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Assessing the determinants of stillbirths and early neonatal deaths using routinely collected data in an inner city area

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Abstract

Background: Within the UK there is considerable variation in the perinatal mortality rate. The objective of this study was to assess the factors associated with stillbirths and early neonatal deaths (ENND) and the suitability of the available databases in a health authority with one of the highest rates in the country.

Methods: Two case-control studies were carried out in three hospital trusts in the Lambeth, Southwark and Lewisham Health Authority, London, using routinely collected information. In one study, 342 stillbirths and 1,368 controls were included, and in the other study, 205 ENND and 820 controls were included. In the two studies cases and controls were matched for hospital trust.

Results: A birthweight below 1.5 kg was found in 54% and 48% of the stillbirths and ENND, respectively. More than 50% of the cases, stillbirths and ENND, had a length of gestation below 32 weeks. Length of gestation, birthweight, emergency caesarean section and age of the mother were associated with stillbirths. Birthweight and Apgar score at 1 minute as a categorical variable were associated with ENND. There was no direct evidence of an effect of social deprivation on the outcomes of interest.

Conclusion: Birthweight and length of gestation are the most influential factors on an unfavourable outcome. Conception at an older age has a serious impact on stillbirth rates. In our health authority social disadvantage did not have a direct impact on stillbirth and ENND. Maternity information systems should collect routine data on fewer variables, but their quality in terms of value, standardization and completion rates must improve.

Background

As Lambeth, Southwark and Lewisham Health Authority (LSLHA) had the second highest perinatal mortality rate in the UK [1] we were interested in identifying factors amenable to change in our health authority. It is well known that very low birthweight (VLB) is the dominant factor affecting stillbirth and neonatal mortality in any analysis, accounting for approximately 75% of the variance of the outcome, which may obscure the effect of less conspicuous factors [2]. However, even moderate and mild preterm births (between 32 and 36 weeks) have been shown to increase the risk of infant mortality [3]. Most of the decrease in early infant deaths that has occurred in developed countries has been due to weight-specific mortality rates [2]. Several studies have shown that fetal losses and neonatal mortality can be reduced further, as highlighted in a report [4] which concluded that in 20% of perinatal deaths at least one avoidable factor could be identified that might have altered the outcome. Others have also shown that factors such as maternal height, twin pregnancy, hypertension, antenatal care and ethnic background can also influence the outcome [5-7]. This highlighted a need for an analytical study of possible causes associated with stillbirths and neonatal deaths in LSLHA.

Within LSLHA there were three hospital trusts delivering maternity care, each having its own maternity information system used mainly to provide routine data on provision of services. There was interest from LSLHA and the three hospital trusts in using the routinely collected information to identify the risk factors associated with stillbirths and early neonatal deaths (ENND). The quality of the data collected by National Health Service (NHS) maternity units has been considered sub-optimal [8]. Thus we were interested in ascertaining whether the information collected by the three NHS hospital trusts would allow us to carry out two case-control studies, one for stillbirths and another for ENND using data available for the 1996–1998 period. The expectation was that these analyses would shed some light on the relatively high fetal losses and ENND in LSLHA and also that it would provide clues for further improvement of the information systems in place.

Methods

Data sources

A listing of all deaths up to one year of age occurring in the South East Thames region between 1996 and 1998 inclusive was obtained from the Confidential Enquiry into Stillbirths and Deaths in Infancy (CESDI). CESDI receives information on deaths from 20 weeks gestation to one year of age, being notified by the relevant maternity or neonatal unit. A three-year period was chosen in order to provide a sample size large enough to detect an odds ratio of 3 between the cases and controls with a power of 80% for events occurring with a prevalence of 10% in the controls [9]. Stillbirths and ENND, that is, deaths within seven days of birth, were defined as cases. A length of gestation of at least 24 weeks was required for the purposes of this study. Cases, stillbirths or ENND, delivered at Guy's, St. Thomas', King's College or Lewisham Hospitals were selected.

