ORIGINAL ARTICLE

Variations in the number of births by day of the week, and morbidity and mortality in very-low-birth-weight infants

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KEYWORDS
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Morbidity;
Mortality;
Weekday birth;
Weekend birth;
Staffing

Abstract
Objective: To know the distribution of births of very low birth weight infants by day of the week, and whether this distribution affects the morbidity and mortality in this group of patients.
Methods: This was a retrospective analysis of data collected prospectively in the Spanish SEN1500 network (2002–2011). Outborn infants, patients with major congenital anomalies, and those who died in the delivery room were excluded. Births were grouped into “weekdays” and “weekends.” A multivariate logistic regression analysis was conducted to evaluate the independent effect of the birth moment on outcomes, and Cox regression for survival.
Results: Out of a total of 27,205 very low birth weight infants born at and/or admitted to the participating centers, 22,961 (84.4%) met inclusion criteria. A reduction of 24% in the number of births was observed during the “weekends” compared with “weekdays.” In the raw analysis, patients born on weekends exhibited higher morbidity and mortality (mortality rate: 14.2% vs. 16.5%, p < 0.001), but differences were no longer significant after adjusting for confounding factors.

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Conclusions: The present results suggest that current care practices reduce the proportion of births during the weekends and tend to cluster some high-risk births during this period, increasing crude morbidity and mortality. However, after adjusting for confounding factors, the differences disappear, suggesting that overall care coverage in these centers is appropriate.

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Introduction

Over several decades, different studies have pointed out a reduction in the number of births during the weekend, along with an increase in mortality among babies born at this time; however, these findings have not been consistent in all studies. Greater severity or a possible decrease in the quality of care during the weekends have been suggested as possible causative factors. This effect may also be due to the selective effect of obstetrical intervention during delivery. Although healthcare policies in many countries have focused on the appropriateness and universality of perinatal care everyday and year-round, there is a lack of contemporary evaluations of perinatal results adjusted by pattern of daily births, obstetrical interventions, and sociodemographic factors, which could allow the characterization of this phenomenon, as well as its magnitude and potential relevance. In addition, most evaluations in literature have referred mainly to mortality, without analyzing morbidity. The objectives of the present study were to determine whether there are significant variations in the number of births according to the day of the week (weekday or weekend) and whether these variations influence the morbidity and neonatal mortality of VLBW infants.

Methods

The authors retrospectively analyzed data prospectively collected in the national network SEN1500 for ten consecutive years (2002–2011). The characteristics of the database have been described elsewhere, and the protocol for data collection and processing previously approved by the institutional review board of each center. Outborn patients and newborns with major congenital anomalies were excluded. Patients who died in the delivery room (DR) were also excluded to avoid selection bias related to elective limitation of therapy in patients born at the limit of viability or in very poor condition. Births that took place from 08:00 am on Monday until 11:59 pm on Friday were considered as weekday births, and those that took place from 00:00 am on Saturday until 07:59 am on Monday were considered weekend births. Gestational antecedents, type of delivery, perinatal interventions, and neonatal morbidity and mortality were studied. Potential confounding factors based on literature review and those available in this hospital’s database were selected for multivariate analysis.
Statistical analysis

SPSS (IBM SPSS Statistics for Windows, version 20.0, NY, USA) was used for statistical analysis. Continuous variables with normal distribution were expressed as means and standard deviations (SD), and differences between groups were studied with the Student’s t-test. Qualitative variables and variables with non-normal distributions were expressed as median and interquartile range (IQR). Inter-group comparisons were carried out using the chi-squared test ($\chi^2$), Fisher’s exact test, and the Mann-Whitney U test, as appropriate. To evaluate the independent effect of the time of birth, a multivariate logistic regression analysis was carried out and the results were expressed as adjusted odds ratios (aOR) with 95% confidence intervals (95% CI). To study the probabilities of survival, the Cox proportional hazards regression model was used, and the results were expressed as adjusted hazards ratios (aHR) with 95% CI. All hypotheses were two-tailed tested, and statistical significance was established at $p < 0.05$ for all comparisons.

