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The Impact of Lunar Phases During Day and Night Cycles on Perinatal Outcomes: A Nationwide Cohort Study

Karin Windsperger[1] | Tim Dorittke[1] | Dana A. Muin[1] | Herbert Kiss[1] | Wilhelm Oberaigner[2] | Hermann Leitner[3] | Alex Farr[1]

[1]Division of Obstetrics and Feto-Maternal Medicine, Department of Obstetrics and Gynecology, Medical University of Vienna, Vienna, Austria | [2]Department of Public Health, Health Services Research and Health Technology Assessment, Institute of Public Health, Medical Decision Making and Health Technology Assessment, UMIT University for Health Sciences, Medical Informatics and Technology, Hall in Tirol, Austria | [3]Department of Clinical Epidemiology, Tyrolean Federal Institute for Integrated Care, Tirol Kliniken GmbH, Innsbruck, Austria

Correspondence: Alex Farr (alex.farr@meduniwien.ac.at)

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ABSTRACT

Background: Light changes during the lunar cycle affect rhythms in diverse species. Human studies focusing on whether the moon influences human health have so far neglected the effects of light/dark cycles. The purpose of this study was to investigate whether lunar phases impact perinatal outcomes by considering illumination levels due to day/night rhythms.

Methods: To assess the influence of moon phases, this nationwide cohort study identified cases with a singleton pregnancy that involved daytime (06:00 a.m. to 08:59 p.m.) and nighttime (09:00 p.m. to 05:59 a.m.) delivery at $\geq 23+0$ gestational weeks with a birthweight of ≥ 500 g. Data on women who underwent elective cesarean or labor induction were excluded from the analyses. The lunar cycle was categorized as full moon, new moon, or other lunar phases. The standardized birth ratio (SBR) was chosen as the primary outcome parameter, while the duration of labor and adverse neonatal short-term health (pH of < 7.2 and/or a 5-min Apgar score of < 7) were chosen as the secondary outcome variables.

Results: We identified a total case number of 462,947 births, of which 242,518 (52.4%) occurred during the day and 220,429 (47.6%) at night. Different moon phases did not appear to influence either the SBR or adverse neonatal outcomes. However, nighttime births may show a trend toward a prolonged maximum duration of labor related to moon phases (62 vs. 65 vs. 70 h for new/full/other moon phases, $p = 0.05$).

Discussion: Considering illumination levels, some moon phases may increase the risk for prolonged births during nighttime. However, assessing the effect of lunar phases on health variables is complex. Co-environmental agents should be incorporated into future analyses.

1 | Introduction

The medical field has largely dismissed the effects of the lunar cycle as mythological superstition, both among patients and professionals [1, 2]. While some studies have investigated whether lunar phases affect health parameters, especially in obstetrics, only a few found a link between moon phases and birth rates [3, 4]. Most research fails to demonstrate an impact of the lunar cycle on labor and childbirth, showing no association between lunar phases and conception rates after assisted reproduction [5], birth rates [2, 6–8], or on maternal or neonatal complications [2, 8].

The Moon is the Earth's only natural satellite. It rotates on its own axis in approximately 27.3 days (a sidereal day) and orbits the Earth with a synodic period of about 29.5 days (a lunar month), during which the Moon's phases are observed. These cycles give rise to environmental rhythms, such as illumination levels, tides, and geomagnetic fields [9]. The moon's appearance changes depending on its position relative to the sun, whose light it reflects. The lunar phases include new moon, first quarter, full moon, and third quarter. During the new moon, the moon is between the sun and Earth and is not visible at night, while during the full moon, the Earth is between the sun and moon, fully illuminating the moon [10]. The Earth's illuminance at full moon can reach 0.25 lx, 250 times greater than during the new moon [11].

Light changes during the lunar cycle are known to affect animal species [9]. As a key time cue, it influences foraging, habitat use, communication, navigation, predation, and reproduction by synchronizing or desynchronizing biological clocks [9]. While the impact of natural moonlight on animal rhythms has been well studied, research on how moon phases affect human health has so far overlooked the light/dark cycle corresponding to day and night.

