Periodicity of Deliveries – Findings from Six Selected North Indian Hospitals

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Abstract
We present here a report, based on data obtained from six selected North Indian hospitals, on variations in the number of human deliveries over the period from 1 October 2010 to 30 September 2011. We tried to identify whether there are any cycles exhibited by the data. We discover cyclicity over different months of the year and days of the week whereas cyclicity over different phases of the lunar cycle is not clearly established.

Review of Studies on Birth Periodicity
Initially research on periodicity of births was motivated by the desire to investigate the age-old belief that deliveries are more frequent during full moon and new moon days. As we know, the duration of the menstrual cycle (average 28 days) is very close to the duration of the lunar cycle (29.53 days), thus a causal link was drawn between the two. Many studies investigated the link between the lunar cycle and deliveries. Another focus area has been seasonal cyclicity: systematic variation over different months of the year. Finally there is the question of variation over different days of the week. Anecdotal reports of this type of variation need to be investigated.

The first systematic study of the lunar cycle in human births took place in late 19th century. A very marked double periodicity according to the lunar month was reported, the first maximum occurring on day 6 or 7 and the second maximum on day 24 or 25. Two massive surveys, one of around 12 million deliveries and the other of around 6 million found not only a link with the lunar cycle but also a weekly pattern (maximum deliveries on Tuesdays; minimum on Sundays and Saturdays) and an annual pattern in which the maximum number of births took place in May and a minimum in November. A study of 140,000 live births in New York City in 1968 found that the lunar cycle had an impact on fertility and births with peak fertility in the 3rd quarter. It has also been reported that melatonin levels appear to correlate with the menstrual cycle, which indicates that the lunar cycle may have an impact on human reproduction, in particular fertility, menstruation, and birth rate (Zimecki, 2006).

On the other hand, numerous studies have dismissed any link between the lunar cycle and human births. A meta-study of the same issue has come to a similar conclusion (Kelly & Martens, 1994).

Seasonal variations over different months of the year have been studied. In Europe scholars have detected a global spring peak, a local September peak, and a significant trough during the late fall and early winter with the gap between the peak and the trough being as high as 30 percent. The US pattern is similar except that in the spring there is a peak in deliveries in Europe and a trough in deliveries in the USA. However, the US pattern shows some variation as between different states and even as between blacks and whites. Also, over the past few hundred years, seasonal variations have come down but they still persist, even while the US pattern has come closer to the European one.

A recent study of births in India used National Health Survey data based on the replies given by a sample of women to a question about the month and year of birth of their children (Lokshin & Redyakin, 2009). It found: “The highest birth rates are registered in August, September and October—these children were conceived in winter. The least number of children were born during the winter months of December, January and February—these children were conceived in spring. The wedding season in India, which falls in the months from November to February, could partially explain this seasonality of birth”. Based on data from a rural medical college in India, Bharati et al (2012) found “no significant differences in the frequency of births during various phase of lunar cycle regardless of route of delivery”.

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Significance of the present study

If deliveries exhibit regular patterns or cycles identifiable, this information would definitely be of interest to hospital administrators. In addition, if patterns are observed, this would raise a number of issues connected with the factors underlying the process of human reproduction. Most studies reviewed have concentrated on the link between the lunar cycle and deliveries; this study seeks to investigate three types of periodicity: (i) over different days of the week, (ii) over different phases of the lunar cycle and (iii) over different months of the year. Only two of the studies reported in the journals have used data from India. The present study uses Indian data.

Apart from the age-old ‘theory’ of the connection between births and phases of the moon, the periodicity of births is likely to be influenced by (a) the climatic and geographical factors (b) social customs affecting marriage and reproduction (c) management practices in different hospitals.

Data for most of the studies has been drawn from national/local birth registers which mix together data on deliveries from heads of households and hospitals. In contrast the present study uses data from hospitals which is possibly more accurate on the different kinds of births: full term vs. pre-term, vaginal vs. caesarian. The objective was to identify the cycles, if any, in human deliveries.

Research Approach: It was a retrospective quantitative survey. The data was collected under the supervision of the authors with the help of research assistants from six hospitals in North India, viz. AIIMS, New Delhi; Fatima Hospital, Mau, UP; Holy Family Hospital Kurji, Patna, Bihar; Safdarjung Hospital, New Delhi; St Joseph’s Hospital, Hoshangabad, MP; St Stephen’s Hospital, Delhi.

Sampling technique: Convenience-based choice of hospitals was made. Six hospitals were chosen because of (a) willingness of hospital authorities concerned to provide the data; (b) availability of research assistants who could go through the daily records of deliveries (which are still not computerised) and provide the data to the authors.

Inclusion criteria was (a) all deliveries taking place after 28 weeks of gestation, and (b) all deliveries taking place over the course of one year between 1 October 2010 and 30 September 2011.

Sample size: The number of Live births was 38,790 of which the share of the largest hospital, Safdarjung, New Delhi was 23,616.

