Daily and seasonal variation in live births, stillbirths and infant mortality in England and Wales, 1979–96

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This article describes analyses of live births, stillbirths and early neonatal, late neonatal and postneonatal deaths by day of birth from the early 1980s to the mid 1990s. Using statistical models to analyse daily, seasonal and longer term trends simultaneously, it found a pronounced weekly cycle in live births, with more births on weekdays and fewer births at weekends and also on bank holidays. Stillbirth and early neonatal mortality rates tended to be higher on Saturdays and Sundays respectively, compared with other days. All the mortality rates varied according to the time of year.

Background

By the mid 1960s, a weekly cycle had developed in the numbers of births each day in England and Wales and this became more marked during the 1970s.[1–3] In most weeks, similar numbers of live births occurred from Tuesdays to Fridays, with fewer births on Mondays and Saturdays and the lowest numbers of births on Sundays. Similar patterns have been reported in Australia[4] and the United States,[5, 6] while in Israel there was a deficit in the numbers of live births on Saturdays,[7] which are holidays, while Sundays are working days. Below average numbers of live births occurred on days that were public holidays in England and Wales in the 1970s,[1–3] in the United States[5] and in Israel.[7] It has been suggested that the patterns reflect the impact of obstetric practice, with elective delivery concentrating births onto working days.

Seasonal rhythms of births, with smaller numbers of births in winter compared to summer months, have been apparent for many years in England and Wales, with a small peak in the number of births in September, corresponding to Christmas conceptions.[2,8] Similar patterns have been found in other countries, including the USA[6] and Norway.[9]

It is often thought that the lunar cycle might affect the pattern of births. A peak in the number of live births at the time of the full moon was found in 57 hospitals in New York city during 13 lunar months beginning in January 1 1954.[10] An analysis published in the early 1970s of five hundred thousand live births over a period of three years in New York City, found the birth rate to be above average before the full moon and below average after the full moon.[11] On the other hand, studies elsewhere have shown no evidence of a relationship between the lunar cycle and births.[12]

In the 1970s in England and Wales, the perinatal death rate was found to be higher among babies born at the weekends, compared with those born on weekdays.[13] There were concerns that lower levels in staffing at the weekend may have led to this raised mortality, but no data were available to investigate this. It was also suggested that spontaneous preterm births might have accounted for a higher proportion of the lower numbers of births at weekends and thus would have inflated mortality rates.

Associations between the day of the week of death and postneonatal mortality were found in the 1970s in England and Wales. Cot deaths were found to be more common at the weekends than on weekdays and numbers of deaths ascribed to congenital anomalies were particularly high on Thursdays and Fridays.[13] A later study in New Zealand also found sudden infant deaths to be more common at the weekend and suggested that this may in part be explained by sharing a bedroom with an adult at that time.[14] A more recent analysis of deaths attributed to the sudden infant death syndrome in England and Wales from 1971 to 1998, showed higher rates of postneonatal deaths at weekends and on public holidays than on other days.[15]

Seasonality was a marked feature in postneonatal mortality for many decades,[15, 16] with a greater number of deaths occurring in winter than in summer months. Following the decline in postneonatal mortality between 1988 and 1992, primarily among deaths attributed to sudden death, cause unknown, one article suggested that this seasonality has diminished, if not disappeared,[18] while a subsequent analysis suggested the contrary.[19]

A study of intrapartum deaths in Wales between 1993 and 1995 found that rates were higher for babies born in July and August than among those born in other months.[20] In Scotland during the same period similar patterns were found, but none of the differences were significant.[21]

In this study, ONS data for the 1980s and early 1990s were examined to see if the day of the week pattern was still present in live births. It also considered long term trends, seasonality, and relationships with bank holidays, and how these changed over time. In addition, possible associations with the phases of the moon and selected economic factors was also explored.

Day of the week and seasonal variations and long term trends in stillbirth and deaths in the early neonatal, late neonatal and postneonatal periods were also analysed along with possible associations with bank holidays and broad economic indicators. Since it was unclear whether or not seasonality was still apparent in deaths whose underlying cause was classified as sudden death, cause unknown, it seemed appropriate to study these separately from other postneonatal deaths. Previous studies considered seven day cycles, seasonality and long term trends separately, but this study used statistical models to analyse associations with these and other factors simultaneously.

Data

The numbers of live births and stillbirths in England and Wales on each day were derived from the Office for National Statistics' (ONS) individual records of live births and stillbirths. For consistency over time, only stillbirths at 28 or more completed weeks of gestation were included.

Anonymised individual records of infant deaths during an eleven year period, 1986–96, were made available by ONS. From these, counts of the numbers of children born on each day who died during the early, late neonatal or postneonatal periods were derived. Postneonatal deaths were subdivided, and those whose underlying cause was coded as sudden death, cause unknown (International Classification of Diseases, ninth revision code 798.0) were analysed separately from other postneonatal deaths.

Factors for the day of the week, month of the year and years in the series were derived from the data. In addition, dates of all public holidays over this period were added in. These comprised the Easter period, early and late spring and August bank holidays, Christmas Day, Boxing Day and New Year's Day. Seven factors were created to correspond with bank holidays. Some of these distinguished between bank holidays in the Christmas period and other bank holidays. Others incorporated additional days assigned to be bank holidays when Christmas or New Year fell at the weekend or included days preceding or following bank holidays.

Three variables relating to the lunar cycle were also created. The first was a simple binary variable indicating the days on which there was a full moon. The second was a sine wave which peaked at the full moon and the third was a sine wave which was higher before the full moon and lower afterwards. Both sine waves were created to coincide with the phases of the lunar cycle throughout the period.