Cajochen et al. [12] reported that melatonin levels in humans are reduced during full moon nights compared to other moon phases. The neurohormone melatonin, secreted by the pineal gland, follows a circadian rhythm, with high levels at night and 10 to 15-fold lower baseline levels during the day, as light exposure acutely suppresses its synthesis [13]. Melatonin influences various processes, including fetal development, the timing and process of labor, and the risk of offspring diseases [13, 14]. In pregnant women, nighttime melatonin concentrations increase with advancing gestation, peaking during labor. Through uterine melatonin receptors, the hormone enhances uterine sensitivity to oxytocin, increasing uterine contractility [13–15].

Given what is known of these hormonal pathways, we found it reasonable to assess whether the moon phase impacts perinatal outcomes, considering the light changes associated with circalunar chronobiology. Our study is the first to examine differences in birth rates, labor duration, and neonatal short-term outcomes in relation to both parameters that influence humans' nocturnal rhythms.

2 | Methods

2.1 | Study Design and Participants

This nationwide cohort study retrospectively analyzed data from the Austrian birth registry—a prospective, population-based database, comprising deliveries from all 82 obstetric departments in Austria. In detail, comprehensive information on both maternal characteristics and perinatal outcomes is included in this registry. Data collection from all hospitals occurs quarterly to ensure adequate data control and quality. To assess the influence of lunar phases in dependence on the day/night cycle, we retrospectively identified cases with a singleton pregnancy over an 8-year period involving daytime (06:00 a.m. to 08:59 p.m.) and nighttime (09:00 p.m. to 05:59 a.m.) deliveries at $\geq 23+0$ gestational weeks and a birthweight of ≥ 500 g. Independent variables were categorized by the lunar cycle as full moon, new moon, or other lunar phases (short "others"). The standardized birth ratio (SBR) was calculated as the primary outcome parameter. Duration of labor and adverse neonatal short-term health were chosen as secondary outcome variables. The latter was defined as a pH of <7.2 and/or a 5-min Apgar score of <7. Data on women who underwent elective cesarean or labor induction, and cases with missing data, were excluded from the analyses.

2.2 | Assessment of Lunar and Day/Night Cycles

The dates for the lunar cycles were obtained from the Astronomical Applications Department of the US Naval Observatory [16]. The phases of the Moon are determined by the angle between the Moon's ecliptic longitude and the Sun's, with 0° marking the new moon and 180° marking the full moon [17]. As light changes are maximal between new moon and full moon, the independent variable was dichotomously operationalized. Firstly, the variable "new moon" was coded "one" and tested against all other moon phases, which were coded "zero". Secondly, the variable "full moon" was coded "one" and tested against all other moon phases, which were coded "zero". In addition, to build these variables, 2 days before and 2 days after each moon phase were considered. Based on lunar phases, assumptions regarding illumination levels can be derived. As described in Mayoral et al. [18], illumination levels (defined as the amount of luminous flux striking a surface per unit area)—based on the Moon's natural light—vary specifically, ranging from 0.001 lx during a new moon to 0.25 lx during a full moon. No additional light measurements were taken for this study.

For creating the dichotomous variable of day/night cycle, the definition of civil twilight (i.e., the time when the geometric center of the sun's disk is at most 6° below the horizon) was used to set the lower and upper limits for the nighttime period [19]. During this time, artificial light might be needed, especially in unclear weather conditions. In Austria, which lies at a latitude of about 47° N, the variation of civil twilight due to seasonal changes is less significantly affected than the overall duration of daylight hours [19].

2.3 | Primary Outcomes Measure

For the primary outcome parameter, we aimed to evaluate whether different lunar phases at day or night have an impact on the birth rate. Consequently, we used the SBR as an adjusted calculation, in order to eliminate potentially confounding variables, such as known variations regarding weekdays, months and years. The SBR represents the quotient of the observed number of births per lunar phase (Obs), divided by the expected number of births (Exp). We determined Exp (based on Austria as a reference group) by calculation. The average number of births per day was broken down by the combinations of weekday, month, and year; then the expected number per combination of weekday, month, and year was calculated per lunar phase and finally summed up. SBR is similar to the terms "standardized mortality ratio" and "standardized incidence ratio" and should offer the advantage of a standardized interpretation [3, 6].

