OBSTETRICS

Working-hour phenomenon in obstetrics is an attainable target to improve neonatal outcomes

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BACKGROUND: Giving birth in a health care facility does not guarantee high-quality care or favorable outcomes. The working-hour phenomenon describes adverse outcomes of institutional births outside regular working hours.

OBJECTIVES: The objectives of the study were to evaluate whether the time of birth is associated with adverse neonatal outcomes and to identify the riskiest time periods for obstetrical care.

STUDY DESIGN: This nationwide retrospective cohort study analyzed data from 2008 to 2016 from all 82 obstetric departments in Austria. Births at ≥ 23+0 gestational weeks with ≥500 g birthweight were included. Independent variables were categorized by the time of day vs night as core time (morning, day) and off hours (evening, nighttime periods 1−4). The composite primary outcome was adverse neonatal outcome, defined as arterial umbilical cord blood pH <7.2, 5 minute Apgar score <7, and/or admission to the neonatal intensive care unit. Multivariate logistic regression was used to develop a model to predict these adverse neonatal outcomes.

RESULTS: Of 462,947 births, 227,672 (49.2%) occurred during off hours and had a comparable distribution in all maternity units, regardless of volume (<500 births per year: 50.3% during core time vs 49.7% during off hours; ≥500 births per year: 50.7% core time vs 49.3% off hours; perinatal tertiary center: 51.2% core time vs 48.8% off hours). Furthermore, most women (35.8−35.9%) gave birth between 2:00 and 5:59 AM (night periods 3 and 4). After adjustment for covariates, we found that adverse neonatal outcomes also occurred more frequently during these night periods 3 and 4, in addition to the early morning period (night 3: odds ratio, 1.05; 95% confidence interval, 1.03−1.08; $P < .001$; night 4: odds ratio, 1.08; 95% confidence interval, 1.05−1.10; $P < .001$; early morning period: odds ratio, 1.05; 95% confidence interval, 1.02−1.08; $P < .001$). The adjusted odds for adverse outcomes were lowest for births between 6:00 and 7:59 PM (odds ratio, 0.96; 95% confidence interval, 0.93−0.99; $P = .006$).

CONCLUSION: There is an increased risk of adverse neonatal outcomes when giving birth between 2:00 and 7:59 AM. The so-called working-hour phenomenon is an attainable target to improve neonatal outcomes. Health care providers should ensure an optimal organizational framework during this time period.

Keywords: adverse neonatal outcome, circadian rhythm, neonatal acidemia, neonatal intensive care unit, neonatal morbidity, neonatal mortality, obstetrics, parturition, pregnancy outcome, working-hour phenomenon

The keystone in the arch of safe motherhood and childhood is the provision of professional childbirth care.[1] Most countries have endeavored to gradually move childbirth from the setting of the home to an institutional setting to ensure risk surveillance and provide appropriate medical intervention warranted at any time during birth.[2−5]

Despite the substantial progress that has been made over the past decades, the magnitude of adverse obstetrical outcomes remains staggering. The World Health Organization estimates perinatal mortality rate to range from 0.2% to 3%, depending on the income level of the country.[6] Furthermore, approximately 300,000 women die annually as a result of conditions related to childbirth, with about 3000 of these deaths occurring in middle- and high-income countries.[7] In addition, 25% of mothers suffer from childbirth-related morbidity.[8] These data suggest that giving birth in an institutional setting is not a guarantor for high-quality care or favorable outcomes.[3]

One organizational element that has been implicated as a substantial contributor to adverse obstetric events in hospitals is the timing of birth. Several studies have reported a significant association between births occurring during off-hour periods (evening and nighttime) and a higher proportion of adverse neonatal outcomes, including 5 minute Apgar scores below 7 and below 3, severe birth trauma, and admissions to the neonatal intensive care unit (NICU), compared with daytime births.[9−12] Furthermore, some scientific reports have identified both evening births and nighttime births as significant predictors for increased intrapartum and neonatal mortality,[9,13] even as others do not concur.[14] With regard to maternal care, the association between adverse pregnancy outcomes and off-hour births remains unclear as well, owing to inconsistent data on maternal morbidity and/or mortality during nighttime.[14,15]

Earlier studies have evaluated obstetrical outcomes and their relationship with the time of day or night in a rather general manner. For instance, only 2 or 3 different time periods (eg, night vs day, or night vs day vs twilight) were studied. In addition, the definitions of these time periods were heterogeneous. Therefore, the currently available literature hinders the identification of factors that significantly affect the quality of obstetrical care, which is an ongoing challenge.

