Original Article

The Lunar Effect on Delivery and Other Birth Outcomes in Rural Zambia

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ABSTRACT

Objective: It is a widely held belief that the period of a full moon is associated with higher birth rates compared to periods when the moon is not full. We investigated whether more births occurred during a full moon in a rural African population.

Design: Data collected from 42 clinical sites in rural Zambia associated with the Better Health Outcomes through Mentoring and Assessment (BHOMA) Study were evaluated. We compared the proportion of pregnancies born during a full moon to the proportion that would be expected if there were no association.

Main outcomes: Proportion of births during the full moon.

Measures: Demographics and birth outcomes.

Results: A total of 10,127 women delivered at a participating site between 8 December 2010 and 19 August 2015. Mean maternal age was 25.1 years (standard deviation [SD] 6.4 years), mean maternal weight 62.7 kg (SD 13.9 kg), 14.4% were HIV seropositive, and 3.7% were syphilis positive. The mean birth weight was 3032 g (SD 0.5 g); 49.6% newborns were female, and 1.48% were stillborn. There was a full moon during 70 of the 1715 days under observation. In the absence of an association, we would expect 70 / 1715 (4.08%) of births to occur on these days. We observed a total of 434deliveries (4.29%; 95% Confidence Interval [CI]: 3.89%, 4.68%) during these 24-hour periods. Thus, an association between the full moon and higher delivery rates was not observed (p=0.87). An additional analysis, where the entire lunar cycle was divided into 8 equal bins, also yielded no association. Finally, we did not identify any other birth outcomes that were associated with lunar cycle (birthweight, stillbirth, gender, or congenital malformation).

Conclusions: In this large, rural population, we found no evidence of a lunar effect on delivery or adverse birth outcomes. These results refute a common belief and should provide assurance to managers who opt to ignore lunar cycle when scheduling midwife staffing of rural clinics.

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INTRODUCTION

People have believed for millennia that the moon can affect human health and behavior. This belief in a "lunar effect" persists to the present day and support for it can be found in a wide range of studies and reports. For instance, a study of crime in the United States between the years of 1978 and 1982 found that crime rates were significantly higher on full moon days. In addition, a study of veterinary visits showed that cats and dogs are taken to the emergency room far more often during full-moon nights than during other moon phases.

The theory that the full moon can play a role in determining what happens on a given day is not wholly without basis. We know that the moon causes oceanic tides, as well as "earth tides" which are minute changes in the ground surface caused by

the pull of the moon. The moon has also been known to have a substantial effect on the climate, because of the atmospheric movement it causes, and the heating that its reflection of sunlight allows during the night time.

Studies on the rates of birth during full moons have been done before, in countries like Australia and the United States. None, however, have focused on women living in the developing world, and none have been conducted in predominantly rural areas. We hypothesized that if there were an effect of lunar phase on human birth, it would be most evident in rural areas with limited access to electrification and nighttime lighting. People living in rural Africa are more agriculturally-based and away from certain distractions such as television and computers, that may affect the circadian clock. It could also be argued that they are generally more connected to their environments, thereby increasing the likelihood that a lunar effect, if present at all, would be evident in their birth outcomes.

Methods

We used data from the Better Health Outcomes Through Mentoring and Assessment study (BHOMA), which was conducted in rural Zambia between 2010 and 2015. BHOMA was funded by the Doris Duke Charitable Foundation and has been described in a prior publication. It has undergone continuing ethical review by the University of Zambia Biomedical Research Ethics Committee. For this analysis, we used data collected at 42 BHOMA sites in three rural districts. All women who delivered a baby at one of the BHOMA sites were captured in an electronic database, which recorded: date of admission, date of delivery, medical complications, and infant outcomes, such as birth weight, birth defects, and stillbirth. In some, but not all cases, the healthcare workers were able to link a patient's prior medical record (from prenatal care) to her delivery record.

Although BHOMA has some characteristics of a census survey - all births occurring at the 42 BHOMA sites were captured – we are treating it here as a sample, because (1) there were other sites in the area that were not part of BHOMA and (2) the BHOMA system did not capture home births. Further, we wish to draw inferences about the entire country of Zambia from these data drawn from 3 rural districts. All analyses were conducted in the SAS programming language (SAS Institute, Cary, NC).