Data recorded at death registration include dates of birth and death, but not the times of day. These two dates are used to derive the estimated age at death. This takes the value 0 if the birth and death date were the same, 1 if they were a day apart and so on. This means that an estimated age of one day can, in practice, correspond to actual ages at death which range from just a few minutes to almost 48 hours after birth.

Early neonatal deaths of babies born during the last week of 1996 were not included in any of the analyses, as some babies born in this week did not die until the first week of 1997, data for which were not available at the time of analysis. Similarly, babies born in the last 27 days of 1996 were excluded from analyses of late neonatal deaths and all babies born in 1996 were excluded from analyses of postneonatal deaths.

Two economic indicators were obtained. The monthly counts of claimants on unemployment benefit in the United Kingdom were extracted from the Monthly Digest of Statistics and the GDP deflator on a quarterly basis was supplied by General Expenditure Statistics team in the Data Unit of HM Treasury.

Data were first plotted to see if there were any visible daily patterns, seasonal variations or long term trends in the live births, stillbirth and infant mortality rates. Then they were analysed using the methods summarised in Table 1.

In order to examine associations between numbers of live births and the factors mentioned above, log linear models were fitted, as is appropriate for data with a Poisson distribution. A suitable population at risk was not available on a daily basis for use as a denominator, so it was decided to analyse the numbers of live births rather than any form of rate. In addition to examining the seasonality by fitting log linear models with a factor for each month, cosinor analysis[22] was applied to the monthly totals of live births, as they appeared to follow a sinusoidal pattern. The cosine model was fitted to each year separately, making it possible to identify changes in seasonality over the period. To analyse stillbirths and death rates at various stages of infancy, logistic regression was used, as this is appropriate for data with a binomial distribution.

The numerators and denominators are shown in Table 2. In order to form a conditionally independent analysis, the denominator used for the late neonatal deaths was the number of live born babies who survived the early neonatal period, and were therefore at risk of dying in the late

Table 1 **Methods of analysis**

Method of analysis	Data	Description of method	Application
Log linear	Counts of daily live births	Regression for discrete dependent variable	Examination of day of week patterns, fluctuations on bank holidays, seasonality and long term trends in the count of live births, and any changes in the above patterns over the series via interaction terms in the models.
Cosinor	Counts of daily live births	Examine sinusoidal patterns in data	Examination of seasonality in the number of daily live births for each year individually, finds yearly maxima and percentage deviation below and above each maximum.
Logistic regression	Stillbirth, early and late neonatal and postneonatal death rates	Regression method appropriate for data with a binomial distribution	Examination of day of week patterns, fluctuations on bank holidays, seasonality and long term trends in the death rates and stillbirth rate, and any changes in the above associations over the series.
Akaike information criterion	All data	Criterion for whether dropping a term from a model is beneficial	Determination of the appropriate model for the data.
Residual deviance and Null deviance	All data	Judging the degree of matching of the model to the data when the parameter estimation is carried out by maximising the likelihood as in generalised linear models.	Used in conjunction with the AIC to assist in selecting the appropriate model for the data. Gives the proportion of variation explained in data by the model selected.

neonatal period. Similarly the denominator for postneonatal deaths was restricted to live born babies who survived the neonatal period.

The data were analysed using the SPLUS package, version 4.5. This has an automated procedure for selecting models, using an approximation to the Akaike Information Criterion (AIC).[23] Models were conducted in two steps. Firstly a model was chosen using the automated stepwise procedure to add or delete variables from the model. Second a partially subjective approach was applied, to both the addition and removal of variables as well as certain interactions. The latter approach selected models by a combination of their residual deviance and their parsimony.

Results

The models selected are shown in Table 4, along with their residual and null deviances. The findings are summarised in Table 5 and described more fully below.

Live births

The numbers of live births in England and Wales on each day of the whole period 1st January 1979 to 31st December 1996 are shown in Figure 1. Each day's total has been plotted and the points joined consecutively. Triangles and squares indicate Christmas Day and Boxing Day in each year. Overall the numbers of births decreased up to 1983, then increased up to 1990 and decreased up to 1995 before levelling off in 1996, possibly as a consequence of the 'pill scare' in 1995.[24] The overall average number of live births each day during the period was 1,814, with the maximum, 2,278, occurring on 18th September 1990 and the minimum, 1,123, on the 26th December 1979. There was a clear seasonal pattern in the number of daily live births throughout the entire period, with lower numbers of births in the winter than the summer months. In each year, the lowest number of births occurred either on Christmas Day or on Boxing Day, usually the latter. The average daily number of births on Boxing Day was 31 per cent below the overall daily average for the period.

Figures 2 and 3 show and compare data for the first and last years of the period. The total number of daily live births in England and Wales in 1979 is shown in Figure 2. The filled squares correspond to bank holidays. There is an obvious seven day cycle, with fewer births on Sundays compared with births on other days of the week. The average number of births on a Sunday during 1979 was 1,373, with a standard deviation of 60, whereas the overall daily average in 1979 was 1,748, with a standard deviation of 211. In general, there were fewer births on bank holidays compared to other days. A discontinuity in the usual weekly pattern occurred at the end of 1979. This was because in the final week of the year, the fewest births, 1,123, occurred on Boxing Day, which was a Thursday, while on the Sunday there were 1663 live births. In addition to the seasonal pattern seen in Figure 1, there also appears to be a peak in the number of births in the latter part of September.