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AJOG at a Glance

Why was this study conducted?

This retrospective cohort study was performed to evaluate the so-called working-hour phenomenon in obstetrical care, seeking to identify the riskiest time period(s) for institutional deliveries in terms of neonatal outcomes.

Key findings

Regardless of the hospital volume, 49.2% of births occurred during an off-hour period, especially between 2:00 and 5:59 AM. The time period between 2:00 and 7:59 AM was associated with the highest risk for arterial umbilical cord blood pH <7.2, 5 minute Apgar score <7, and/or admission to the neonatal intensive care unit. In contrast, the evening period between 6:00 and 7:59 PM had the lowest risk for adverse neonatal outcomes.

What does this add to what is known?

This study identifies high-risk time periods of the working-hour phenomenon, which should be reflected in organizational concerns to ensure 24-hour availability of high-quality obstetrical care.

The present study evaluates in greater detail whether the time of birth affects neonatal outcomes by stratifying births on the basis of 7 (2 hour) time periods in a nationwide setting, seeking to identify the high-risk hours for institutional births.

Materials and Methods

Study population and ethical considerations

This retrospective cohort study is based on data retrieved from the national birth registry of Austria. The study was conducted in accordance with the Declaration of Helsinki and the good clinical practice guidelines and was approved by the Ethics Committee of the Medical University of Vienna (reference number 2075/2017). Because of the study's retrospective nature, the ethics committee waived the need for informed consent from the study subjects. All patient data were deidentified before analyses.

The Austrian national birth registry, which collects data on a quarterly basis to ensure adequate data control and quality, includes comprehensive obstetrical information and outcomes from all 82 obstetrical departments in the country. These departments include perinatal tertiary centers as well as maternity units that serve either fewer than 500 births or 500 or more births per year.

This classification is based on the number of births and does not take into account the nonuniform availability of in-house neonatology departments at these facilities, even as anesthesiology departments are available in all hospitals that provide obstetrical services. Detailed information about medical staff (eg, number of senior, attending, and/or resident physicians) was not available.

From the national birth registry, we identified pregnant women who delivered between 2008 and 2016 at ≥23+0 gestational weeks, with the birthweight of the neonate being ≥500 g. Data of women who underwent elective caesarean deliveries or induction of labor (for any reason) as well as cases with missing or inconclusive values were excluded.

Definitions of independent and outcome variables

To investigate whether off-hour delivery times had an impact on obstetrical outcomes, we categorized the actual time of birth (the independent variable) as follows: morning (6:00−7:59 am) and day (8:00 AM to 5:59 PM) were considered as core time, whereas evening (6:00−7:59 PM) and night (8:00 PM to 5:59 AM) were considered off hours.

To highlight the most vulnerable time frame during night shifts, off hours were further divided into the following time periods: night 1 (8:00−11:59 PM), night 2 (12:00−1:59 AM), night 3 (2:00−3:59 AM), and night 4 (4:00−5:59 AM). The morning and evening hours were classified on the basis of common timings of staff meetings, handovers, and shift changes.

Of note, the time of shift change was identical in most hospitals. We chose 2 hour time periods to subsume slight time differences in handovers at different hospitals as well as among physicians and midwives. In addition, delivery and operating rooms were presumed to be available without any restrictions at all times.

The primary outcome measure was defined in terms of adverse neonatal outcome, a composite dependent variable based on the early neonatal data. This was defined as either arterial umbilical cord blood pH <7.2, 5 minute Apgar score <7, and/or admission to the NICU.

