The Lunar Cycle and the Number of Deliveries in Austria between 1970 and 1999

T. Waldhoer  G. Haidinger  C. Vutuc
Division of Epidemiology, Institute of Cancer Research, University of Vienna, Austria

Key Words
Lunar cycle · Deliveries · Poisson regression

Abstract
The effect of the moon on the number of newborns has been investigated extensively with few significant findings but with few significant findings. In this paper, a possible lunar effect is analyzed by a nonlinear Poisson regression model similar to a Fourier analysis based on all children (n = 2,760,362) born in Austria between 1970 and 1999, i.e. 371 lunar cycles. We found no significant effect even when considering the influence of parity and gestation. Our study is in contrast to a French study using a similarly large data base which showed a weak but significant effect. Nevertheless, significant p values based on very large samples must be interpreted cautiously. Our study is in concordance with other studies which often use small and selected samples or rather inefficient statistical methods. We conclude that there is no significant effect of the lunar cycle on the number of deliveries in Austria.

Introduction
The effect of the lunar cycle on the number of newborns has been investigated extensively with few significant findings [1, 2]. In two recent publications [3, 4], the number of deliveries was significantly associated with a period extremely close to the lunar cycle. In this paper, we try to estimate the effect of the phase of the moon using a more powerful statistical tool on population-based data which allow the detection even of very small effects.

Patients and Methods
We considered all deliveries (n = 2,760,362) in Austria between 1970 and 1999 (10,957 days = 371 lunar cycles). The data were extracted on a daily basis from the Austrian birth register (Statistics Austria). We used a nonlinear Poisson regression model [5] where the daily number of deliveries is described by a sine function similar to a Fourier time analysis with a predefined wavelength (synodic period \( P = 29.53 \) days) and unknown amplitude (c) and phase angle (\( \phi \), equation 1). A long-term trend was added by means of inclusion of high-order terms of time (time, time^2, time^3). This was done in order to provide for the possibility of a nonlinear time trend in the number of births.

\[
\mu = \int (1 + \beta_1 t + \beta_2 t^2 + \beta_3 t^3 + c \cos(2\pi t/P+\phi)) \, dt
\]  

(1)

The model was estimated by means of maximum likelihood in the software package Gauss [6]. Additionally, we added 6 dummy vari-
ables as indicators for weekday effects. Some authors found nonrandom variations in the number of deliveries in subgroups only [7]. Therefore we estimated the model also for full-term deliveries only (38–42 weeks of gestation) as well as for primiparae and multiparae.

Since the seasonal effect is represented by two parameters (amplitude and phase angle), we calculated its significance by the difference in the likelihoods of the model with and without the seasonal effect based on the $\chi^2$ distribution.

**Results**

In all analyses and subgroups (only primiparae, multiparae, 38–42 weeks of gestation), the effect of the lunar cycle turned out to be nonsignificant ($p > 0.95$).

**Discussion**

The hypothesis of an influence of the moon on human behavior and especially on the number of births has a long tradition. Although a matter for debate, many studies point to a nonsignificant effect. In this paper we tried to estimate the lunar effect using an appropriate statistical method as well as sufficient numbers of observations, i.e. sufficient numbers of newborns and lunar cycles. The moon cycle has a period of about 29.53 days, thus we were able to observe 371 lunar cycles in which 2,760,362 children were born. We are aware of only one study [8] which uses a similarly large database consisting of 12,035,680 births in France observed over a 15-year period (i.e. 185 lunar cycles). At this point, we would like to emphasize that the number of lunar cycles is at least as important as the number of newborns for this type of investigation in order to obtain sufficient power for detecting a true effect. Guillon et al. [8] found a very weak but statistically significant effect of the moon ($p < 0.001$). However, Bauer et al. [9] stressed that for analyses with very large sample sizes the $p$ values for variable selection must approach zero in order to ensure consistent model selection. In light of these data, a $p$ value $<0.001$ for the lunar effect (as observed in [8]) is not surprising and its interpretation should be cautious.

In concordance with many other studies [1, 2], we found no significant lunar effect. However, in contrast to our investigation many studies use small or selected databases or sometimes inefficient statistical methods which make the detection of an existing lunar effect rather unlikely considering the probably small size of the effect. In addition to the use of large population-based data, our analysis avoids multiple testing situations, as for example observed in time series analyses by concentrating on only one wavelength of 29.53, i.e. the lunar cycle.

We conclude that there seems to be no effect of the lunar cycle on the number of Austrian newborns.

**References**