Table 2 **Definitions of numerators and denominators used in analyses**

Rate	Numerator	Denominator
Stillbirth	Number of stillbirths	Number of live births plus number of stillbirths on same day
Early neonatal	Number born alive who died from 0 to 6 days after birth	Number of live births on the day of birth
Late neonatal	Number of babies born on a particular day who died from 7 to 27 days after birth	Number of live born babies who survived the early neonatal period
Postneonatal	Number of babies born on a particular day who died from 28 days but under a year after birth	Number of live born babies who survived the neonatal period

Figure 1 Daily live births, England and Wales, 1979–96

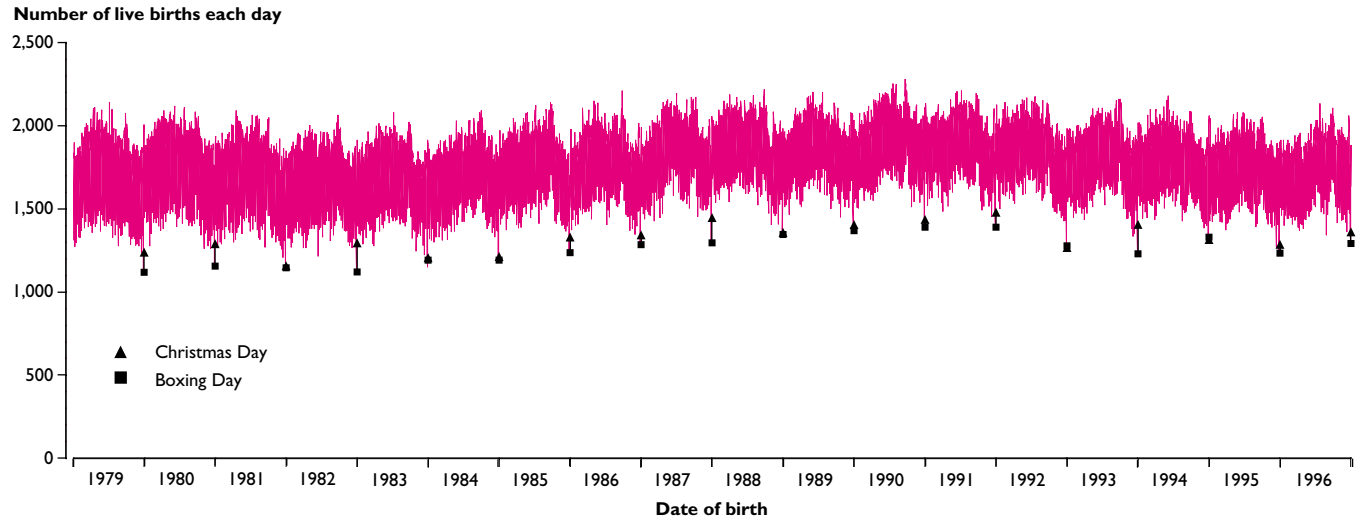


Figure 2 Daily live births, England and Wales, 1979

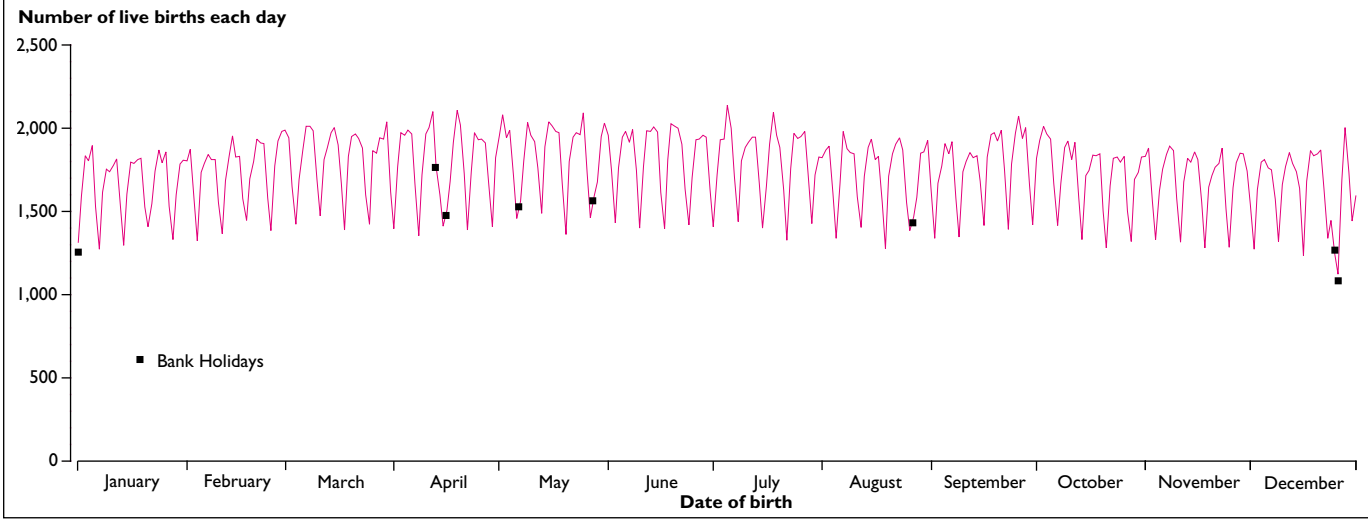
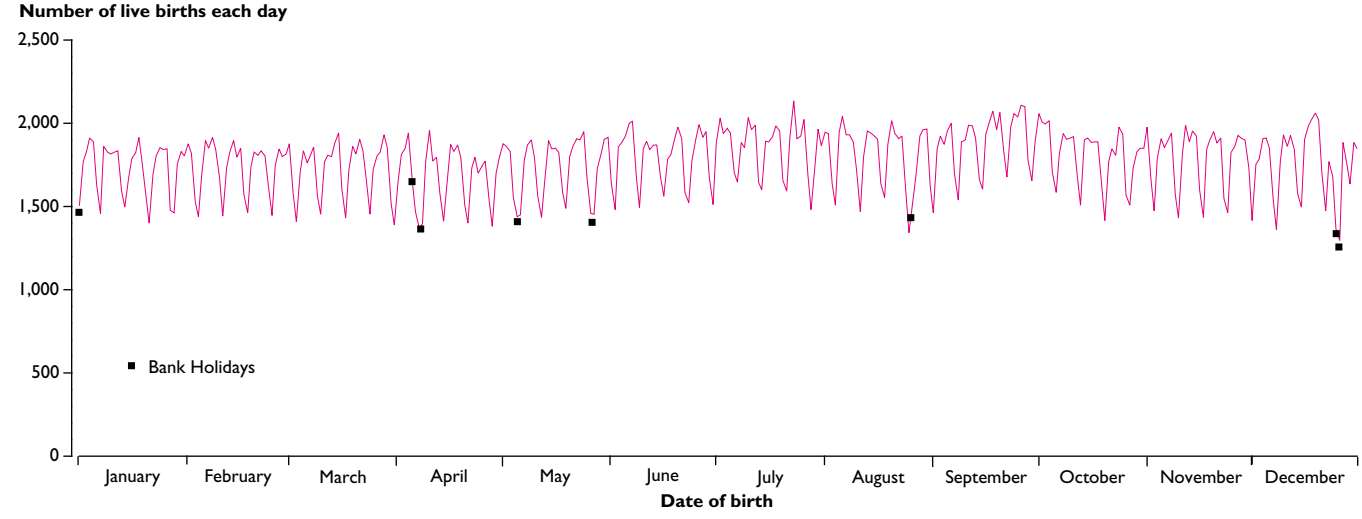