Statistical analysis

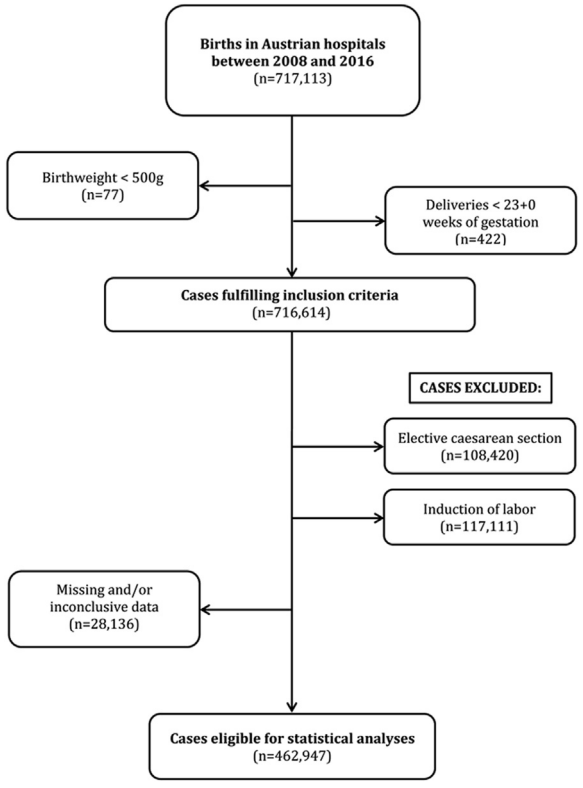
To determine whether the actual time of birth was a potential risk factor contributing independently to adverse neonatal events, we used a multivariate logistic regression model. Following a forward variable selection strategy, we used the likelihood ratio to test whether a priori-selected covariates had a statistically significant contribution to the model.

On the basis of recent literature, we included the following covariates: maternal age, singleton vs multiple gestation, mode of birth, gestational age, birthweight, cesarean delivery in a prior pregnancy, and the volume of the maternity unit.[12,16,17] Univariate and multivariate adjusted odds ratios (OR) with 95% confidence intervals (CIs) were calculated for each risk factor. Data were presented as frequencies (n) and proportions (percentage), unless specified otherwise. A 2 sided value of $P < .05$ was considered statistically significant. For the statistical analyses, we used Stata software, version 13 (StataCorp LLC, College Station, TX).

Results

During the study period, a total of 717,113 births were recorded, of which 716,614 (99.9%) were eligible for inclusion in the study. Of these, 225,531

FIGURE
Criteria of inclusion of 462,947 deliveries during the study period



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(31.5%) were excluded on the basis of exclusion criteria, and 28,136 (3.9%) were excluded because of missing or inconclusive data. The remaining 462,947 births were used for statistical analyses (Figure). Of these, 235,275 (50.8%) births occurred during core time, and 227,672 (49.2%) occurred during off hours.

The distribution of the time of birth was comparable in all maternity units, irrespective of their volume (<500 births per year: 50.3% during core time vs 49.7% during off hours; ≥500 births per year: 50.7% core time vs 49.3% off hours; perinatal tertiary center: 51.2% core time vs 48.8% off hours). With regard to the off hour periods, births occurred most frequently during night periods 3 and 4 (35.8−35.9%).

When comparing obstetrical characteristics with the time of birth, we found that the singleton rate was higher during the off-hour period, compared with the core-time period (98.1% vs 97.8%, $P < .0001$). During off hours, the rate of term births and spontaneous vaginal births with cephalic presentation was significantly higher than during core time (93.2% vs 92.3% and 78.5% vs 75.4%, both $P < .0001$).

Consequently, the cesarean delivery rate was lower during off hours than during core time (14.3% vs 16.3%, $P < .0001$). The percentage of neonates with birthweight between 2500 and 3999 g was higher during off hours compared with core time (87.1% vs 85.9%, $P < .0001$). The distribution of baseline characteristics and neonatal outcomes according to the time of birth is summarized in Table 1.

Overall, 103,992 births (22.5%) had an adverse neonatal outcome. Neonates with umbilical cord arterial blood pH <7.2 were born more commonly during off hours compared with core time (17.0% vs 16.9%, $P < .0001$). The adverse neonatal outcomes with respect to the time of birth are presented in Table 2.

We applied a likelihood ratio test to determine covariates having a relevant contribution to the model for the prediction of adverse neonatal outcomes. This test reported a significant effect of all selected parameters (maternal age, singleton vs multiple gestation, mode of birth, gestational age, birthweight, cesarean delivery in a prior pregnancy, and volume of maternity unit), as shown in Table 3.

After adjustment for these confounders, we found a significant effect of the time of birth as follows: births during off hours (night 3 and night 4) as well as early-morning period were significantly associated with adverse neonatal outcomes (night 3: OR, 1.05; 95% CI, 1.03−1.08; $P < .001$; night 4: OR, 1.08; 95% CI, 1.05−1.10; $P < .001$; early-morning period: OR, 1.05; 95% CI, 1.02−1.08; $P < .001$). In contrast, the odds for poor neonatal outcomes were lowest for births between 6:00 and 7:59 PM (OR, 0.96; 95% CI, 0.93−0.99; $P = .006$), as shown in Table 3.