Data were also obtained from the Guy's and St. Thomas' NHS Trust, King's College Hospital NHS Trust and Lewisham Hospital NHS Trust on all births occurring during the three-year period. Jarman scores for postcodes of mothers living within LSLHA were subsequently made available [10]. This index takes into account the levels of unemployment, overcrowding, lone parents, under-fives, elderly living alone, ethnicity, low social class and residential mobility in the area concerned. It has a mean of zero over England and Wales. Positive values indicate deprivation and negative values indicate relative affluence.

A search was performed in the appropriate hospital trust data files for cases listed in the CESDI records. Linkage was performed on the basis of postcode of mother's address, mother's date of birth and infant's date of delivery. A match was deemed to exist if at least two of these three variables were in agreement. In a very few cases, a stillbirth or ENND was not recorded in CESDI. The degree of completeness of the hospital trust files relative to the CESDI records was ascertained.

Variables for analysis

An initial list of possible variables within the categories of socio-demographic background, type of care, previous maternal-obstetric history, maternal health and nutrition, current pregnancy and on the newborn baby was drawn at the outset of the study. Only variables that were recorded in more than two thirds of pregnancies for all three hospital trusts were selected for subsequent analysis. In addition, the number of previous stillbirths was investigated despite a recording rate of 25% at one of the hospital trusts, as it was thought to be a key factor of interest in looking at subsequent stillbirths and ENND. Information was available for the following variables: mother's date of birth, age at delivery, postcode, ethnic group, marital status, type of patient (NHS or private), booked place of delivery, gravida, length of gestation, presenting part at delivery, type of delivery, blood loss during delivery, use of resuscitation, number of babies and baby's place of birth, sex, one-minute and five-minute Apgar scores and weight. Table 1 shows the variables recorded by all three hospital trusts that were not selected due to incompleteness of the data.

For each chosen variable a categorization that could be applied to all three hospital trusts was derived. Data were then recoded using these new categories. A check was made for outliers and out-of-range values were recorded as missing. We obtained information from CESDI on cause of stillbirth or ENND, categorized by the Wigglesworth classification into congenital malformation, unexplained antepartum death, death from intrapartum 'asphyxia, anoxia or trauma', immaturity, infection or due to other specific causes [11]. CESDI also provided

Table 1: Variables recorded by all three hospital trusts that could not be used in the analyses due to the level of missing data*

Mother's height
Number of previous livebirths
Number of previous miscarriages
Number of previous terminations
Number of caesarean sections
Rubella immune status
Medical problems in pregnancy
Method of onset of labour
Type of monitoring during labour
Analgesia used in labour
Date of full dilatation
Method of rupture of membranes
Head circumference of baby

*Date of delivery not recorded by one hospital trust.

information for stillbirths on the number of days before delivery that the fetus died.

Design

Two case-control studies were performed: one related to stillbirths and another related to ENND. In the stillbirth analysis, for each case, four controls of the same sex and date of delivery were selected from the hospital trust where the case was born. Since the records were listed in order of birth, the nearest two appropriate controls occurring above and below the case were taken. A similar procedure was used to construct a data file for ENND and matched controls. The matched case-control method was selected in preference to a method that used all of the controls, as there would only have been a small gain in power by doing this; studies with highly imbalanced group sizes have relatively low power.

Statistical procedures

Conditional logistic regression analyses were performed separately for the stillbirths and ENND using Stata [12]. Variables were selected by forward stepwise regression (p value for inclusion of a variable = 0.05, p value for subsequent removal of a variable = 0.1). In order to retain a reasonable number of cases and controls for analysis, all variables with more than 10% of the data missing were excluded. The significant variables in the analyses were presented in terms of odds ratios (OR) and their corresponding 95% confidence intervals (CI). Of the variables selected initially, only the number of stillbirths was excluded at this stage.

The analyses of births to mothers living within LSLHA were performed incorporating the Jarman scores (available only for these postcodes). For the births in the three hospital trusts as a whole, the availability (or not) of a Jarman score was used to indicate whether or not the mother lived in LSLHA and hence assess the impact of catchment area on stillbirths and ENND.

Results

According to CESDI, 351 stillbirths occurred in the three hospital trusts between 1996 and 1998. Of these, 334 (95%) were identified in the corresponding hospital trust records. In addition, a further eight stillbirths were found from the hospital trust records. This gave a total of 342 stillbirths for analysis. There were 198 ENND recorded by CESDI and 194 (98%) of these could be identified in hospital trust records. A further 11 ENND were found in the hospital trust records making 205 cases available for analysis.