We began by determining the exact moon phase during each date within the study period. These data were obtained from the US Naval Observatory, which published the exact fraction of the moon illuminated (within each time zone on earth) for every 24-hour period since the year 1700 (http://aa.usno.navy.mil/data/docs/MoonFraction.php). A fraction illuminated of 100% indicates a full moon and 0% a new moon. The moon phases follow a sinusoidal pattern where it is alternately waxing (i.e. the fraction illuminated is increasing from night to night) and waning (where the fraction illuminated is reducing). For our primary analysis, we categorized the dates where the fraction illuminated was 100% as a "full moon" and all other days as "not full moon." (It should be noted that occasionally the moon achieves 100% illumination very close to midnight and this causes 2 consecutive days to be classified as full moon.) We then calculated the proportion of "full moon dates" under the observation period and compared this expected value to the observed proportion of actual deliveries that occurred on these days using a 1-sample Z test of proportions. Our null hypothesis was that proportion of deliveries on days classified as full moon would not differ from that expected by random chance. We also constructed the exact binomial 95% confidence interval around the observed proportion of deliveries occurring on a full moon day.

To test the association between lunar cycle and various maternal and infant factors, we used the T-test for the continuous variables (maternal age, maternal weight, and birth weight), all of which were normally distributed. We used the Chi Square test for categorical variables. We considered $p < 0.05$ to be statistically significant.

Finally, it is also possible that a lunar effect may be apparent in days other than a full moon. To investigate this association, we assigned each date under observation into 1 of 8 mutually exclusive moon phase categories: new, waxing crescent, first quarter, waxing gibbous, full, waning gibbous, third quarter, and waning crescent. (Figure)Because of its elliptical orbit, the length of the lunar cycle is not exactly the same from cycle to cycle. On average, it is 29.53 days. Thus, an attempt to divide the moon phase into 8 categories of equal length would assign 3.69 days to each phase. We used a cosine function with a period of 29.53 days toassign each date'svalue for fraction of the moon illuminated to 1 of 8 equal moon phase bins, according to the following formula:

$$Y = 0.5*COS((2\pi/29.53059) * (X-3.69132375/2))+0.5$$

RESULTS

BHOMA data were collected between 8 December 2010 and 19 August 2015 at the 42 rural sites. Over these 1715 days under observation, there was a full moon during 70 of them (4.08%). Over this same period, a total of10,127 deliveries occurred, 434 of which (4.29%) occurred during a full moon. The 95% exact binomial confidence interval around this proportion is: 3.89%, 4.68%. This confidence interval includes the expected value of 4.29%. This is evident in the 1-sample Z test of proportions, which yields a p value of 0.87. We have therefore failed to reject the null hypothesis and must conclude no association between full moon and likelihood of delivery.

Maternal characteristics were as follows: The women's mean age was 25.1 (±6.4) years and they weighed 62.7kg (±13.9) kilograms. A total of 1277 of 8851 (14.4%) in whom an HIV test was performed were HIV positive. Furthermore, a total of 58 of 1601 (3.65%) in whom a syphilis test was performed were syphilis positive. None of these maternal characteristics were associated with moon phase (Table).

Infant characteristics were as follows: The mean birth weight was 3032 g (±0.5) grams. As expected, almost exactly half, 49.6%, were female, 1.48% were stillborn (i.e. born without any sign of life), and 3.4% had a major birth defect. None of these infant characteristics were associated with moon phase (Table).

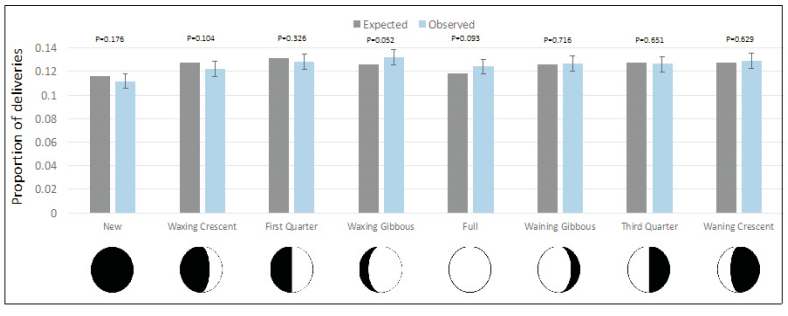
Table: Maternal Characteristics and Infant Outcomes for 10,127 deliveries in rural Zambia (Dec 2010 – Aug 2015)