Comment

Principal findings of the study

The present study analyzed nationwide data of adverse neonatal outcomes with regard to the so-called working-hour phenomenon. In contrast to the existing literature, we evaluated 7 distinct time periods of the day to examine whether births in the institutional setting were associated with adverse outcomes while adjusting for pregnancy-related risks. Intriguingly, we found that the time between 2:00 and 7:59 AM (night periods 3 and 4, as well as the early-morning period) was the most vulnerable period with the highest risk for adverse events, whereas the lowest risk was associated with the time between 6:00 and 7:59 PM.

The working-hour phenomenon in context of the literature

Worldwide, off-hour deliveries are known to be a challenge ubiquitous at all levels of health care. However, the association between off hours and neonatal

TABLE 1
Baseline characteristics according to the time of birth of 462,947 deliveries in Austria between 2008 and 2016

	Frequency (n) (proportion, %)						
Variable	Morning 6:00–7:59	Day 8:00–5:59	Evening 6:00–7:59	Night 1 8:00–11:59	Night 2 12:00–1:59	Night 3 2:00–3:59	Night 4 4:00–5:59
Maternal age, y							
<18	188 (0.5%)	964 (0.5%)	183 (0.5%)	362 (0.5%)	184 (0.5%)	181 (0.4%)	185 (0.5%)
18–29	17,195 (45.4%)	92,757 (47%)	15,673 (46.3%)	33,387 (45.9%)	17,599 (44.8%)	18,421 (45%)	18,608 (45.5%)
30–34	12,566 (33.2%)	64,152 (32.5%)	10,932 (32.3%)	23,909 (32.9%)	13,316 (33.9%)	13,696 (33.5%)	13,631 (33.4%)
≥35	7932 (20.9%)	39,521 (20%)	7065 (20.9%)	15,061 (20.7%)	8,191 (20.8%)	8644 (21.1%)	8444 (20.6%)
Total	37,881 (100%)	197,394 (100%)	33,853 (100%)	72,719 (100%)	39,290 (100%)	40,942 (100%)	40,868 (100%)
Singleton/multiple gestation							
Singleton	37,180 (98.1%)	192,873 (97.7%)	33,207 (98.0%)	71,240 (97.9%)	38,621 (98.3%)	40,131 (98%)	40,164 (98.2%)
Twins	682 (1.8%)	4395 (2.2%)	631 (1.9%)	1444 (2%)	655 (1.6%)	798 (1.9%)	695 (1.7%)
Triples/ quadruplets	19 (0.1%)	126 (0.1%)	15 (0.1%)	35 (0.1%)	14 (0.1%)	13 (0.1%)	9 (0.1%)
Total	37,881 (100%)	197,394 (100%)	33,853 (100%)	72,719 (100%)	39,290 (100%)	40,942 (100%)	40,868 (100%)
Mode of birth							
Spontaneous vaginal	30,617 (80.8%)	146,806 (74.4%)	25,317 (74.8%)	55,215 (75.9%)	31,266 (79.6%)	33,400 (81.6%)	33,570 (82.1%)
Instrumental assisted	2497 (6.6%)	16,492 (8.4%)	2758 (8.1%)	5416 (7.4%)	2500 (6.4%)	2513 (6.1%)	2525 (6.2%)
Vaginal breech position	82 (0.2%)	438 (0.2%)	83 (0.2%)	143 (0.2%)	88 (0.2%)	98 (0.2%)	83 (0.2%)
Nonelective cesarean	4280 (11.3%)	31,226 (15.8%)	5303 (15.7%)	11,180 (15.4%)	5037 (12.8%)	4552 (11.1%)	4320 (10.6%)
Emergency cesarean	405 (1.1%)	2432 (1.2%)	392 (1.2%)	765 (1.1%)	399 (1%)	379 (1%)	370 (0.9%)
Total	37,881 (100%)	197,394 (100%)	33,853 (100%)	72,719 (100%)	39,290 (100%)	40,942 (100%)	40,868 (100%)
Gestational age at birth, wk							
≥37+0	35,435 (93.6%)	181,724 (92.1%)	31,248 (92.3%)	67,221 (92.5%)	36,838 (93.8%)	38,494 (94%)	38,419 (94%)
32+0–36+6	2203 (5.8%)	13,298 (6.7%)	2223 (6.5%)	4732 (6.5%)	2167 (5.5%)	2173 (5.3%)	2202 (5.4%)
28+0–31+6	165 (0.4%)	1662 (0.8%)	265 (0.8%)	515 (0.7%)	197 (0.5%)	190 (0.5%)	174 (0.4%)
23+0–27+6	78 (0.2%)	710 (0.4%)	117 (0.4%)	251 (0.3%)	88 (0.2%)	85 (0.2%)	73 (0.2%)
Total	37,881 (100%)	197,394 (100%)	33,853 (100%)	72,719 (100%)	39,290 (100%)	40,942 (100%)	40,868 (100%)

