a weekday/weekend outcome comparison for California’s more than 300 delivery hospitals. It will be important to assess if weekend birth is equally safe regardless of number of births, level of hospital care, and the socioeconomic profile of the women giving birth. The third caveat is that due to limitations of fetal death certification, we were unable to assess the possibility of a weekend increase in intrapartum deaths—a very important indicator of the quality of perinatal care.

Even with these caveats, the evaluation of potential deficiencies in weekend care based on case mix–adjusted neonatal mortality is a promising strategy to assess the quality of perinatal care. Using this strategy, we found that unlike the care of Canadian adults with complex illness, perinatal care in California does not appear to be compromised on the weekend. One possible explanation is that in California there is a high level of clinical and legislative commitment to maintain effective perinatal staffing and services on the weekend. For example, Title 22 of the California Code of Regulations specifies that there be at least 1 registered nurse assigned to the labor and delivery suite each shift along with sufficient trained personnel to assist the family, monitor and evaluate labor, and assist with the delivery at all times. A ratio of 1 registered nurse trained in neonatal intensive care to 2 or fewer intensive care infants is also required, and ratios proposed by Governor Davis in response to a new law will require 1 licensed nurse for every 2 or fewer women in labor.

In summary, we found no evidence that the quality of perinatal care in California was compromised during the weekend. Because resources and commitment to perinatal health may differ across states and countries, it is not possible to generalize our findings beyond California. Fortunately, the availability of state vital records as well as national linked birth-death data sets that include day of birth make it possible for other states to evaluate the extent to which mortality for their weekend births may be increased and the contribution of case mix and care.

Author Contributions: Study concept and design: Gould, Chavez. Acquisition of data: Chavez. Analysis and interpretation of data: Qin, Marks, Gould, Chavez. Drafting of the manuscript: Qin, Chavez. Critical revision of the manuscript for important intellectual content: Gould, Marks, Chavez. Statistical expertise: Qin, Chavez. Obtained funding: Chavez. Administrative, technical, or material support: Marks. Study supervision: Gould.

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