Table 2 gives information about the cases and controls for the stillbirths and ENND respectively. Both short gestation and all categories of low birthweight were more prevalent for cases than controls. There is a trend towards older mothers with stillbirths and a much larger percentage of mothers of white ethnicity with ENND compared with their matched controls. Table 3 gives the cause of death for stillbirths and ENND according to the Wigglesworth classification. More than 50% of stillbirths were unexplained antepartum fetal deaths, followed in frequency by severe congenital malformations and deaths from intrapartum causes. The main causes of ENND were immaturity and congenital malformations.

Table 4 shows the results of the logistic regression for the stillbirths for LSLHA. A short length of gestation, low birthweight, high maternal age and use of emergency caesarean section were highly associated with increased odds of a stillbirth occurring. A similar finding resulted from the analysis of all the stillbirths.

Table 2: Characteristics of stillbirths and early neonatal deaths (ENND) compared with controls*

	Stillbirths		Controls		ENND		Controls	
	Number	%	Number	%	Number	%	Number	%
Maternal age (years)								
<20	19	5.6	84	6.1	13	6.3	50	6.1
20–29	113	33.6	600	43.9	91	44.4	369	45.1
30–39	181	53.9	641	46.9	97	47.3	376	46.0
40+	23	6.8	43	3.1	4	2.0	23	2.8
Ethnicity								
White	138	40.4	642	46.9	126	61.5	402	49.0
Black Caribbean	50	14.6	187	13.7	18	8.8	117	14.3
Black African	89	26.0	319	23.3	37	18.0	170	20.7
South-east Asian	15	4.4	39	2.9	7	3.4	32	3.9
Other	50	14.6	181	13.2	17	8.3	99	12.1
Length of gestation (weeks)								
<32	167	54.4	25	1.9	104	52.3	22	2.7
32–36	71	23.1	77	5.8	29	14.6	58	7.2
37+	69	22.5	1236	92.4	66	33.2	729	90.1
Birthweight (kg)								
<0.75	29	9.2	3	0.2	6	3.4	3	0.4
0.75–0.999	91	28.9	15	1.1	63	35.4	10	1.2
1.0–1.499	51	16.2	11	0.8	17	9.6	12	1.5
1.5–2.499	68	21.6	71	5.2	32	18.0	49	6.0
2.5–2.999	29	9.2	278	20.4	29	16.3	164	20.2
3.0+	47	14.9	982	72.2	31	17.4	574	70.7
Gravida (mean)	2.59		2.35		2.25		2.24	
Jarman score (mean)	21.44		20.93		19.11		20.28	

*Numbers do not necessarily sum to study totals due to missing data.

Table 3: Causes of stillbirths and early neonatal deaths (ENND) in LSLHA between 1996 and 1998 based on the Wigglesworth classification as recorded by CESDI

Cause of death	Stillbirths *N* (%)	ENND *N* (%)	Total *N* (%)
Congenital defect (severe or lethal)	88 (25.5)	78 (39.6)	166 (30.6)
Unexplained antepartum fetal death	180 (52.2)	N/A*	180 (33.2)
Death from intrapartum asphyxia/anoxia or trauma	50 (14.5)	17 (8.6)	67 (12.4)
Immaturity (livebirths only)	N/A*	82 (41.6)	82 (15.1)
Infections	13 (3.8)	11 (5.6)	24 (4.4)
Due to other specific causes	14 (4.1)	9 (4.6)	23 (4.2)
Total	345	197	542†

*N/A, not applicable. †There were 351 stillbirths and 198 ENND recorded by CESDI. For seven cases (six stillbirths, one ENND) diagnosis was missing.