2.4 | Secondary Outcome Measures

We used the duration of labor and adverse neonatal short-term outcomes as secondary outcome measures. The onset of labor was marked by the occurrence of regular, painful contractions at least once every 10 min irrespective of actual cervical dilation and was reported by the patient [20]. There is little consensus regarding a standard definition of labor onset in the research literature; however, the same definition is used according to Hanley's et al. [20] systematic review by most studies (71%). Adverse neonatal short-term outcome—a composite variable based on early neonatal data—was defined as either a 5-min Apgar score of <7 and/or an umbilical cord arterial blood pH of <7.2. We used the parameters since they are well-known for both obstetricians and neonatologists and are critical for the evaluation of neonatal short-term outcomes [21–24].

2.5 | Statistical Analyses

Data were presented as frequencies (*n*) and proportions (%) or as medians with minimum (min) and maximum (max). To analyze whether different lunar phases influence the SBR, 95% confidence intervals (CIs) were calculated. An SBR is statistically significantly increased if the lower limit of the CI is >1 and statistically significantly decreased if the upper limit of the CI is <1. Multivariate logistic regression models were applied to determine whether the lunar cycle was a potential risk factor contributing independently to prolonged labor and/or adverse neonatal outcomes. With a forward variable selection strategy, we used likelihood ratio to test whether a priori selected covariates yielded a statistically significant contribution to the model. Based on the available literature, we included the following covariates in the model: maternal age, mode of delivery (spontaneous vaginal, instrumental-assisted, vaginal breech position, nonelective cesarean), gestational age, and birthweight [25–27]. Regarding the consistency of the models, the set of confounders retained in the final model was the same across all models we tested. Univariate and multivariate adjusted odds ratios (ORs) with 95% CIs were calculated for each risk factor. A two-sided *p* value of <0.05 was considered statistically significant. For the statistical analyses, we used the Stata software version 13 (StataCorp LLC, College Station, TX, USA).

3 | Results

3.1 | Study Population

We identified a total of 717,113 births during the observational period, of which 716,614 (99.9%) fulfilled the inclusion criteria. Out of these, we excluded 225,531 cases due to the exclusion criteria and another 28,136 cases due to incomplete data (Figure 1). Of the 462,947 remaining births, 242,518 (52.4%) occurred during daytime and 220,429 (47.6%) occurred during nighttime. In more detail, 8137 (3.4%) cases showed daytime birth at new moon, 8089 (3.3%) daytime birth at full moon, and 226,292 (93.3%) daytime birth during other lunar phases. Of the nighttime birth cases, 7616 (3.5%) births were at new moon, 7560 (3.4%) at full moon, and 205,254 (93.1%) during other lunar phases. Baseline characteristics of the study participants

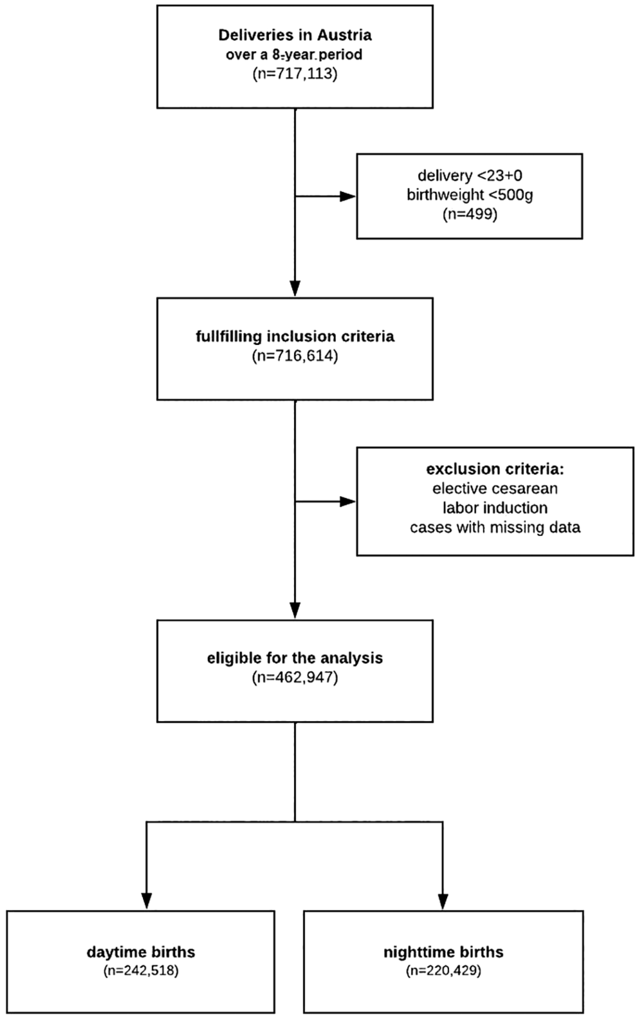

FIGURE 1 | Eligibility of the 462,947 deliveries during the study period.

stratified by day versus night and lunar phases are shown in Table 1.