Results

During the study period, a total of 27,205 VLBW infants were admitted to the participating centers. Of these, 25,305 (93%) were born. Of these, 1533 (6.1%) with major congenital anomalies and 253 (1%) who died in the DR were excluded. Patients who died in the DR were significantly more immature those who survived (mean [SD] GA was 24.3 [2.3] vs. 29.2 [2.9] weeks; p < 0.001). Data regarding limitation of therapy were collected in 142 (56%) of these 253 patients; in 117 cases (82.4%), an elective decision to withhold or withdraw therapy had been taken. Of the patients born on Monday, the hour of birth had not been properly collected in 558 cases, and as a result they could not be classified as being born on the weekend (between 00:00 am and 07:59 am) or on a weekday (from 08:00 am onwards); these cases were also excluded from the study. Finally, 22,961 (84.4%) newborns were included for the analysis. Fig. 1 shows the distribution of births by day of the week. Should the distribution of births across all days of the week be homogeneous, the expected theoretical proportion would be 14.3% of births per day. However, the mean proportion of weekday births was 15.3%, whereas only 11.7% of births occurred on weekend days, indicating a reduction of 24%. These proportions did not vary significantly during the study period.

Table 1 presents the obstetric antecedents in both patient groups. Mothers of infants born during weekends had significantly less prenatal care (defined as at least one medical visit during gestation), assisted reproductive technology (ART), a complete course of antenatal steroids, multiple gestation, maternal hypertension, intrauterine growth restriction, or delivery via C-section. In turn, mothers of infants born on weekends had a higher incidence of chorioamnionitis and maternal antibiotic administration.

Table 2 shows the somatometric characteristics of patients, their condition at birth, and some relevant aspects of the initial management. Infants born during weekends were more immature, had lower birth weights, and lower Apgar scores at 1 and 5 min after birth. Although continuous positive airway pressure (CPAP) use in DR was similar in both groups, patients born during weekends were intubated, received oxygen, epinephrine, or cardiac compressions more

### Table 1 Gestational antecedents and type of delivery.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Weekday (n = 16,426)</th>
<th>Weekend (n = 6535)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prenatal care (at least one visit)</td>
<td>14,220/15,899 (89.4)</td>
<td>5599/6344 (88.3)</td>
<td>0.011</td>
</tr>
<tr>
<td>Assisted reproductive technologies</td>
<td>2879/15,365 (18.7)</td>
<td>1057/6079 (17.4)</td>
<td>0.021</td>
</tr>
<tr>
<td>Antenatal steroids (at least one dose)</td>
<td>13,458/16,083 (83.7)</td>
<td>5396/6404 (84.3)</td>
<td>0.285</td>
</tr>
<tr>
<td>Antenatal steroids (complete course)</td>
<td>10,400/16,083 (64.7)</td>
<td>4039/6404 (63.1)</td>
<td>0.024</td>
</tr>
<tr>
<td>Multiple gestation</td>
<td>6119/16,415 (37.3)</td>
<td>2245/6530 (34.4)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Maternal hypertension</td>
<td>1288/5988 (21.5)</td>
<td>410/2388 (17.2)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Chorioamnionitis</td>
<td>925/6134 (15.2)</td>
<td>430/2459 (17.5)</td>
<td>0.006</td>
</tr>
<tr>
<td>Maternal antibiotics</td>
<td>6967/15,140 (46.0)</td>
<td>3096/5960 (51.9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Intrauterine growth restriction</td>
<td>5676/13,925 (40.8)</td>
<td>1777/5607 (31.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Cesarean section</td>
<td>12,056/16,426 (73.4)</td>
<td>4346/6535 (66.5)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

All values are n/N (%), where N is the total number of patients with valid collected result for the indicated variable. Some variables, such as maternal hypertension and chorioamnionitis started to be collected in 2006, which is the reason for a smaller N in comparison to the other variables.
frequently than those born on weekdays. Physiological instability in the first 12 h after delivery, assessed according to the Clinical Risk Index for Babies score, was higher in the weekend group.