Figure 3 Daily live births, England and Wales, 1996



The weekly pattern in live births and the deficit on bank holidays was still present in 1996, and took a similar form to that in 1979, as shown in Figure 3. The variation in the daily rates appeared to be smaller in 1996 than in 1979. Figure 3 also shows higher numbers of live births in the week prior to Christmas, compared with preceding weeks. Similar excesses were also evident in several other years.

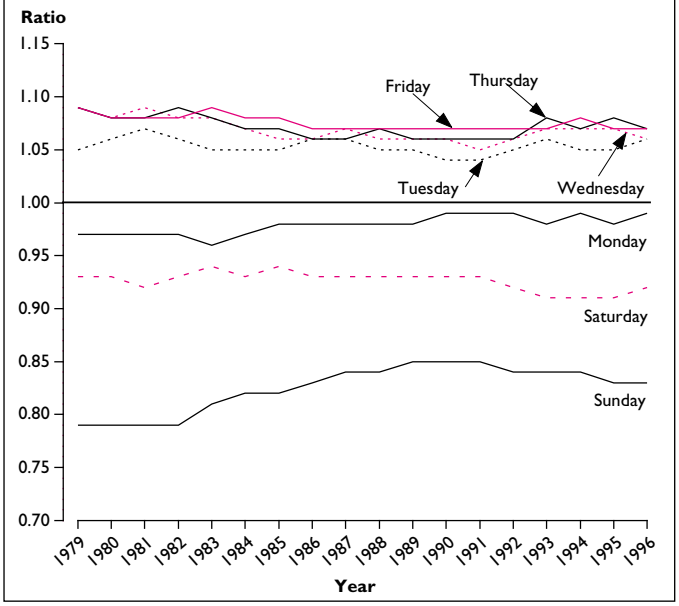
The weekly cycle is summarised in Figure 4, which shows the ratio of the average daily live births on each day of the week, to the overall yearly average for the years 1979–96. In each year, the average numbers of live births on Mondays, Saturdays and Sundays were consistently lower than the overall yearly average. The average for Tuesday to Friday was always above the overall yearly average. From 1979 to 1990, the relative difference between the number of live births on Sunday and the overall number of live births decreased. In contrast, from 1991 to 1993, the relative difference between the average births on Saturday and the overall yearly average increased.

Statistical model

The final model chosen for the live births contained factors for the day of the week, month and year and two variables relating to bank holidays, as shown in Table 4. In addition, the two sine wave variables relating to the lunar cycle were included along with the variables for the GDP and unemployment. Three interactions were included, one between bank holidays and days of the week, another between day of the week and year, and the third between month and year. The residual deviance for this model was 11,022, on 6,184 degrees of freedom, a reduction of 92.5 per cent compared with the null deviance. In other words the model explained a large proportion of the original variation in the daily live births.

This analysis confirmed the existence of a seven-day cycle, with fewer births on Sundays, and a concentration of births from Tuesday to Thursday and a slight narrowing of these differences after 1984. There was significant evidence that fewer births tended to occur on bank holidays compared with other days, and also an indication that the days before bank holidays had higher numbers of births compared with other days, though this was not true for all bank holidays. If a bank holiday occurred at the weekend, then the numbers of births were in general even lower than for a bank holiday or a weekend alone, but the decrease was by less than the sum of respective bank holiday and weekend factors. Only Christmas Day, Boxing Day, or New Year's Day can occur at a weekend.