3.2 | Standardized Birth Ratio

To take both time of day and seasonal variations (as described above) into account, the standardized birth rate with a 95% CI was calculated for the different moon phases, as shown in Table 2. Since neither the lower limit of the CI was larger than 1, nor the upper limit of the CI was smaller than 1 in the observed lunar phases, there were no statistically significant deviations from the average birth rate.

3.3 | Labor Duration

The overall median duration of labor during daytime was 6 h (min 0; max 61), compared to 5 h (min 0; max 65) at night. A more precise analysis shows that daytime labor lasts 6 h on average during all three moon phase categories (new moon: min 0, max 52; full moon: min 0, max 63; others: min 0, max 70; $p=0.19$). During nighttime, the average duration was 5 h for each moon phase, with the following corresponding min and

TABLE 1 | Baseline characteristics, as total and stratified by day/night and lunar cycles, among 462,947 deliveries in Austria over an 8-year period.

	Frequency (*N*), (proportion, %)							
	Daytime (*N* = 242,518)				Nighttime (*N* = 220,429)			
Variable	**New moon**	**Full moon**	**Others**	**Total**	**New moon**	**Full moon**	**Others**	**Total**
Maternal age (years)								
< 18	53 (0.6%)	40 (0.5%)	1095 (0.5%)	1188 (0.5%)	52 (0.7%)	35 (0.5%)	972 (0.5%)	1059 (0.5%)
18–29	3832 (47.1%)	3792 (46.9%)	105,875 (46.8%)	113,499 (46.8%)	3454 (45.4%)	3462 (45.8%)	93,225 (45.4%)	100,141 (45.4%)
30–34	2653 (32.6%)	2608 (32.2%)	73,754 (32.6%)	79,015 (32.6%)	2502 (32.9%)	2525 (33.4%)	68,160 (33.2%)	73,187 (33.2%)
35–40	1306 (16.1%)	1332 (16.5%)	36,956 (16.3%)	39,594 (16.3%)	1292 (16.9%)	1264 (16.7%)	34,755 (16.9%)	37,311 (16.9%)
≥ 41	293 (3.6%)	317 (3.9%)	8612 (3.8%)	9222 (3.8%)	315 (4.1%)	274 (3.6%)	8142 (4%)	8731 (4%)
Total	8137 (100%)	8089 (100%)	226,292 (100%)	242,518 (100%)	7616 (100%)	7560 (100%)	205,254 (100%)	220,429 (100%)
Mode of delivery								
Spontaneous vaginal	6126 (75.3%)	6119 (75.6%)	170,172 (75.2%)	182,417 (75.2%)	5977 (78.5%)	5995 (79.3%)	161,802 (78.8%)	173,774 (78.8%)
Instrumental-assisted	651 (8.0%)	641 (8.0%)	18,279 (8.1%)	19,571 (8.1%)	557 (7.3%)	537 (7.1%)	14,036 (6.9%)	15,130 (6.9%)
Vaginal breech position	14 (0.2%)	18 (0.2%)	519 (0.2%)	551 (0.2%)	18 (0.2%)	19 (0.2%)	427 (0.2%)	464 (0.2%)
Non-elective cesarean	1346 (16.5%)	1311 (16.2%)	37,322 (16.5%)	39,979 (16.5%)	1063 (14%)	1009 (13.4%)	28,989 (14.1%)	31,061 (14.1%)
Total	8137 (100%)	8089 (100%)	226,292 (100%)	242,518 (100%)	7616 (100%)	7560 (100%)	205,254 (100%)	220,429 (100%)
Gestational age at birth (weeks)								
≥ 37 + 0	7477 (91.9%)	7481 (92.5%)	208,668 (92.2%)	223,626 (92.2%)	7094 (93.2%)	7044 (93.2%)	191,615 (93.3%)	205,753 (93.3%)
32 + 0–36 + 6	569 (7.0%)	517 (6.4%)	16,146 (6.7%)	16,146 (6.7%)	474 (6.2%)	440 (5.8%)	11,938 (5.8%)	12,852 (5.8%)
28 + 0–31 + 6	69 (0.8%)	63 (0.8%)	1934 (0.8%)	1934 (0.8%)	28 (0.4%)	53 (0.7%)	1153 (0.6%)	1234 (0.6%)
23 + 0–27 + 6	22 (0.3%)	28 (0.3%)	762 (0.3%)	812 (0.3%)	19 (0.2%)	23 (0.3%)	548 (0.3%)	590 (0.3%)
Total	8137 (100%)	8089 (100%)	226,292 (100%)	242,518 (100%)	7616 (100%)	7560 (100%)	205,254 (100%)	220,429 (100%)
Birthweight (g)								
< 1000	21 (0.3%)	26 (0.3%)	682 (0.3%)	729 (0.3%)	13 (0.2%)	7 (0.1%)	491 (0.2%)	521 (0.2%)
1000–1499	44 (0.5%)	42 (0.5%)	1287 (0.6%)	1373 (0.6%)	29 (0.4%)	40 (0.5%)	764 (0.4%)	833 (0.4%)
1500–2499	412 (5.1%)	376 (4.7%)	10,849 (4.8%)	11,637 (4.8%)	314 (4.1%)	304 (4.0%)	8820 (4.3%)	9438 (4.3%)
2500–3999	6999 (86.0%)	6995 (86.5%)	194,404 (85.9%)	208,398 (85.9%)	6648 (87.3%)	6557 (86.8%)	178,894 (87.2%)	192,099 (87.1%)
≥ 4000	661 (8.1%)	650 (8%)	19,070 (8.4%)	20,381 (8.4%)	611 (8%)	642 (8.6%)	16,285 (7.9%)	17,538 (8%)
Total	8137 (100%)	8089 (100%)	226,292 (100%)	242,518 (100%)	7616 (100%)	7560 (100%)	205,254 (100%)	220,429 (100%)

