Births and their outcomes by time, day and year: a retrospective birth cohort data linkage study

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Scientific summary

A retrospective birth cohort data linkage study

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Background

In recent years, a succession of analyses showing raised mortality among patients admitted to hospital at weekends has been published, and 'weekend effects' have been prominent on the policy agenda in England. Maternity and neonatal services have always had to operate 24 hours a day, 7 days a week. Analyses of births and their outcome by time of day and day of the week have a long history and are important for informing staffing arrangements and monitoring outcomes.

Studies of daily variations in numbers of births in England and Wales from the 1970s onwards found a pronounced weekly cycle, with numbers of births per day being lowest on Sundays, followed by Saturdays, and highest from Tuesdays to Fridays. Numbers of births were low on public holidays, with Christmas Day and Boxing Day having the lowest numbers of births in each year.

These analyses did not include data about the time of day of birth, as in England and Wales this was not included in routine national data systems until 2005. It has long been established in local analyses, however, that numbers of spontaneous births varied by time of day and were higher at night than during the day.

Overall patterns of birth have changed with the rise in rates of obstetric intervention. The rising rates of elective caesarean section have concentrated increasing numbers of births on to weekday mornings while the rationale for increasing rates of induction in the 1970s was to concentrate births into daytime hours.

This is the first national analysis of births by time of day as well as day of the week in England and Wales. We aimed to explore the implications of patterns of birth and its outcomes for NHS maternity and neonatal services, using administrative data for births in England and Wales in the early years of the 21st century.

Objectives

To build on work done in a previous project to link data from civil registration, notification of birth to allocate NHS Numbers to Babies and data about care during labour and birth and to analyse these linked maternity and neonatal data for England and Wales about births in the years 2005–14 to answer the following questions:

1. How do numbers of births vary depending on time of day, day of the week and time of year of birth and how does this relate to methods of onset of labour and delivery and multiplicity?
2. Subject to the availability of data, how do patterns of birth vary between maternity services in relation to variations in medical and midwifery staffing, patterns of intervention and size of unit?
3. How does the outcome of pregnancy in terms of rates of cause-specific intrapartum stillbirth and neonatal and infant mortality rates and rates of morbidity recorded at birth and at hospital admission in the first year of life vary depending on time of day, day of the week and time of year in relation to gestational age, and intervention in the onset of labour and delivery?
4. Have the patterns observed changed over the period 2005–14?

Methods

In the project, we had access to patient identifiers such as NHS number, date of birth and postcode. These key data items enabled linkage of three national datasets on births in England and Wales. The data therefore had to be held in the secure environment of the Virtual Microdata Laboratory (VML), now known as the Secure Research Service (SRS) at the Office for National Statistics (ONS).

Data sources

When a baby is born in England and Wales, data are recorded in several separate information systems. When babies' parents register the birth, mainly sociodemographic data, such as date of birth, sex, place of birth, parents' country of birth and usual place of residence, are collected. A smaller set of data, including gestational age, time of birth and the baby's ethnicity, is recorded when the birth is notified by the midwife so that the baby can be allocated a NHS number, a unique identifier, at birth. Birth notification data have been routinely linked to birth registration data since 2005 by the ONS and we have described these linked data as 'ONS birth records'. The ONS provided these linked records for births occurring from 2005 to 2014 in England and Wales.

The ONS also provided death registration records for all deaths of babies and children born from 2005 to 2014, linked routinely to their corresponding birth records. Deaths of women within a year of giving birth had also been linked to the corresponding births by ONS for use in confidential enquiries into maternal deaths, and these were provided for 2008 onwards.

Data about care during labour and birth are recorded in the Hospital Episode Statistics (HES) if the birth occurs in England or in the Patient Episode Database for Wales (PEDW), which is linked to the National Community Child Health Database (NCCHD). HES and PEDW collect data about all hospital admissions, including maternity episodes. Birth registration and notification records were linked to Maternity HES by the Health and Social Care Information Centre (HSCIC), now known as NHS Digital, and to NCCHD and PEDW by NHS Wales Informatics Service (NWIS).

The Centre for Maternal and Child Enquiries (CMACE) collected data on all stillbirths and neonatal deaths up to 2010. The CMACE data for England and Wales from 2005 to 2009 were linked to stillbirth registration records to distinguish between antepartum and intrapartum stillbirths, as this information is not available reliably in the ONS stillbirth registration dataset. Data for 2010–14 were not available.

Data linkage

Records of 6,676,912 births in England were linked to the HES delivery and birth records by HSCIC using a combination of patient identifiers such as NHS number, date of birth and postcode, using an algorithm similar to that used by HSCIC to link death registration records to HES. Similarly, 336,892 births in Wales were linked to NCCHD and PEDW records.

A probabilistic linkage algorithm was developed to link CMACE stillbirths in 2005–7 to birth registration records using common data items, such as day and month of birth, age of mother, and time and place of birth. CMACE data for 2008 and 2009 included registration details that are also recorded on the stillbirth registration records, so these data were linked by the ONS.

Records of subsequent admissions of mothers and babies were linked by HSCIC and NWIS to HES and PEDW records.

Quality assurance of linked dataset

Linkage of ONS birth records to HES delivery records was quality assured and duplicate delivery records were discarded along with records that were incorrectly linked. A stepwise procedure was developed to look at common data items in the ONS birth records and HES delivery records to check if the linked record referred to the same baby. If there was more than one linked HES delivery record to choose from, the

record with the fullest onset of labour and mode of birth information was chosen, as these variables were of key importance for the analysis.