Figure 4 Ratio of the average live births on each day of the week to the overall yearly average



The analysis also confirmed that there were fewer live births in the winter months than in the summer months, regardless of the year, and that numbers also peaked in September, corresponding to Christmas conceptions. For each year of the series, the monthly maximum for the live births occurred between May and August. Although there was clear seasonality in all of the years, the deviation below the average monthly live births was never more than 10 per cent in any year and the deviation above the mean was never more than 7 per cent. The two methods of analysis indicated that seasonality had remained constant over the period.

Two variables relating to the lunar cycle were also included in the model. As both took the form of sine waves, but each peaked at a different time in the lunar cycle, it is hard to interpret their association with the numbers of live births and it is likely that these are chance findings rather than indicators of a possibly causal association.

Stillbirths and infant deaths

Trends

There was an obvious decline in the stillbirth rate over the period from 1979 to 1996, with the steepest decline being between 1979 and 1983, as shown in Figure 5. In 1979, the stillbirth rate was 8.0 per 1000 total births, with a standard deviation of 2.3. By 1996 it had fallen to less than half the average rate for 1979 and was 4.0, with a standard deviation of 1.6.

The early neonatal rate clearly declined during the period from 1986 to 1996, as shown in Figure 6, though not as dramatically as the stillbirth rate. In 1986, the average daily rate per 1,000 live births was 4.3, whereas in 1996 the average daily rate was 3.1, a decrease of approximately 27 per cent. For the period 1986 to 1989 there was significant evidence of a general decline in the early neonatal mortality rate. This appeared to continue from 1990–96, but the decrease was not significant.

The rate of late neonatal deaths, shown in Figure 7, was lower than the early neonatal rate, and there were a number of days of birth for which there were no late neonatal deaths. The analysis detected a decline in the late neonatal rate over the period. By 1996 the average daily late neonatal birth cohort rate was 0.8 with a standard deviation of 0.7, a reduction of 25 per cent on the average rate for 1986.

The clear decline from 1986 to 1995 in the daily birth cohort rate of postneonatal deaths with underlying cause coded as sudden death, cause unknown is shown in Figure 8. In 1995, the average daily rate was 0.52 per 1,000 adjusted live births, with a standard deviation of 1.07. This was 74 per cent lower than the average daily rate for 1986. Among other postneonatal deaths the rate fell over the period from 1986 to 1995, as shown in Figure 9, although this was not as prominent as the decline in the rate of deaths recorded as sudden death, cause unknown. The rate per 1,000 adjusted live births was 2.2 in 1995 with a standard deviation of 1.2, a reduction of 31 per cent on the 1986 rate.

Figure 5 Daily stillbirth rate, England and Wales, 1 january 1979 to 31 December 1996

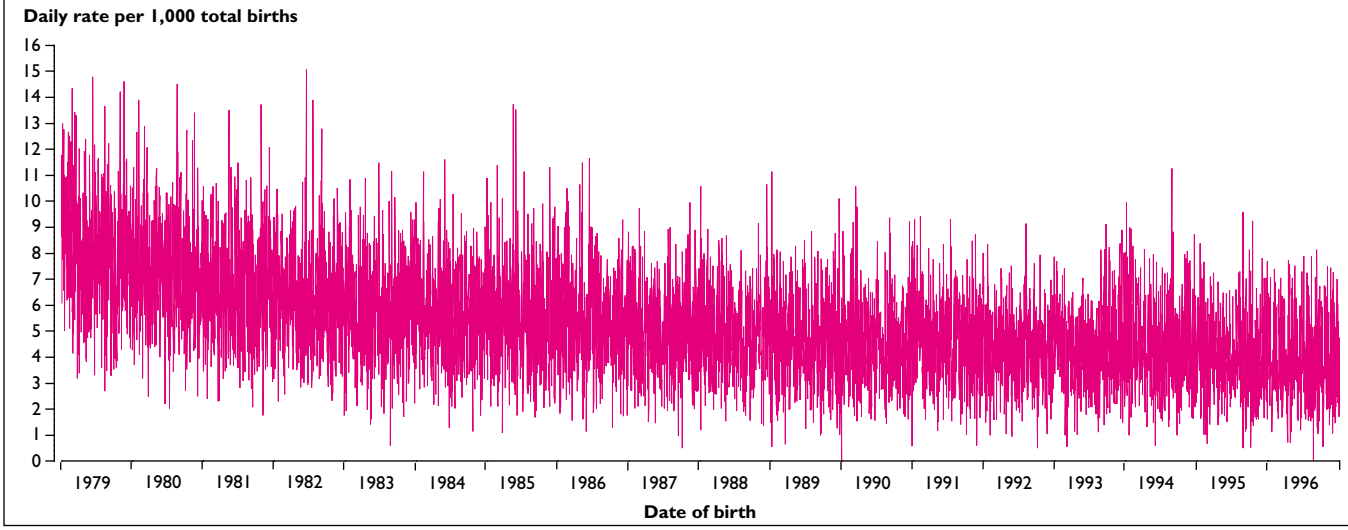


Figure 6 Birth cohort early neonatal death rate, England and Wales, 1 January 1986 to 25 December 1996