max values: 0 to 62 h for new moon, 0 to 65 h for full moon, and 0 to 70 h for other moon phases. The prolonged maximum labor duration during night in relation to the moon phases was borderline statistically significant ($p = 0.05$) (Figure 2).

3.4 | Neonatal Outcomes

Overall, 45,614 (18.8%) cases with birth during daytime showed adverse neonatal short-term outcomes, of which 1590 (3.5%) occurred during new moon, 1546 (3.4%) during full moon, and 42,478 (93.1%) during other moon phases. Of the cases with birth during nighttime, 41,927 (19.0%) showed an adverse neonatal outcome; of these, 1408 (3.4%) occurred during new moon, 1435 (3.4%) during full moon, and 39,084 (93.2%) during other moon phases. The distribution of newborns with a 5-min Apgar score of < 7 and/or an umbilical cord pH of < 7.2 stratified by day versus night and by the moon cycles is shown in Table 3.

TABLE 2 | Standardized Birth Ratio (SBR), calculated by the quotient Obs/Exp number of births, for the lunar phases new moon, full moon, and others.

Lunar cycle	SBR	ObsNB	ExpNB	95% CI
New moon	0.9957	15,752	15819.6	0.9802–0.9957
New moon +1 day	1.0055	31,737	31563.2	0.9945–1.0055
New moon +2 days	1.0025	31,566	31487.5	0.9915–1.0025
Full moon	1.0000	15,649	15649.0	0.9844–1.0000
Full moon +1 day	1.0017	31,339	31286.1	0.9906–1.0017
Full moon +2 days	1.0009	31,363	31335.9	0.9898–1.0009
Others	0.9991	305,541	305805.8	0.9956–0.9991

Abbreviations: CI, confidence interval; ExpNB, expected number of births; ObsNB, observed number of births; SBR, standardized birth ratio.