Delimitation: The study was delimited to deliveries taking place in the hospital. Also, the data received relates to the number of births, whereas the question of periodicity relates to delivery. There will be a difference between the two to the extent that there are multiple pregnancies; however, the difference is likely to be small since multiple pregnancies account for around 1 in 80 births in India (Datta, 2004).

Results

The data on average number of Live Births, Full term (more than 37 weeks) deliveries, Pre-term (less than 37 weeks) deliveries, Forceps and Vacuum deliveries, Caesarean Births and Normal Vaginal Deliveries (Table 1). Unfortunately, data was not separately available in some of the hospitals, including Safdarjung, regarding Full Term deliveries (above 37 weeks gestation). To make sure that details regarding
the other hospitals were not missed, the birth data for each hospital was studied in detail. The mean number of full term deliveries (all six hospitals taken together) was 106.27 per day and the Standard Deviation was 20.04. The corresponding data for normal deliveries (all six hospitals taken together) was 76.82 and 16.17 respectively.

Chi-squared tests were performed to test the null hypothesis that there was no variation in the number of births on different days of the week. It was found that variations over the days of the week were significantly different (p<0.01) in two of the Hospitals, namely, AIIMS and St Stephen’s both in Delhi. In the other four Hospitals, namely Fatima Mau, Holy Family Kurji Patna, St Joseph’s Hoshangabad and Safdarjung Delhi, the p-values were in excess of 0.15 indicating that in these hospitals the number of deliveries on different days of the week were not significantly different from each other.

Taking the average number of deliveries taking place on each day of the week we obtained a weekday index for each day of the week for each of the series of data. For example, for the series on All Live Births taking place in all the six hospitals together the week day index was: Monday: 0.967062, Tuesday: 1.020627, Wednesday: 1.044514, Thursday: 1.001264, Friday: 1.015396, Saturday: 1.011036, Sunday: 0.940099.

This indicates that Wednesdays were the busiest days for deliveries in these six hospitals with 4.4 percent above normal deliveries and Sundays were the least busy with about 6 percent below normal deliveries.

To check whether the weekly variations in births alone were sufficient to explain the variations we obtained residuals by dividing the original values by the relevant daily index values, and then checked whether the residuals were of the “white noise” type or were exhibiting any patterns. The logic underlying this procedure is that if the residuals or error terms obtained when fitting a model on to time series data are random in the Gaussian sense (expected value of each error term at zero, the Standard Deviation of error terms fixed and Covariance between any two error terms at zero), then this would indicate that the fitted model has more or less explained the variations in the data. To test the residuals we used Bartlett’s Cumulative Periodogram Test for White Noise (Newton, 1996). The general finding was that the residuals were not in the nature of white noise as indicated in Figure 1 which shows that there is a large jump in the periodogram at frequency approximately 0.03 which indicates that there is some cycle of period 1/0.03 or around 30. This led us to investigate whether there is some monthly cycle also within the data.

For this purpose, we divided the original data values e.g. the number of live births by the relevant day index to obtain a new series in which fluctuations on account of the day of the week effect were eliminated; then we calculated the 29 day moving averages of the new series we are able to suppress the variations taking place within a month, thus bringing out the variations taking place over the different months of the year (Figure 2). Deliveries were more frequent between July and December while noticeably less in the months of January, February, April, May and June.

In studying the lunar patterns of deliveries, the major problem is that the lunar cycle does not fit exactly into the diurnal cycle. Therefore it is not possible to specify the particular date on which, say the full moon or the new moon occurs. To take care of this in every lunar cycle
we designate five days as corresponding to the period when the moon is more or less full; similarly five other days are specified in each lunar cycle as days on which the moon is at its lowest visibility, the remaining days are called rising or diminishing days depending on whether the moon was increasing or decreasing in visibility.

We first removed the effect of the weekly cycle from the data by dividing the number of deliveries on each day by the relevant day index. Then we calculated average number of deliveries occurring on each day of the lunar cycle. Figure 3 shows the variation in deliveries during lunar cycle; the evidence on the existence of a lunar cycle is not clear-cut, although there appears to be some kind of pattern.

**Testing for different types of cyclicity using the dummy variable technique:** In order to cross check the above findings we applied the dummy variable technique. We defined a total of 22 dummy variables: 6 dummies for different days of the week; 5 dummies for different phases in the lunar cycle and 11 dummies for different months of the year.

Linear regressions were run for each of the six hospitals. For each regression there were 365 observations. The dependent variable was the number of normal deliveries in the hospital on the relevant date. As explanatory variables we had a total of 22 dummies plus a constant term. The meaning of each of these 22 dummies was as follows:

- **DayDummy1:** refers to Monday, **DayDummy2:** refers to Tuesday, **DayDummy3:** refers to Wednesday, **DayDummy4:** refers to Thursday, **DayDummy5:** refers to Friday, **DayDummy6:** refers to Saturday,
- **MonthDum2:** refers to February, **MonthDum12** and so on, till December.
- **MoonDumD:** refers to the latter half of the diminishing phase of the moon, **MoonDumF:** refers to the Full moon phase, **MoonDumN:** refers to the New Moon phase, **MoonDumR1:** refers to the earlier part of the rising phase of the moon, **MoonDumR2:** refers to the latter part of the rising phase of the moon.