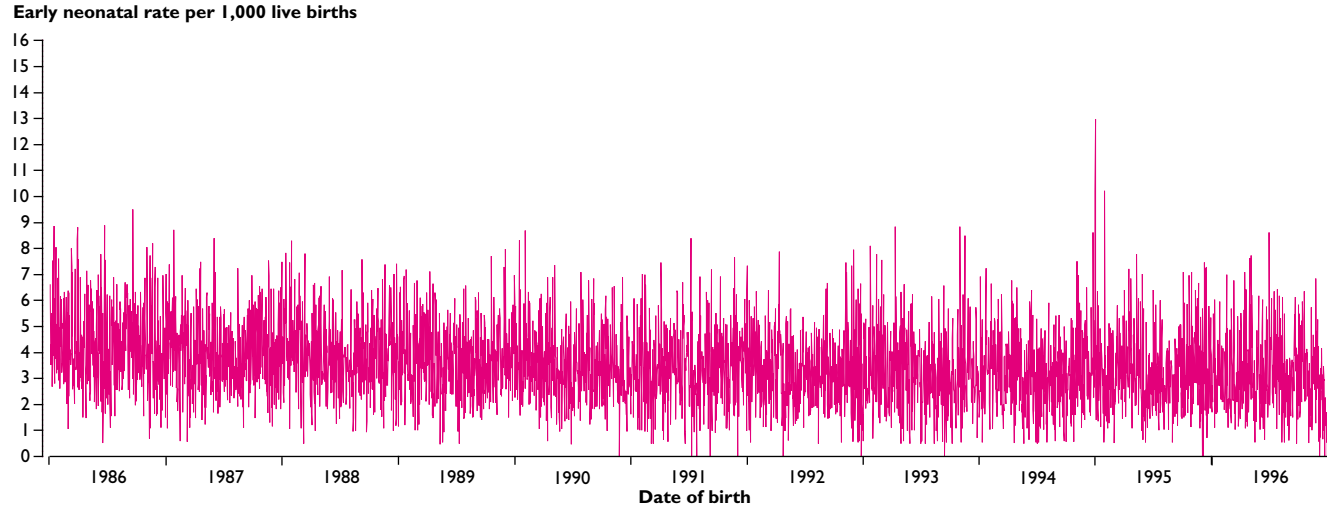


Figure 7 Birth cohort late neonatal mortality rate, England and Wales, 1 January 1986 to 31 November 1996

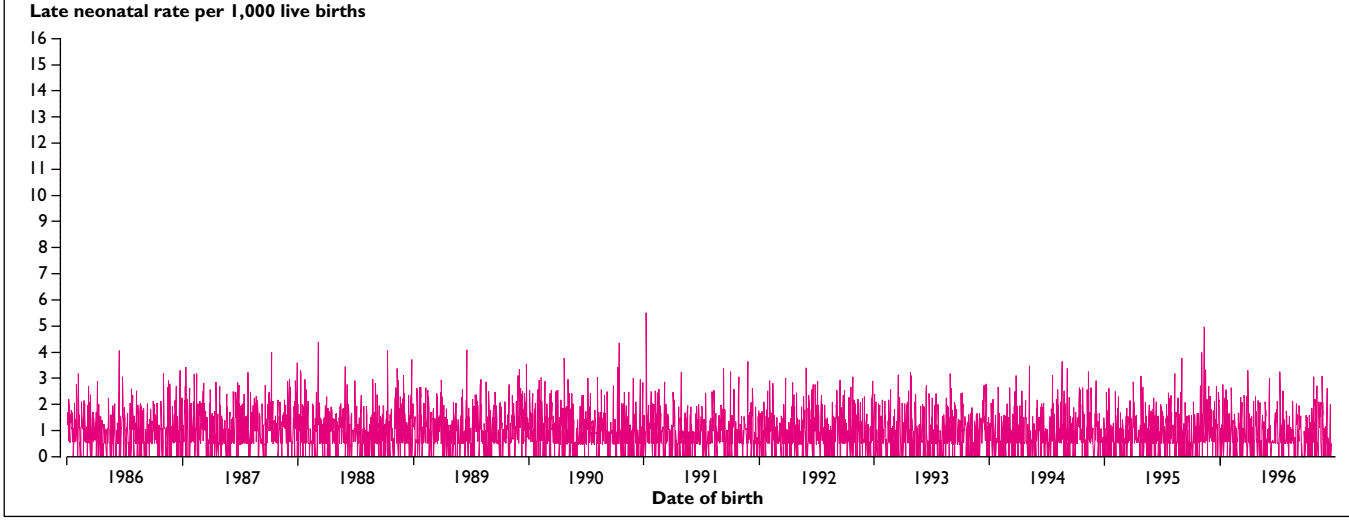


Table 3 **Age distribution of early neonatal deaths by day of the week of birth**

Day of the week of birth	Estimated length of life, days						
	0	1	2	3	4	5	6
	Percentage of the early neonatal deaths among babies born on a given day						
Monday	43.0	21.9	13.1	9.3	5.4	4.2	3.2
Tuesday	43.4	22.1	13.7	8.9	5.1	3.3	3.6
Wednesday	44.6	22.5	13.9	7.1	4.9	3.8	3.2
Thursday	44.3	22.2	12.3	7.7	5.4	4.3	3.5
Friday	45.5	22.1	12.8	8.0	5.0	3.9	2.8
Saturday	46.5	21.9	11.9	7.2	5.0	3.7	3.8
Sunday	47.6	22.0	12.2	7.2	4.8	3.8	2.3
All days	45.0	22.1	12.8	7.9	5.1	3.9	3.2

evidence of above average late neonatal or postneonatal death rates for babies born on bank holidays, except for a very slight indication of a higher postneonatal mortality rate attributed to sudden death, cause unknown among babies born on bank holidays.

Seasonality

No seasonality in the stillbirth rate is visible in Figure 5, possibly because of the width of the variation in the daily rates. Despite this, there was an indication that the stillbirth rate was higher in the winter than in the summer, with the highest rate being in January. Seasonality was also detected in the early neonatal mortality rate, which was higher for babies born in December and January than for babies born in the summer months. This pattern did not diminish over the period studied. In some of the years there was a suggestion of a higher early neonatal mortality rate for babies born in August.