3.5 | Adjusted Odds Ratio Models

Univariate analysis showed that the moon phase did not have a statistically significant impact on the neonatal outcome of either daytime (OR, 1.05; 95% CI, 0.99–1.11; $p = 0.08$ for new moon; OR, 1.02; 95% CI, 0.96–1.08; $p = 0.44$ for full moon) or nighttime births (OR, 0.96; 95% CI, 0.91–1.02; $p = 0.23$ for new moon; OR, 0.99; 95% CI, 0.94–1.06; $p = 0.89$ for full moon). After adjustment for potential confounders, newborns from daytime and nighttime birth showed no altered odds of facing adverse neonatal outcomes in relation to the moon phase (daytime: OR, 1.05; 95% CI, 0.99–1.13; $p = 0.08$ for new moon; OR, 1.03; 95% CI, 0.97–1.09; $p = 0.39$ for full moon; nighttime: OR, 0.96; 95% CI, 0.90–1.02; $p = 0.15$ for new moon; OR, 0.99; 95% CI, 0.93–1.05; $p = 0.64$ for full moon), as shown in Table 4.

4 | Discussion

The moon is the primary source of environmental nighttime illumination. Since light changes during the lunar cycle affect rhythms in animal species [9], this study, for the first time, examined the impact of moon phases on perinatal outcomes in humans, considering day and night cycles. We hypothesized that full moon, new moon, or other moon phases would significantly affect the SBR, median labor duration, and neonatal short-term outcomes due to varying nighttime illumination levels, but this was not confirmed. However, our large birth registry dataset may suggest a trend toward longer maximum labor duration during nighttime births associated with moon phases compared to daytime births.

Over the past 30 years, a substantial body of evidence has emerged attempting to debunk the scientific correlation between the moon and human health [28]. Authors from different countries failed to prove a correlation of birth rate to lunar phases [2, 3, 6, 8, 29, 30]. The landmark study was conducted in the USA evaluating 8142 spontaneous vaginal deliveries over a 4-year period, from 1974 to 1978, which were not correlated in any way to the lunar cycle [29]. However, these authors simply calculated the mean number of births during different moon

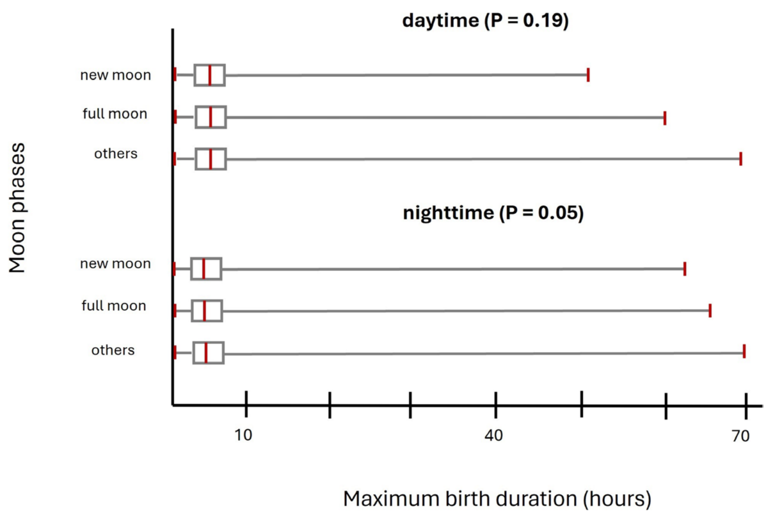

FIGURE 2 | Median values (with min and max values) of labor duration, stratified by the moon phases among 462,947 deliveries during the study period. [Colour figure can be viewed at wileyonlinelibrary.com]

TABLE 3 | Neonatal outcomes, as total and stratified by day/night and lunar cycles, among 462,947 deliveries in Austria over an 8-year period.

	Frequency (*N*), (proportion, %)							
	Daytime (*N* = 242,518)				Nighttime (*N* = 220,429)			
Variable	**New moon**	**Full moon**	**Others**	**Total**	**New moon**	**Full moon**	**Others**	**Total**
Umbilical cord arterial blood pH								
<7.1	161 (2.0%)	142 (1.8%)	4866 (2.2%)	5169 (2.1%)	157 (2.2%)	168 (2.2%)	4596 (2.2%)	4931 (2.3%)
7.1 to <7.20	1266 (15.5%)	1216 (15%)	33,046 (14.6%)	35,528 (14.7%)	1105 (14.5%)	1145 (15.1%)	30,883 (15.1%)	33,133 (15%)
≥7.2	6710 (82.5%)	6731 (83.2%)	188,380 (83.2%)	201,821 (83.2%)	6343 (83.3%)	6247 (82.6%)	169,775 (82.7%)	182,365 (82.7%)
Total	8137 (100%)	8089 (100%)	226,292 (100%)	242,518 (100%)	7616 (100%)	7560 (100%)	205,254 (100%)	220,429 (100%)
5-min Apgar score								
0–6	47 (0.6%)	65 (0.8%)	1580 (0.7%)	1692 (0.7%)	49 (0.6%)	51 (0.7%)	1347 (0.7%)	1447 (0.7%)
7–10	8090 (99.4%)	8024 (99.2%)	224,712 (99.3%)	240,826 (99.3%)	7566 (99.4%)	7509 (99.3%)	203,907 (99.3%)	218,982 (99.3%)
Total	8137 (100%)	8089 (100%)	226,292 (100%)	242,518 (100%)	7616 (100%)	7560 (100%)	205,254 (100%)	220,429 (100%)