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(continued)

TABLE 1
Baseline characteristics according to the time of birth of 462,947 deliveries in Austria between 2008 and 2016 *(continued)*

Variable	Frequency (n) (proportion, %) Morning 6:00–7:59	Day 8:00–5:59	Evening 6:00–7:59	Night 1 8:00–11:59	Night 2 12:00–1:59	Night 3 2:00–3:59	Night 4 4:00–5:59
Birthweight, g							
<1000	69 (0.2%)	635 (0.3%)	107 (0.3%)	225 (0.3%)	78 (0.2%)	71 (0.2%)	65 (0.2%)
1000–1499	110 (0.3%)	1208 (0.6%)	176 (0.5%)	338 (0.5%)	128 (0.3%)	126 (0.3%)	120 (0.3%)
1500–2499	1621 (4.3%)	9613 (4.9%)	624 (4.8%)	3379 (4.7%)	1630 (4.2%)	1620 (4%)	1588 (3.9%)
2500–3999	32,926 (87%)	169,170 (85.8%)	29,211 (86.3%)	63,203 (86.9%)	34,420 (87.6%)	35,836 (87.5%)	35,731 (87.4%)
≥4000	3155 (8.2%)	16,768 (8.4%)	2735 (8.1%)	5574 (7.6%)	3034 (7.7%)	3289 (8%)	3364 (8.2%)
Total	37,881 (100%)	197,394 (100%)	33,853 (100%)	72,719 (100%)	39,290 (100%)	40,942 (100%)	40,868 (100%)

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outcomes with regard to the risk across different time periods has not yet been examined, particularly not in the European context.

Similar to several earlier scientific reports, we identified a greater risk of acidosis (arterial umbilical cord blood pH <7.2), neonatal distress (5 minute Apgar <7), and admission to the NICU in deliveries occurring at nighttime compared with daytime,[9–12,18] although these findings were in contrast to those of some studies.[14,19] However, in addition to concurring with the existing literature, our data provide further detailed evidence regarding the vulnerable time periods during working hours that are significantly associated with adverse neonatal outcomes.

The stratification into 2 hour time periods enabled us to identify a night period (2:00–5:59 AM) as well as an early morning period (6:00–7:59 AM) as independent risk factors for adverse neonatal outcomes. This finding is of particular interest because we know that early morning is the time when staff meetings, handovers, and shift changes of physicians and midwives take place.

In the light of this finding, we propose that organizational factors might contribute to (what we define as) the working-hour phenomenon.[1,12] Beyond regular working hours, hospitals must deal with the challenge of medical staff compromised not only in strength but also by relative inexperience. Because most senior physicians arrive only on call and are not always present in the labor and delivery ward, they are less likely to be involved in both the initial diagnosis as well as the management of critical situations.[20] Moreover, a day-night heterogeneity concerning the facility equipment and services, such as immediate availability of neonatological amenities, is often observed.[21,22]

It has recently been demonstrated that in addition to the working-hour phenomenon, the volume of the hospital unit[23,24] as well as capacity strain compound clinical complications.[25,26] In light of this, one may therefore hypothesize that the distraction of handovers as well as the physical absence from the patient may explain the vulnerable time

TABLE 2
Neonatal outcomes according to the time of birth of 462,947 deliveries in Austria between 2008 and 2016