Seasonality was also apparent in the rate of late neonatal deaths. On average the rate was higher for babies born in winter than for those born in summer. This may arise from differences in risks according to the season of death, the season of birth, or a combination of both of these. If the result were due to the former, rather than the latter, the risk period would be moved forward between 7 days and a month.

Seasonality was apparent in both groups of postneonatal deaths. For deaths attributed to sudden death, cause unknown, the seasonality was not constant over time. From 1986 to 1990 the rate appeared to be highest among babies born in October, and generally higher among babies born between August and December than among those born in the first half of the year. During 1991, the seasonality was masked by the steep decline in the rate. From 1992 to 1995 there was still seasonality in the birth cohort rate, although less marked than in earlier years. The main feature was that the rate appeared to be highest for babies born in August, though not conclusively so.

There was no evidence that the seasonal pattern in the other postneonatal deaths changed over the period studied. It appeared to be higher for babies born in the later months of the year compared to the earlier months. In particular, the rate appears to have been highest for babies born in November and December. There is also a suggestion that it was higher for babies born in August than for those born in the following months.

Table 4 **Results of model fitting**

Rate	Main effects	Interactions	Null deviance	Residual deviance
Live births	Day of week Month of year Bank holidays Two sine waves for the lunar cycle GDP Unemployment	Bank holidays and day of week Day of the week and year Month and year	147,938 on 6,574 df	11,022 on 6,184 df
Stillbirths	Day of week Month of year Bank holidays other than Christmas and Boxing Day Year of series	-	9,555 on 6,574 df	6,774 on 6,539 df
Early neonatal	Bank holidays Month Day of the week GDP	Day of the week and bank holidays Month and year	4,920 on 4,010 df	4,437 on 3,866 df
Late neonatal	Month GDP Unemployment	-	4,911 on 3,990 df	4,845 on 3,977 df
Postneonatal, sudden death, cause unknown	Month Year	Month and year	6,577 on 3,651 df	4,033 on 3,532 df
Postneonatal, other causes	Day of week Month GDP	-	4,285 on 3,651 df	4,011 on 3,633 df

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Table 5 **Summary of results**

	Day of week	Bank holidays	Seasonality
Live births	Fewer on Sundays, concentrated from Tuesday to Thursday.	Lower numbers of live births on Bank holidays, least on Boxing Day followed by Christmas Day.	Fewer live births in winter than in summer, peak in September.
Stillbirths	Higher on Saturdays, fewer on Mondays.	Higher stillbirth rate on bank holidays.	Higher for babies born in winter than in summer.
Early neonatal	Higher on Sundays, fewer on Tuesdays.	Higher early neonatal rate on bank holidays.	Higher for babies born in December and January than in summer, indication of higher rate for babies born in August.
Late neonatal	No evidence of a seven day cycle.	No evidence of a higher rate for babies born on bank holidays.	Higher for babies born in winter compared with summer.
Postneonatal, sudden death, cause unknown	No evidence of a seven day cycle.	Slight indication of higher rate for babies born on bank holidays.	From 1986 to 1990 higher for babies born August to December, compared with earlier months. From 1992 to 1995 higher for babies born in August.
Postneonatal , other causes	Higher on Tuesdays, fewer on Saturdays.	No evidence of a higher rate for babies born on bank holidays.	Higher for babies born in later months of year compared with those born in earlier months.

Discussion

It seems unlikely that the weekly cycle in the live births resulted from any weekly pattern of conceptions being carried forward to the time of birth. A more likely explanation is that it and patterns seen on bank holidays reflected obstetric practice. Information about methods of onset of labour and of delivery are not recorded at birth registration, but data from the Maternity Hospital Episode Statistics about births in England in 1994–95 have been analysed by day of week and method of onset of labour.[25] This showed particularly marked deficits in births at weekends in elective caesarean sections and births following induced labour. Among elective caesarean sections, only 2.2 per cent occurred on Sundays and 3.0 per cent on Saturdays. Births following induction of labour were least common on Sundays, below average on Mondays and Saturdays and most common on Thursdays and Fridays.[25] Analyses of data from the US, from 1989 to 1997 showed that repeat caesareans and induced vaginal births were much more likely to occur on weekdays than at weekends.[6] The disparity between weekday and weekends for all births increased over the period, despite the general decline in the induction rate.

Analyses of birthweight by day of the week were not included in this study, as some birthweight data were missing before 1983 and from 1989 to 1994.[2] There were some signs that low birthweight births accounted for a slightly higher proportion of births at weekends compared with weekdays in the early 1980s. This was not the case in the late 1980s and early 1990s.[26] It is unlikely, therefore that differences in the incidence of low birthweight accounted for the higher early neonatal rate on Sundays in comparison to other days. This suggests that other factors may have contributed.

Although no seven day cycle was found for the late neonatal deaths, this may be because the numbers of late neonatal deaths were small, or because of the considerable time which had elapsed between birth and death for late neonatal deaths. In the case of postneonatal deaths attributed to causes other than sudden death, cause unknown, some evidence was found of a weekly cycle, despite the even longer time period between birth and death, but the maximum fell on Tuesdays rather than at weekends. This could possibly be an indirect association with the day of the week of death, but as this is mathematically confounded with the day of the week of birth, the day of the week of death, and the length of life, it is impossible to distinguish the key factor in analyses of this type.