Table 4: Factors associated with stillbirths in LSLHA resident population

Variable	OR	(95% CI)	*p* value
Gestation (weeks)	0.74	(0.64, 0.85)	<0.001
Birthweight (kg)	0.48	(0.29, 0.81)	0.005
Emergency Caesarean section	19.43	(2.31, 163.59)	0.006
Age of mother (years)	1.07	(1.02, 1.12)	0.008

For many unsuccessful pregnancies, such as 25% of those who died on the day of delivery, there was a lethal or severe malformation and low birthweight was a consequence rather than a cause of stillbirth. With this in mind, an analysis was performed using the variables in the initial analysis but excluding birthweight and length of gestation. There were eight significant factors for increased odds of a stillbirth: breech or face presentation (OR 6.55 (95% CI 3.65 to 11.76)), a switch from intended place of delivery (OR 3.21 (95% CI 1.76 to 5.84)), number of fetuses (OR 4.91 (95% CI 2.03 to 11.87)), higher gravida (OR 1.15 (95% CI 1.04 to 1.27)), spontaneous breech delivery (OR 22.43 (95% CI 2.70 to 184.53)), south-east Asian ethnicity (OR 3.03 (95% CI 1.40 to 6.59)), black ethnicity (OR 1.59 (95% CI 1.10 to 2.31)) and living outside LSLHA (OR 1.89 (95% CI 1.15 to 3.12)).

Tables 5 and 6 show the results of the analyses for the ENND, LSLHA and all births respectively. Within LSLHA, low birthweight, a one-minute Apgar score (Apgar 1-min) of less than 7 and a low Jarman score (denoting a lower level of deprivation) were associated with increased odds of an ENND occurring. For the all births analysis, low birthweight, an Apgar 1-min of less than 7, white ethnicity and a postcode outside of LSLHA increased the odds of a neonatal death.

As a low Apgar 1-min score was so highly associated with ENND we assessed the factors associated with a low Apgar 1-min in a multiple linear regression analysis. A short length of gestation (0.23 (95% CI 0.19 to 0.26)), breech or face presentation (-0.99 (95% CI -1.67 to -0.30)), living outside LSLHA (-0.66 (95% CI -1.03 to -0.29)), spontaneous breech mode of delivery (-2.70 (95% CI -4.24 to -1.17)) and emergency caesarean section (-2.04 (95% CI -3.58 to -0.50)) were associated with low Apgar 1-min.

Discussion

We have demonstrated that the routinely collected information in obstetric departments can be used for analytical studies even when different computerized systems are in place. For a large number of important variables the percentage of missing values was high, and for others, such as maternal blood pressure, there is lack of standardization so that information cannot be used. Among the variables that we could use in the analysis, unsurprisingly [2,3,13] low birthweight was highly associated with both stillbirths and ENND, and length of gestation was independently associated with stillbirths. Increased maternal age was an important factor in explaining stillbirths. In the ENND analyses, the confidence intervals for Apgar 1-min were very wide but all values for the ORs within these were nevertheless of strong clinical importance (OR > 20). Thus a low Apgar 1-min was highly associated with ENND reflecting the poor condition of the newborn. Unusual presentation, multiple births, ethnicity and change from intended place of delivery were significantly associated with stillbirths only when birthweight and length of gestation were omitted in the analysis. Reports in the USA have shown excess mortality in the black population explained by low birthweight consistent with our results [7,14].

Table 5: Factors associated with early neonatal deaths (ENND) in LSLHA resident population

Variable	OR	(95% CI)	p value
Birthweight (kg)	0.232	(0.127, 0.424)	<0.001
Apgar score at 1 minute:			
0–2	364.89	(21.25, 6264.37)	<0.001
3–6	11.68	(2.62, 52.14)	0.001
Jarman score	0.947	(0.849, 0.997)	0.038

Table 6: Factors associated with early neonatal deaths (ENND) regardless of place of residence

Variable	OR	(95% CI)	*p* value
Birthweight (kg)	0.232	(0.145, 0.373)	<0.001
Apgar score at 1 minute:			
0–2	630.86	(41.61, 9564.23)	<0.001
3–6	9.32	(3.04, 28.59)	0.001
Outside LSLHA	4.01	(1.53, 10.52)	0.005
White	3.44	(1.40, 8.47)	0.007