Table 3 presents the most relevant findings of morbidity and mortality in the bivariate and logistic regression analysis. Patients born on weekends had a higher incidence of respiratory disease, hemodynamic instability, anemia requiring transfusion, early and late onset neonatal sepsis, necrotizing enterocolitis (NEC) stage 2 or higher, germinal matrix intraventricular hemorrhage (IVH) grades 3 or 4, and retinopathy of prematurity grade 2 or higher. However, these differences disappeared in the multivariate analysis after correcting for GA, BW, sex, antenatal steroids, multiple gestation, intrauterine growth restriction, and type of delivery. Only the incidence of patent ductus arteriosus (PDA) was significantly higher among patients born during weekends after correction for confounding factors. However, this fact was not associated with a greater need for pharmacological or surgical closure. Finally, mortality was higher among patients born on weekends (14.2% vs. 16.5%; p < 0.001), but the probability of survival after adjusting for confounders by the Cox regression analysis was similar (hHR: 1.002 [95% CI: 0.967–1.038]; p = 0.915). The distribution of deaths according to the day was similar during weekdays (Mondays, 14.8%; Tuesdays, 15.5%; Wednesdays, 14.6%; Thursdays, 14.7%; and Fridays, 15.5%) while it was significantly lower on the weekend (Saturdays, 13% and Sundays, 12%; p < 0.001). Among the 3280 infants who died, data regarding limitation of therapy were collected in 1963 cases (59.8%). A decision to withhold or withdraw therapy was present in 644 cases (32.8%), and the decision to withhold/withdraw therapy was more frequently taken during weekdays (34.4%) than during weekends (28.1%; p = 0.035). The age at death was similar in both groups (median [IQR]: 6 (2–18) vs. 7 (2–18) days; p = 0.288).

Discussion

The present study indicated a significant reduction in the number of VLBW infant births during the weekend than on weekdays, as well as an increase in morbidity and mortality, although these differences disappeared after adjusting for confounders. This reduction of births during weekends had already been pointed out by other authors several years ago, and it is still observed nowadays in different countries. It seems unlikely that these differences are due to a biological cycle, and some authors have suggested a relationship with obstetrical interventions such as inductions and elective C-sections. In Spain, the rate of C-sections in this group of patients was 71.4%, and this rate remained stable during the ten-year period of the study, but C-sections were performed more frequently during weekdays. Unfortunately, data concerning induction or indication for C-section were not systematically collected in this database. As shown in Table 1, the present data suggest that in certain high-risk situations (such as multiple gestations, maternal hypertension, and intrauterine growth restriction), a decision to finalize the gestation electively
could have been made during weekdays. Despite this, babies born on weekends were smaller, had lower Apgar scores, needed more intervention during resuscitation, and were more unstable in the first 12 h of life, exhibiting more morbidity in the bivariate analysis, as well as a 16.2% greater mortality rate when compared with those born on weekdays.

Comparison between studies is difficult, because the definition of weekend itself varies across them. Bell et al.,