	Phase of Moon at Delivery				Total Cohort		
	Not Full (N=9,639)		Full (N=434)		(N=10,127)		P-Value
Maternal Characteristics	N	Value	N	Value	N	Value	
Maternal age, mean yrs (SD)	7913	25.1 (6.5)	344	24.7 (6.3)	8257	25.1 (6.4)	0.27
Maternal weight, kg (SD)	234	62.2 (14.2)	5264	62.8 (13.9)	5498	62.7 (13.9)	0.54*
HIV Positive, n (%)	388	55 (14.2)	8463	122 (13.8)	8851	1277 (14.4)	0.88**
Syphilis Positive, n (%)	1526	57 (3.8)	61	1 (1.7)	1601	58 (3.65)	0.07***
Infant Outcomes							
Birthweight, g (SD)	425	3.03 (0.50)	9399	3.03 (0.50)	9824	3032 (0.50)	0.81*
Female, n (%)	419	217 (51.8)	9284	4597 (49.5)	9703	4814 (49.6)	0.36**
Stillbirth, n (%)	418	8 (1.91)	9300	136 (1.46)	9718	144 (1.48)	0.45**
Malformation, n (%)	338	18 (5.33)	7449	249 (3.34)	7787	267 (3.43)	0.05**

Statistical tests used: *T-test **ChiSquare ***Fisher's Exact Test

An additional analysis, where the entire lunar cycle was divided into 8 equal bins also yielded no association between phases of the moon and number of births. (p> 0.05 for all 8 comparisons: Figure)

Figure: Timing of 10,127 deliveries over 8 lunar phases in rural Zambia (Dec 2010-Aug 2015)



DISCUSSION

In this multi-site analysis of rural Zambian women delivering over a period of nearly five years, we found no association between lunar phase and the likelihood of birth. We also did not find associations between moon phase and any of the maternal or infant characteristics that were available in the dataset. Our study results are consistent with other published reports. Gans and Leigh conducted a study in Australia, examining 7,108,772 births, over a course of 10,592 days, finding no association between full moon and birthday. Similarly, Arliss and colleagues conducted a study in North Carolina, observing 564, 039 births, over 62 lunar cycles, also finding no association. Our study differed from these in an important way – it was conducted in rural Zambia, where women where electricity is scarce, there is less light pollution, and people may be more attune to actual lunar cycles.

This study has several strengths. In addition to its rural African population, it was large and conducted over the course of nearly five years. Thus, many lunar cycles were included. By observing over 10,000 births, the confidence interval created around the observed birth rate was very narrow. This makes us confident that random error has not affected the findings very much, if at all.

The study also has several weaknesses, which include the following. First, there some missing data. The BHOMA system relied on healthcare personnel to enter information at the time of delivery and most clinics in Zambia are terribly understaffed. Therefore, while the date of delivery is very complete, some of the other accompanying information such as maternal age and syphilis results are missing from some patients. Data that are missing at random do not introduce bias, but data that are missing systematically can introduce bias. We would be more worried about the missing data if our study had shown an association and if we thought that the missing data was systematically missing.

Another weakness is that the BHOMA system does not capture any information about women who gave birth at home. Thus, we are forced to comment only on those rural women who were able to make it to the clinic in order to deliver. This is less likely at night. Perhaps it is possible that a lunar effect could be operating at night and those women don't come to the clinic to deliver, but it is also possible that during a full moon women are more likely to deliver at the clinic because the moon helps guide them. Although both of these things could be possible in theory, our analysis can't really comment on it.

In conclusion, we did not find an association between lunar phase and timing of birth. The moon affects the tides and maybe even our environment, but despite the old wives' tales, it does not seem to affect birth timing. These results refute a common belief and should provide assurance to managers who opt to ignore lunar cycle when scheduling midwife staffing of rural clinics.

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