phases, a method that overlooks the known influence of seasonality on birth rates. Decades later, several researchers accounted for this factor in their analyses by calculating the SBR—as we did in our study—but found no significant differences in birth frequency across moon phases [3, 6]. Since then, additional studies have incorporated various atmospheric and meteorological factors to evaluate outcome parameters in relation to the lunar cycle [6, 30]. Morton-Pradhan et al. examined 167,956 spontaneous vaginal deliveries over a 5-year period and found no significant correlation between birth rates and lunar phases when considering temperature, barometric pressure, precipitation, and dew point [6]. Our study analyzed 462,947 births over an 8-year period and, for the first time, considered the individual day/night cycle. However, even with varying illumination levels between day and night, moon phases did not affect the SBR. All these findings contrast with a few studies that reported a slight correlation between lunar phases and birth frequency [3, 4].

Given the importance of circadian rhythms, particularly the light/dark cycle, in parturition, our study examined birth duration as a secondary outcome [13, 14]. In humans, spontaneous births occur at all hours, but the likelihood of parturition is higher at night than during the day [31, 32]. This nocturnal pattern appears to be linked to an increase in maternal circadian melatonin levels at night [33]. Melatonin, in synergy with other hormones like oxytocin, strengthens uterine contractions during the night [13, 14]. Interestingly, strong evidence shows that chronodisruption and subsequent suppression of melatonin production are associated with impaired deliveries in both animals and humans [14, 31, 34, 35]. For instance, Olcese et al. [31] demonstrated that exposure to 10,000 lx full-spectrum light at night—an intensity known to suppress endogenous melatonin—weakens uterine contractions in pregnant volunteers. This highlights a compelling research avenue to investigate whether nighttime illumination could be a tool to delay or prevent preterm labor.

In alignment with our study, Staboulidou et al. [2] demonstrated on 6724 spontaneous vaginal deliveries over a 6-month period no predictable influence of moon phases on neonatal outcomes. Whereas the authors included birth weight, birth length, and head circumference in their study, our focus lay on the neonatal short-term outcome, a composite variable based on either a 5-min Apgar score of < 7 and/or an umbilical cord arterial blood pH of < 7.2, reflecting an increased risk of adverse neurological outcomes in newborns [2, 22].

From a clinical perspective, our data—suggesting a potential trend toward a longer maximum duration of nighttime deliveries during certain moon phases—could have practical implications. On one hand, care teams may allow longer birth durations while closely monitoring the patient, thus supporting a more natural birth process without early intervention unless necessary. On the other hand, for deliveries during such nights, care teams might opt for quicker interventions, such as vaginal-assisted deliveries or cesarean sections, at the first signs of fetal and/or maternal distress. Understanding the potential impact of the lunar cycle on labor duration could also inform decisions on labor inductions, helping clinicians determine the optimal timing for initiating labor to ensure a safer delivery for both the mother and infant. Additionally, understanding these environmental factors

TABLE 4 | Multivariate logistic regression of variables predicting adverse neonatal outcomes among 462,947 deliveries in Austria over an 8-year period.