for instance, considered weekend as the period between Friday midnight to Sunday midnight. In other studies, the period was extended until Monday midnight. In the present study, however, it was decided to include until 07:59 am on Monday because care coverage during this time is a prolongation of that on Sunday in the present hospitals. Despite these differences, the results of some studies were similar to the present findings. Gould et al. conducted a study in the United States between 1995 and 1997 including patients with all GA and BW. They found a reduction of 17.5% in the number of weekend births, along with a reduction from 22% to 16% in the proportion of C-sections carried out. Neonatal mortality was 2.8% among babies born on weekdays vs. 3.1% among those born on weekends (OR, 1.12 [95% CI, 1.05–1.19]; p = 0.001). Mortality was also higher in babies born by C-section than via vaginal delivery: 6.85% vs. 4.94%, respectively (OR, 1.39 [95% CI, 1.25–1.55]; p < 0.001). Nevertheless, in both cases, the statistical differences disappeared after adjusting for BW. Likewise, Luo et al. carried out a population-based study in Canada between 1985 and 1998, and reported a 24% reduction in the number of births during the weekends, together with an increase of the relative risk (RR) of stillbirths (RR, 1.06 [95% CI, 1.02–1.09]), and early neonatal mortality (RR, 1.11 [95% CI, 1.07–1.16]), which also disappeared after adjusting for GA in this case. In another population-based study, Salihu et al. studied single fetuses with GAs ranging from 20 to 44 weeks, and reported higher mortality among infants born on weekends (3.25% vs. 2.87%). C-section delivery was associated with increased neonatal mortality (HR, 3.147 [95% CI, 1.579–6.74]). In addition, mortality was higher for C-sections carried out during weekends than those carried