The value taken by the constant term reflects the average number of deliveries in the hospital concerned on a Sunday during the first half of the diminishing phase of the moon in the month of January. The sign and significance of the regression coefficients will provide an indication of the effect of the particular day of week/phase of moon/month (Table 2):

Table 2 shows that monthly variations are clearly established in all the hospitals except AIIMS. The coefficients for the monthly dummies were significant for nine months in the case of Safdarjung, five months in the case of St Stephens', Delhi, Holy Family Hospital, Patna and Fatima Hospital, Mau, and for three months in St Joseph’s Hospital, Hoshangabad. During August - December deliveries in all the five hospitals except at AIIMS, were higher as revealed by positive values of the coefficients of the dummy variables. In most cases, deliveries in these five months were significantly higher. Deliveries were lower during March - May in five of the hospitals, the exception being Holy Family Hospital, Patna.

Overall, it is clear that seasonal patterns exist but they are not the same in all the regions. AIIMS, as an all-India referral hospital does not seem to exhibit any significant monthly variations at all. The reason could...
be that since AIIMS attracts patients from all over India, hence the seasonal patterns characteristic of even the Delhi region does not emerge very clearly. The typical Delhi pattern is evident from Safdarjung Hospital where deliveries are significantly lower in the months of April, May and June and significantly higher in the months of July to December. St. Stephen's Hospital exhibits an almost similar pattern. In the remaining hospitals there are definitely more deliveries in the months of July to December but the deliveries in March, April and May do not exhibit such a noticeable decline in deliveries.

Weekly patterns are particularly noticeable in the three non-Delhi hospitals. A further check was to run a combined regression for all the six hospitals together. In this case, the first dummy variable for the month of April, May and June and significantly higher in the months of July to December. St. Stephen's Hospital exhibits an almost similar pattern. In the remaining hospitals there are definitely more deliveries in the months of July to December but the deliveries in March, April and May do not exhibit such a noticeable decline in deliveries.

For patterns corresponding to the lunar cycle, it can be hypothesised that if they exist, they should be the same for all the hospitals other than Safdarjung. Correspondingly, if there are no common patterns among the six, then it would imply that probably lunar cycles do not exist at all. We examined the signs of the coefficients of the moon dummies. Taking the first of them, namely, MoonDum2, it was noticed that the coefficient is positive in 2 and negative in 4 of the regressions. Similarly, for the second dummy variable, the coefficient is positive in 2 and negative in 4 of the regressions. Finally, for the remaining three dummy variables, the coefficient is positive in 2 and negative in 4 of the regressions. In general, there is a mix of signs and no conclusive evidence for the existence of any type of lunar cycle in human deliveries.

Weekly patterns are particularly noticeable in AIIMS. It may be hypothesised that in these hospitals, there is some kind of formal or informal process at work by which it is ensured that more deliveries take place in the middle of the week, and if that is not feasible, on Saturday, but, preferably not on Sundays. It may be easier to ensure the presence of the full team of medical specialists on weekdays, hence the informal procedure which pushes away Sunday deliveries. Weekly patterns do not seem to be very noticeable in the three non-Delhi hospitals. However, there is some evidence of lunar cycle in the three non-Delhi hospitals, especially in AIIMS. It may be hypothesised that in these hospitals, there is some kind of formal or informal process at work by which it is ensured that more deliveries take place in the middle of the week, and if that is not feasible, on Saturday, but preferably not on Sundays. It may be easier to ensure the presence of the full team of medical specialists on weekdays, hence the informal procedure which pushes away Sunday deliveries.
rather than 5 x 6 = 30 dummies for phase of the moon. The logic underlying this procedure of keeping uniform lunar dummies for all the hospitals was that while there could be grounds for believing that the daily and the monthly pattern varied for different hospitals, the lunar pattern could not reasonably be expected to vary for different hospitals.

The estimates for the coefficients of the lunar phase dummies (Table 3) show that four of the coefficients were not significantly different from zero. The only exception was the coefficient of the dummy for the latter part of the diminishing phase of the moon. Thus the only evidence to indicate some kind of lunar cycle in deliveries is that in the second half of the declining phase of the moon, the number of births was significantly below that in the first half of the declining phase. The evidence in favour of lunar cyclicity thus turns out to be rather weak.

The variations in deliveries during different months of the year can be explained by the Indian custom of marriage taking place primarily in the months of November to March. Births, fertility, rhythms and lunar cycle: A statistical study of 5,927,978 births. J Gynecol Obstet Biol Reprod 1986; 15(3): 265-71

References