During the 1980s and early 1990s the early neonatal death rate was higher for babies born in December and January, compared with those born in summer. There was also an indication of a higher rate of neonatal deaths for babies born in August compared to preceding and succeeding months. A study which showed a high rate of intrapartum deaths among babies born in Wales in August pointed out that this is the month when junior medical staff take up new posts and suggested that "At these times, junior medical staff may be less well supervised and perinatal services may rely more heavily on locum staff employed to cover annual leave".[20] As with day of the week variations, more detailed local studies are needed to investigate this further as the information required is not recorded at birth and death registration.

Previous studies of seasonality have analysed the rate of sudden infant deaths according to the month of death and found considerable variation up to and including the 1980s. Two studies of deaths in England and Wales in the early 1990s attributed to the sudden infant death syndrome reached conflicting conclusions about whether there were seasonal variations after the fall in the cot death rate at the end of the 1980s. Our analyses showed that seasonal differences persisted into the early 1990s, even though their form had altered. Between 1992 and 1995, the rate of deaths attributed to the sudden death, cause unknown was highest for babies born in August, but this is likely to reflect the age distribution of these deaths and increases in risks of death during winter months among babies born in the summer. In order to consider possible reasons for these associations, further analysis and additional data, for example weather data, would be needed. Earlier analyses, using different analytical approaches, found associations between cot deaths and low temperature.[27,28]

The model suggested an inverse association between both unemployment and GDP at the time of conception and numbers of births. It is unlikely that these associations are causal, as the trends in GDP and unemployment at this period were broad, rather than showing complex patterns. While there was an association between late neonatal deaths and the GDP, there is no way of knowing whether this was causal, or a consequence of changes of other factors. Unexpectedly, perhaps, higher unemployment was associated with a lower rate of late neonatal death, although the association was not very strong and could reflect independent long-term trends in both variables.

The data described in this article relate to a past period from 1979 to 1996. Some of the patterns described were already apparent in the 1970s and are therefore likely to be still present while others indicate a situation which could be changing. Data for years since 1996 should therefore be examined to see if any new patterns have emerged.

Conclusions

This study showed that the seven day cycle seen in live births during the 1970s persisted in the 1980s and the early 1990s. The form of this cycle altered marginally over the period 1979–1996, with a slight reduction in the difference between the average daily births on Sundays and weekdays after 1984 compared with before. The deficit in births on bank holidays in the 1970s was still evident during the 1980s and early 1990s. In addition, there appeared to be higher than average numbers of live births on the days immediately before bank holidays. The numbers of live births also showed a seasonal pattern, with fewer births in the winter compared to the summer and a separate peak in September.

The stillbirth, early, late neonatal and postneonatal mortality rates all declined during the period considered. For the stillbirth rate, the period of steepest decline was between 1979 and 1993.

There was evidence of a seven day cycle in the stillbirth rate. In general the rate was lowest on Mondays and highest on Saturdays. The early neonatal death rate was highest for babies born on Sunday compared to other days of the week. For late neonatal deaths and for postneonatal deaths with underlying cause coded as sudden death, cause unknown, there was no association between death rates and days of the week of birth. There was a weak association between the day of the week of birth and the postneonatal rate for causes other than sudden death, cause unknown.

Stillbirth rates were relatively high on bank holidays during the years 1979–1996. There was also weak evidence that early neonatal rates were higher for babies born on bank holidays than for babies born on other days. There was also an indication that early neonatal mortality rates were higher among babies born in August, compared with other months. If these patterns are still apparent in more recent data, further research is needed to investigate possible explanations.

Over the period from 1979 to 1996, the stillbirth rate was higher in January and lowest in September, but there was no evidence to suggest that the form of the seasonal variation had changed over time. During the late 1980s and early 1990s, the early neonatal death rate was higher for babies born in December and January than for those born in summer. There was also a seasonal pattern in the late neonatal mortality rate between 1986 and 1996, with a higher rate for babies born during winter compared to summer months.

Postneonatal mortality attributed to sudden death, cause unknown showed evidence of seasonality throughout the whole period 1986–1995. During the earlier half of the series there was evidence of a higher rate for babies born between August and December, with the rate being highest for those born in October. During the latter half of the period the form of seasonality altered and from 1992 to 1995 the rate was highest for babies born in August. There were also seasonal patterns in postneonatal deaths attributed to other causes, with a higher rate in November and December than in other months.

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Key findings

- The seven day cycle in live births found in the 1970s, with fewer births on Sundays and a concentration of births from Tuesday to Thursday, persisted during the years 1979 to 1996. The relative difference between numbers of live births on Sundays and the overall daily average narrowed between 1979 and 1990. The stillbirth rate followed a seven day cycle over the whole period, being generally lower on Mondays and highest on Saturdays. It was also relatively high on bank holidays.
- Over the years 1986–96, early neonatal mortality rates were higher for babies born at the weekends compared with those born on Mondays, Tuesdays and Wednesdays.
- Fewer live births took place in the winter months than in the summer months over the period 1979 to 1996, and numbers of live births in late September.
- Seasonal variation was found in the stillbirth rate and in death rates at all stages of the first year of life. Stillbirth rates and late neonatal mortality rates were, in general, higher in the winter months, and early neonatal mortality rates were high for babies born in December and January compared with babies born in summer months.
- Patterns of seasonality in postneonatal deaths attributed to sudden death, cause unknown changed between 1986 and 1995. From 1986 to 1990 the rate appeared to be higher for babies born between August and December and highest for babies born in October compared with the first half of the year. From 1992 to 1995, after a drop in overall mortality, seasonal variation was still apparent in the rate, which was highest for babies born in August.
- There was also seasonal variation between 1986 and 1995 in other postneonatal deaths, with a higher rate for babies born in November and December compared with those born in the earlier months of the year.

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