Table 3 Morbidity and mortality of VLBW born on weekends

| Variable | Bivariate analysis (weekday) | Bivariate analysis (weekend) | Logistic regression | Logistic regression
<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Respiratory distress syndrome</td>
<td>8499/15,934 (53.3)</td>
<td>3630/6298 (57.6)</td>
<td>&lt;0.001</td>
<td>1.000 0.925–1.081 0.999</td>
</tr>
<tr>
<td>Surfactant (any time)</td>
<td>7666/16,380 (46.8)</td>
<td>3357/6517 (51.5)</td>
<td>&lt;0.001</td>
<td>1.036 0.959–1.119 0.375</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>688/16,330 (4.2)</td>
<td>322/6495 (5.0)</td>
<td>0.015</td>
<td>1.003 0.860–1.170 0.970</td>
</tr>
<tr>
<td>Steroids for BPD</td>
<td>827/16,301 (5.1)</td>
<td>379/6485 (5.8)</td>
<td>0.019</td>
<td>1.054 0.911–1.220 0.479</td>
</tr>
<tr>
<td>Oxygen by 28 days</td>
<td>3598/13,412 (26.6)</td>
<td>1566/5250 (29.8)</td>
<td>&lt;0.001</td>
<td>1.022 0.926–1.128 0.671</td>
</tr>
<tr>
<td>CPAP by 28 days</td>
<td>1304/13,277 (9.8)</td>
<td>577/5112 (11.3)</td>
<td>0.003</td>
<td>1.009 0.893–1.140 0.887</td>
</tr>
<tr>
<td>Mechanical ventilation by 28 days</td>
<td>996/13,287 (7.5)</td>
<td>438/5121 (8.6)</td>
<td>0.016</td>
<td>1.011 0.873–1.171 0.883</td>
</tr>
<tr>
<td>Oxygen by 36 weeks PMA</td>
<td>1554/12,248 (12.7)</td>
<td>677/4659 (14.5)</td>
<td>0.002</td>
<td>1.059 0.941–1.192 0.343</td>
</tr>
<tr>
<td>Arterial hypotension</td>
<td>4150/15,823 (26.2)</td>
<td>1764/6217 (28.4)</td>
<td>0.001</td>
<td>0.964 0.888–1.047 0.388</td>
</tr>
<tr>
<td>Anemia (transfusion)</td>
<td>4738/11,300 (41.9)</td>
<td>2051/4484 (45.7)</td>
<td>&lt;0.001</td>
<td>1.028 0.947–1.117 0.505</td>
</tr>
<tr>
<td>Acute renal failure</td>
<td>811/11,269 (7.2)</td>
<td>386/4482 (8.6)</td>
<td>0.003</td>
<td>1.074 0.938–1.229 0.301</td>
</tr>
<tr>
<td>Patent ductus arteriosus (PDA)</td>
<td>4443/15,927 (27.9)</td>
<td>1848/6289 (29.4)</td>
<td>0.028</td>
<td>0.904 0.836–0.977 0.011</td>
</tr>
<tr>
<td>Pharmacological closure of PDA</td>
<td>3613/16,134 (22.4)</td>
<td>1568/6411 (24.5)</td>
<td>0.001</td>
<td>0.970 0.895–1.052 0.464</td>
</tr>
<tr>
<td>Surgical ligation of PDA</td>
<td>719/16,329 (4.4)</td>
<td>319/6494 (4.9)</td>
<td>0.096</td>
<td>0.946 0.814–1.099 0.468</td>
</tr>
<tr>
<td>Early onset neonatal sepsis</td>
<td>629/16,271 (3.9)</td>
<td>301/6477 (4.6)</td>
<td>0.008</td>
<td>1.051 0.891–1.240 0.554</td>
</tr>
<tr>
<td>Late onset neonatal sepsis</td>
<td>4815/16,473 (29.8)</td>
<td>2008/6423 (31.3)</td>
<td>0.033</td>
<td>0.990 0.920–1.064 0.779</td>
</tr>
<tr>
<td>Systemic candidiasis</td>
<td>539/13,329 (4.0)</td>
<td>255/5270 (4.8)</td>
<td>0.016</td>
<td>1.083 0.909–1.289 0.373</td>
</tr>
<tr>
<td>Necrotizing enterocolitis (NEC)</td>
<td>1128/16,317 (6.9)</td>
<td>500/6493 (7.7)</td>
<td>0.037</td>
<td>1.051 0.931–1.187 0.418</td>
</tr>
<tr>
<td>Focal gastrointestinal perforation</td>
<td>328/16,299 (2.0)</td>
<td>154/6480 (2.4)</td>
<td>0.091</td>
<td>1.112 0.989–1.375 0.330</td>
</tr>
<tr>
<td>Surgery for NEC</td>
<td>560/16,319 (3.4)</td>
<td>272/6493 (4.2)</td>
<td>0.007</td>
<td>1.169 0.996–1.373 0.056</td>
</tr>
<tr>
<td>Parenteral nutrition by day 28</td>
<td>1476/13,320 (11.1)</td>
<td>655/5135 (12.8)</td>
<td>0.001</td>
<td>1.103 0.980–1.241 0.105</td>
</tr>
<tr>
<td>Severe IVH</td>
<td>1188/15,271 (7.8)</td>
<td>538/6055 (8.9)</td>
<td>0.008</td>
<td>0.975 0.861–1.104 0.693</td>
</tr>
<tr>
<td>Periventricular leukomalacia</td>
<td>849/15,896 (5.3)</td>
<td>343/6299 (5.4)</td>
<td>0.756</td>
<td>0.915 0.792–1.056 0.223</td>
</tr>
<tr>
<td>Hydrocephalus surgery</td>
<td>204/15,941 (1.3)</td>
<td>74/6302 (1.2)</td>
<td>0.523</td>
<td>0.792 0.589–1.064 0.121</td>
</tr>
<tr>
<td>Severe ROP (≥grade 2)</td>
<td>433/12,076 (3.6)</td>
<td>203/4733 (4.3)</td>
<td>0.032</td>
<td>1.026 0.842–1.251 0.796</td>
</tr>
<tr>
<td>Surgery for ROP</td>
<td>486/16,309 (3.0)</td>
<td>222/6489 (3.4)</td>
<td>0.090</td>
<td>1.014 0.847–1.213 0.882</td>
</tr>
</tbody>
</table>

aOR, adjusted odds ratio; CI, confidence interval; BPD, bronchopulmonary dysplasia; CPAP, continuous positive airway pressure; PMA, postmenstrual age; IVH, intraventricular hemorrhage, ROP, retinopathy of prematurity.

All values are n/N (%), where N is the total number of patients with valid collected result for the indicated variable. In the case of temporal variables (28 days of life or 36 weeks postmenstrual age, PMA) the patients who did not survive to that age were not included in the calculations.