Variable	Frequency (n) (proportion, %)						
	Morning 6:00–7:59	Day 8:00–12:59	Evening 6:00–7:59	Night 1 8:00–11:59	Night 2 12:00–1:59	Night 3 2:00–3:59	Night 4 4:00–5:59
Umbilical cord arterial blood pH							
<7	96 (0.3%)	510 (0.3%)	97 (0.3%)	207 (0.3%)	130 (0.3%)	107 (0.3%)	90 (0.3%)
7 to <7.1	732 (1.9%)	3743 (1.9%)	643 (1.9%)	1333 (1.9%)	744 (1.9%)	841 (2%)	827 (2%)
7.1 to <7.2	6016 (15.9%)	28,876 (14.6%)	4676 (13.8%)	10,316 (14.1%)	5793 (14.8%)	6387 (15.6%)	6597 (16.1%)
≥7.2	31,037 (81.9%)	164,265 (83.2%)	28,437 (84%)	60,863 (83.7%)	32,623 (83%)	33,607 (82.1%)	33,354 (81.6%)
Total	37,881 (100%)	19,7394 (100%)	33,853 (100%)	72,719 (100%)	39,290 (100%)	40,942 (100%)	40,868 (100%)
5 minute Apgar score							
0–6	203 (0.6%)	1427 (0.8%)	243 (0.8%)	527 (0.8%)	256 (0.7%)	254 (0.7%)	229 (0.5%)
7–10	37,678 (99.4%)	195,967 (99.2%)	33,610 (99.2%)	72,192 (99.2%)	39,034 (99.3%)	40,688 (99.3%)	40,639 (99.5%)
Total	37,881 (100%)	197,394 (100%)	33,853 (100%)	72,719 (100%)	39,290 (100%)	40,942 (100%)	40,868 (100%)
NICU admission							
No	35,980 (94.9%)	185,875 (94.2%)	31,932 (94.4%)	68,570 (94.3%)	37,357 (95.1%)	38,972 (95.2%)	38,872 (95.2%)
Yes	1901 (5.1%)	11,519 (5.8%)	1921 (5.6%)	4149 (5.7%)	1933 (4.9%)	1970 (4.8%)	1996 (4.8%)
Total	37,881 (100%)	197,394 (100%)	33,853 (100%)	72,719 (100%)	39,290 (100%)	40,942 (100%)	40,868 (100%)

NICU, neonatal intensive care unit.

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frame from 6:00 to 7:59 AM early morning.

Apart from the aforementioned aspects of physician staffing and stress, circadian misalignments may lead to chronic fatigue in night workers, which could be another contributing factor for adverse outcomes during nightshifts.[27] Working at night and sleeping during the day is in contradiction of the internal circadian rhythm and may be responsible for a higher rate of mistakes.

Additionally, this chronic fatigue may be superimposed by acute sleep deprivation in physicians because of long working hours.[28,29] Alertness and performance decline rapidly after 16–18 hours of wakefulness (assuming that work begins at 8:00 AM and continues until midnight).[28,30] This nocturnal deactivation has also been demonstrated by electroencephalographic studies.[31] Circadian misalignment paired with chronic fatigue and acute sleep deprivation might explain the increased risk of adverse neonatal outcomes associated with births during the morning period (6:00–7:59 AM) but not during the evening period (6:00–7:59 PM). Nevertheless, according to our multivariate regression analysis including several significant covariates, the working-hour phenomenon seems to be multifactorial.

Some authors understand this phenomenon as a wider construct, comparing patients' outcomes during weekdays with those during weekends or those during regular working days with those during holidays. However, the literature is thus far inconsistent; while some report an association of weekends and/or holidays with adverse outcomes,[32,33] others do not.[34] As a consequence, we designed our nationwide study to evaluate differences between daytime and nighttime outcomes, with respect to different time periods.

Implications for clinical practice

Because clinical procedures and duty working hours in Europe and the United States are comparable, knowledge of the working-hour phenomenon and its potential determinants is crucial with practical relevance for the management of obstetrical care. The existing

TABLE 3
Multivariate logistic regression of relevant factors to predict adverse neonatal outcomes in 462,947 deliveries in Austria between 2008 and 2016