National database of births and childhood deaths

A relational database was built by bringing together national data on births and infant and childhood deaths for England and Wales for 2005–14 and HES data for England, including birth, delivery and readmission records for mothers and babies. Because of the structure of the database and storage of data on Structured Query Language (SQL) server in the VML, it is now possible to undertake complex analyses with relatively little processing time.

Results

Data linkage

For births in England, over 90% of ONS birth records were linked to HES delivery records. This improved over time, although there were issues with the quality of linkage. More than 99% of ONS birth records of births in Wales were linked to the NCCHD and 95% of these records were also linked to PEDW records. Nearly 90% of CMACE records were linked to stillbirth and neonatal death registration records for 2005–9.

Quality assurance

Of the total 6,468,586 ONS singleton birth records in England, 97% had been linked to one or more HES delivery records and the linkage could be quality assured. Of these, 98% remained linked to one HES delivery record and 2% had all HES links discarded after quality assurance. Ninety-five per cent of all ONS singleton birth records overall were left with a link to a HES record for analysis.

Of the 208,326 ONS multiple birth records, 95% were linked to one or more HES delivery records and the linkage could be quality assured. Of these, 98% remained linked to one HES delivery record and 2% had all HES links discarded after quality assurance. Ninety-three per cent of all ONS multiple birth records overall were left with a link to a HES record for analysis.

The quality assurance procedure took the equivalent of 55 working days for singleton births and 16 days for multiple births.

The quality of linkage of ONS births records in Wales to PEDW and NCCHD was good so, no formal quality assurance was required.

Variations in overall numbers of births in England and Wales by time of day and day of the week

Over the period 2005–14, the overall numbers of births in England and Wales showed the same pattern as in preceding years, with a regular weekly cycle, with the numbers of births each day increasing from Mondays to Fridays, lower numbers on Saturdays and the lowest numbers of births on Sundays. This pattern was interrupted by public holidays, with the lowest numbers of births in most years being on Christmas Day and Boxing Day. In addition, numbers of births varied seasonally, with a peak in late September.

The patterns of birth by time of day varied little over time in early years, with the exception of a peak in numbers of births from 10.00 to 10.59, which broadened out in later years to cover the time period from 09.00 to 11.59. Smaller peaks early and late in the afternoon had become less prominent.

Numbers of singleton births in hospitals with obstetric units peaked in the mornings from 09.00 to 12.00. After a much smaller afternoon rise, numbers decreased from 17.00 to 20.00, then increased again from 20.00, reaching a maximum number in the early hours of the morning, before falling again from 06.00 onwards. Numbers of singleton births in freestanding midwifery units (FMUs) and at home were highest

from midnight to 07.00, peaking from 04.00–06.00. They were lowest during the day and during the hours up to midnight. Births in military hospitals had a sharp peak at 08.00 and private hospitals had morning peaks followed by early and late afternoon peaks.

The small numbers of births that occurred either in hospitals without maternity units or 'elsewhere' are unlikely to have occurred there intentionally. Births in non-maternity units tended to occur during mornings whereas those 'elsewhere' followed similar patterns to births at home and in FMUs, although with a flatter peak from 04.00–08.00.

Births in NHS hospitals in England by onset of labour and method of delivery

The timing of singleton births by time of day and day of the week varies considerably by onset of labour and mode of birth. Births after spontaneous onset and spontaneous birth were more likely to occur between midnight and 06.00 than at other times of day. Elective caesarean births were concentrated in weekday mornings. Births after induced labours were more likely to take place during the hours around midnight on Tuesdays to Saturdays, irrespective of the mode of birth.

Intrapartum stillbirths

Preliminary unadjusted analyses of intrapartum stillbirths for 2005–9 showed that the rates were higher on weekdays from 17.00 to 08.59 and at weekends, compared with on weekdays from 09.00 to 16.59, particularly among preterm and very low birthweight babies. This was associated with a higher risk of stillbirth attributed to asphyxia, anoxia or trauma and 'other conditions'. Further statistical analysis is required before any firm conclusion can be derived from these observations.

Other analyses

This project was severely delayed by problems in accessing data from HSCIC and problems associated with the information technology infrastructure, so we were unable to complete many planned analyses.

A planned key analysis would have grouped maternity units and trusts by levels of obstetric intervention to look at possible associations with patterns of the timing of birth and its outcome. We had planned to use a number of outcome measures from the linked dataset to reflect the outcome and quality of maternity care for women and babies in terms of mortality and morbidity as well as positive outcomes such as 'normal birth'. We are now applying elsewhere for funding to complete the planned analyses.

Discussion

The analyses are based on a large dataset, derived from more than 7 million births, giving sufficient numbers of births for detailed analyses. By linking the datasets together and creating a relational database to store and manage the data, we have greatly increased the numbers of variables available for analysis and there is scope for further analysis to look at social, demographic and clinical factors, which we have not touched on here.

Overall, a linkage rate of over 90% was achieved and this improved over time. The findings from the quality assurance exercise are relevant for other users of Trusted Third Party linkage who should not assume that datasets linked using patient identifiers are error-free or optimised for their analysis. HSCIC may need to improve its linkage algorithm.

Although ONS birth registration data have remained of consistently high quality, there have been issues with quality and completeness of data submitted to Maternity HES.

Completed analyses showed that the timing of births varies by place of birth, onset of labour and mode of birth. These patterns have implications for midwifery and medical staffing. Despite the rising levels of obstetric intervention, the extent to which births have been concentrated into 'normal' office hours is

minimal and numbers of births following induction peak around midnight, irrespective of the mode of birth.

Future work

Further research funding is needed to complete our planned analyses. In addition, the analyses undertaken so far have raised questions about mechanisms influencing the timing of birth. They also raised questions about the possible impact of variations in staffing levels and organisational factors. Different approaches are needed to explore these factors.

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