Includes surfactant in delivery room.
out on weekdays (HR, 4.00 [95% CI, 1.07–15.03]). Among
the sociodemographic factors indicated by the authors as
risk factors for neonatal mortality were maternal age <18
years old, black ethnicity, and a lower parental educational
level. In that study, mothers older than 35 years had a bet-
ter prognosis, which is allegedly related to better control
of pregnancies and a better compliance of birth plans agreed
by parents and professionals. In a recent study in the United
Kingdom, after correcting for GA, BW, and maternal age,
perinatal mortality was higher among babies born on week-
ends (aOR, 1.07 [95% CI, 1.02–1.13]), and the incidence of
puerperal infections, fetal injuries, and readmissions in the
first three days after hospital discharge were also higher
among weekend-born babies compared to weekday-born
babies. That study suggested that during weekends, there
would be approximately 770 perinatal deaths and 470 mat-
ernal infections more each year than expected if care coverage
were uniform throughout the week.

Other studies have shown different results. In a study
conducted by Bell et al., in a network of university
hospitals, residents’ working hours restriction did not influence
the risk of neonatal mortality, which in their opinion
suggested an appropriate pattern of care coverage by profes-
sionals. This fact is relevant in the field of neonatology,
because the initial care to the patient in the first few
minutes of life significantly contributes to the survival of
extremely preterm infants as well as to the short- and
long-term clinical results. In a recent study by Frank-Wolf
et al., although shift time of birth was related to mode of
delivery, neonatal morbidity was similar among shifts and
between weekends and weekdays.

The present study has some strengths but also limi-
tations. This database collected approximately two-thirds
of all VLBW infants in Spain, including most regions, with
approximately 60 hospitals, mostly levels 2 and 3, contribut-
ing data. This fact reduces the possibility of selection bias,
allowing the generalization of results. A potential limitation
could be that other holidays were not taken into account,
during which the care conditions could be the same as those
during Saturdays and Sundays. This is because some holidays
vary by communities and/or localities, making it impossible
to detect, given the anonymity of cases incorporated into the
database. In turn, there may be organizational differences
between communities, and the authors do not have specific data regarding the availability of profes-
sionals in each center and by days of the week. In addition,
if a shortage of professionals or resources during weekends
was one of the causes of variations in the number of births
or perinatal outcomes, certain periods of the day, such as
night shifts, where similar such shortcomings could take
place, may have partially masked our results for weekdays.
In this sense, it would be interesting to know with cer-
tainty the differences in care coverage during night shifts,
weekends, and public holidays, and their impact on the
results in the different participating centers. Another pos-
sible limitation is that the study period extended to ten
years, during which perinatal care may have varied sig-
ificantly, which could have affected the morbidity and
mortality outcomes. Finally, there are potential biases
inherent in this study type, which are derived from
unknown confounding factors, which cannot be included and
evaluated.

In conclusion, the present results suggest that current
care practices tend to cluster high-risk births on weekdays,
significantly reducing the number of births on weekends.
Paradoxically, this causes urgent and unexpected high-risk
deliveries on weekends, increasing the crude morbidity and
mortality of patients born during those days. However,
after adjusting for risk factors, these differences disappear,
suggesting that the coverage of care in these centers is
appropriate. However, it is important to emphasize that the
analysis carried out in this study is global, including many
centers of different categories. The study design does not
allow the identification of significant differences between
centers. Further studies are required to understand which
organizational factors could influence results and, more-
over, to compare the systems of different institutions and
to generalize those with better results. It is also important
to know the possible interrelationships between the mater-

da, Sociodemographic, community, and institutional factors
influencing the results of a particular gestation as, undoubt-
edly, these results have to depend on the healthcare system
as a whole.

Conflicts of interest

The authors declare no conflicts of interest.

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(Laura Castells Villalba); Hospital G. de Granollers (Israel
Anquela Sanz); Hospital Germans Trias i Pujol (W. Coroleu);
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Sanz); Hospital San Pedro de Logroño (Inés Esteban Díez);
Hospital San Pedro de Alcántara (Mª Jesús López Cuesta);
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