Variable	OR	95% CI	*P* value
Time of birth			
Core time (day)	Reference		
Off hours			
Evening	0.96	0.93–0.99	.006[a]
Night 1	0.98	0.96–1.00	.111
Night 2	1.00	0.97–1.03	.902
Night 3	1.05	1.03–1.08	< .001[a]
Night 4	1.08	1.05–1.10	< .001[a]
Core time (morning)	1.05	1.02–1.08	< .001[a]
Maternal age, y			
0–17	Reference		
18–29	0.77	0.70–0.85	< .001[a]
30–34	0.69	0.63–0.76	< .001[a]
≥35	0.68	0.61–0.75	< .001[a]
Singleton/multiple gestation			
Singleton	Reference		
Twins	1.13	1.08–1.19	< .001[a]
Triplets/quadruplets	1.08	0.81–1.44	0.62
Mode of birth			
Spontaneous vaginal	Reference		
Instrument assisted	2.3	2.24–2.35	< .001[a]
Vaginal breech position	2.76	2.43–3.14	< .001[a]
Nonelective cesarean	0.75	0.74–0.77	< .001[a]
Emergency cesarean	2.46	2.32–2.61	< .001[a]
Gestational age at birth, wk			
≥37+0	Reference		
32+0–36+6	2.07	2.00–2.14	< .001[a]
23+0–31+6	4.73	4.24–5.27	< .001[a]
Birthweight, g			
<999	4.64	3.84–5.60	< .001[a]
1000–1499	2.77	2.42–3.16	< .001[a]
1500–2499	1.94	1.87–2.02	< .001[a]
2500–3999	Reference		
≥4000	1.39	1.36–1.43	< .001[a]
Previous cesarean delivery			
Yes	Reference		
No	0.3	0.27–0.33	< .001[a]

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TABLE 3
Multivariate logistic regression of relevant factors to predict adverse neonatal outcomes in 462,947 deliveries in Austria between 2008 and 2016 *(continued)*

Variable	OR	95% CI	*P* value
Volume of maternity unit			
<500 births per year	0.82	0.80–0.85	< .001[a]
≥500 births per year	Reference		
Perinatal tertiary center	1.27	1.25–1.29	< .001[a]

CI, confidence interval; *OR*, Odds ratio.

[a] Significant *P* values (< 0.05).

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imbalance between the organizationally understaffed off hours and the fact that the majority of women give birth during nighttime rather than during daytime suggests a shift in focus is warranted to improve obstetrical care. Thus, on the basis of the findings of our study, a better idea of the status quo has emerged, whereby appropriate solutions may be devised.[35]

Various studies have reported frequencies of nighttime deliveries of up to 55.8%[36]; in our cohort, the rate of births at nighttime was 49.2%. In agreement with previously published data, we found more vaginal deliveries and fewer nonelective and emergency cesarean deliveries during nighttime compared to daytime.[37] This is possibly because the onset of labor that begins at night is known to be physiologically more efficient than the onset of labor during the day, leading to a shorter birth period.[37]

Implications for research

Because the working-hour phenomenon mirrors the organizational vulnerability of hospital units during off hours, the effect is unlikely to be limited to obstetrics but is also likely to occur in other specialties, such as oncological gynecology or pediatric intensive care units.[33,38] Thus, it is possible that the working-hour phenomenon is a ubiquitous medical issue, warranting due scientific attention to identify affected medical fields in the interest of patient safety. Furthermore, the differentiation of summer and wintertime will be another interesting covariate to study because it is known that the circadian rhythm is strongly driven by the light/dark cycle. However, it is imperative to note that the concept of chronobiology is more complex because it also has genetic, developmental, and external influences.[27]

Strengths and Limitations

The greatest strength of our study lies in its ability to transfer the generated theoretical knowledge of the working-hour phenomenon into practical solutions regarding organizational management among maternity units (eg, increasing the number of staff and/or experienced physicians/midwives during high-risk hours, restructuring the start and end timings of day and/or night shifts). In setting out key challenges in obstetrical care, our data emphasize the significant effect of off-hour periods on adverse events, suggesting that improving the quality of medical care provided outside regular working hours is an attainable target for improving neonatal outcomes.

The weakness of our study is its retrospective nature, which is accompanied by the inherited limitation of establishing a causal relationship between off-hour deliveries and adverse neonatal outcomes. However, the nationwide setting enabled the availability of an enormously large data set, which yields robust estimates of significant factors, including the working-hour phenomenon, which was shown to influence neonatal outcomes. Unfortunately, we were unable to incorporate outcome measures of maternal health into our analyses because the available data were of heterogeneous quality, which might have led to wrong conclusions.

Conclusions

To conclude, our study shows that there is an increased risk of adverse neonatal outcomes between 2:00 and 7:59 AM in tertiary and nontertiary hospitals. We consider this so-called working-hour phenomenon an attainable target to improve obstetrical care, which should be reflected in organizational concerns to ensure adequate 24 hour availability of high-quality medical service. ■

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