	Daytime			Nighttime		
	OR	**95% CI**	***p***	**OR**	**95% CI**	***p***
Lunar cycle						
New moon	1.05	0.99–1.13	0.08	0.96	0.90–1.02	0.15
Full moon	1.03	0.97–1.09	0.39	0.99	0.93–1.05	0.64
Others		Reference			Reference	
Maternal age (years)						
0–17	1.45	1.27–1.65	< 0.001	1.30	1.12–1.49	< 0.001
18–29		Reference			Reference	
30–34	0.91	0.88–0.93	< 0.001	0.92	0.89–0.94	< 0.001
35–40	0.90	0.88–0.93	< 0.001	0.88	0.85–0.91	< 0.001
≥ 41	0.97	0.92–1.03	0.31	0.90	0.85–0.96	< 0.001
Mode of delivery						
Spontaneous vaginal		Reference			Reference	
Instrumental-assisted	2.17	2.10–2.24	< 0.001	2.63	2.54–2.72	< 0.001
Vaginal breech position	3.14	2.65–3.73	< 0.001	3.31	2.74–4.00	< 0.001
Non-elective cesarean	1.56	1.46–1.70	< 0.001	1.73	1.59–1.87	< 0.001
Gestational age at birth (weeks)						
≥ 37 + 0		Reference			Reference	
32 + 0–36 + 6	0.97	0.92–1.02	0.23	0.97	0.92–1.03	0.35
28 + 0–31 + 6	2.01	1.7–2.34	< 0.001	2.18	1.82–2.60	< 0.001
23 + 0–27 + 6	4.12	3.29–5.17	< 0.001	4.48	3.40–5.88	< 0.001
Birthweight (g)						
< 1000	1.23	1.23–2.24	< 0.001	1.23	1.22–2.23	< 0.001
1000–1499	1.96	1.64–2.34	< 0.001	2.08	1.68–2.58	< 0.001
1500–3999		Reference			Reference	
> 4000	1.18	1.11–1.26	< 0.001	1.04	0.97–1.10	0.29

Abbreviations: CI, confidence interval; OR, odds ratio.

could help personalize pain management strategies by aligning them with the natural rhythms of labor, ensuring that pain relief is provided at the most crucial moments. Healthcare providers may also consider adjusting staffing levels and resources according to the lunar cycle, anticipating periods of increased labor intensity. This proactive approach could optimize workload management and improve patient care during these times. In this context, psychological and cultural beliefs about the influence of lunar phases on the birth process may also play a role, shaping patients' behaviors and expectations, such as seeking medical care more urgently during specific moon phases.

Future studies must recognize the complexity of assessing the impact of lunar phases on health [9, 36]. Research on moonlight chronobiology is challenging in an era of widespread artificial nighttime illumination, which may distort the relationship between moonlight and health outcomes. We recently found that women in areas with medium to high light pollution (LP) had higher odds of prolonged labor, while this was not the case for those in areas with low LP [37]. Given Austria's mix of urban and rural environments with varying LP levels, these effects may balance out in our full-cohort analysis of moonlight's influence on birth duration. Still, our data—based on 462,947 births—underscore the importance of accounting for co-environmental factors (e.g., LP, seasons, weather) in future studies. Additionally, moving from country-based to individual light analyses would be beneficial. Mobile light sensors worn by patients could provide more accurate, individualized assessments of light exposure.

The greatest strength of this study is its large and homogenic birth registry dataset collected over an 8-year period. The study distinguishes itself from the existing literature by analyzing the effect of the lunar cycle on obstetric parameters by considering different illumination levels at day versus night. The main limitation of this study is its retrospective nature. Due to the data source, we were unable to account for potential confounding variables such as sleep patterns, factors affecting birth duration (e.g., the use of epidural anesthesia, oxytocin, and/or hospital policies), or factors influencing illumination levels, such as LP and regional variations, as this information was not available. While the study's findings still offer useful insights, the absence of these key covariates might lead to an over- or underestimation of findings. Given that our data are derived from a single country, further research involving larger and more diverse populations is needed to validate the association between moonlight and birth duration and enhance the generalizability of the findings.

5 | Conclusion

Moonlight illuminance does not affect the SBR, nor does it influence neonatal short-term outcomes, though a trend may be observed toward a longer maximum duration of labor during nighttime compared to daytime births. Our large nationwide dataset emphasizes the importance of incorporating intertwined co-factors, such as LP, and breaking down nationwide to individual-based analyses when evaluating the current environmental status impacting human health.

Acknowledgments

N/A

Ethics Statement

The local ethics committee of the Medical University of Vienna granted a waiver of informed consent and approved our study on the 5th of December 2017 (EK number 2074/2017).

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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