Low socio-economic environment did not have an effect on the outcomes as expected. The findings on the effects of an aggregate index of socio-economic status using an ecological design are inconsistent in the literature. Guildea and colleagues found that the Townsend deprivation score was unrelated to ENND [15] while others reported an effect using the Jarman score or the Carstairs deprivation index [16,17]. Although some researchers have their preferred measure, it has been shown that the Jarman and the Townsend scores are highly correlated (0.90) to predict their value for stillbirth, neonatal and infant mortality rates [18], so either of the two deprivation indicators would be equally helpful. Our analysis indicates that social deprivation is not an important factor in explaining stillbirths or ENND in our health authority. When birthweight and length of gestation were removed from the logistic regression, the black and South-east Asian ethnic groups were associated with stillbirths. However, analysis of the ENND did not show a similar association; in fact whites were disadvantaged. These findings suggest that a possible negative effect of black or South-east Asian ethnicity could be brought about through low birthweight and length of gestation. Taken together, the associations due to ethnicity were inconsistent. The strongest association with one of the outcomes was found in South-east Asians, proportionally, a small group in LSLHA leading to a modest impact in the population.

The strength of this study stems from the inclusion of the overwhelming majority of stillbirths and ENND occurring between 1996 and 1998 in the three NHS hospital trusts within LSLHA. As recognized in a review on data collection of NHS maternity units in Britain [8], data for many variables were incomplete or not collected by all the three hospital trusts.

A particular problem of this type of study is the difficulty in determining whether a factor is a possible cause of the unfavourable outcome or the consequence of the outcome. Factors such as birthweight or fetal presentation may be both the consequences of an unfavourable outcome and a possibly intervening factor in the chain of events leading to death. Wilcox has provided a powerful critique on the limitations of birthweight as a causal factor on infant mortality, but his critique was less forthcoming in proposing analytical approaches to infant mortality when many independent variables can affect the outcome [19].

As birthweight and length of gestation are the main factors associated with stillbirths and ENND it is worth exploring whether the proportions of low birthweight (less than 2.5 kg) and very low birthweight (less than 1.5 kg) have changed more in LSLHA than in England and Wales. In LSLHA, low birthweight increased from 10.1% in 1992 to approximately 11.4% in 1996 and very low birthweight from 2.6% in 1992 to 3.2% in 1996 [11]. The comparable figures for England and Wales were 6.6% in 1992 and 7.2% in 1996 for low birthweight and 0.9% and 1.2%, respectively, for very low birthweight [20]. Although the increases in LSLHA are greater, the relative increases have been similar in LSLHA and England and Wales as a whole.

Ethnic composition, a change of intended place of delivery and the selective admission of women with difficult pregnancies from outside the catchment area may explain the high rate of low birthweight in hospital trusts within LSLHA. Our analysis demonstrated that women from outside LSLHA added significantly to ENND and, possibly, through low birthweight or preterm births contributed disproportionately to the number of stillbirths. These groups should be carefully monitored to ascertain avoidable fetal loss. It is unfortunate that national information on length of gestation is unavailable. In Canada and the USA, monitoring of both birthweight and length of gestation has been helpful in ascertaining the potential for further progress in reducing stillbirths and neonatal death rates [21]. Kramer argued that policies aimed at making the birthweight distribution more favourable would have a minimal impact in reducing infant deaths whereas a reduction in the proportion with preterm delivery would have a marked effect in reducing mortality [3,21]. A problem with this approach is that it is well established that birthweight distribution can be changed by, for example, the cessation of smoking during pregnancy, but knowledge about the determinants of preterm birth is much less clear [22].

As in other studies [23,24] maternal age was a factor independently associated with stillbirth rates. This relationship is independent of previous reproductive history [22]. In the UK, there has been a substantial increase in the number of births to mothers over the age of 30, especially to those aged 35 years or more, over the last 15 years. As average child bearing age continues to increase the risk of stillbirth will rise correspondingly, with resource implications for both the NHS and society as a whole.

Conclusions

In conclusion, routinely collected information is helpful for analytical studies, but a comprehensive modification of the content and structure of these databases would greatly increase their value. A more effective approach to data collection would be to focus on fewer variables but to record these more carefully. These should be carefully standardized so that repeated measurements such as blood pressure and data from different hospitals are comparable. Length of gestation, birthweight and to a lesser extent maternal age may influence the trends on early mortality. There is a need to carefully monitor outcomes in particular groups such as those referred from outside the catchment areas of our hospitals, those who change intended place of delivery and emergency caesareans.

Authors' contributions

RR suggested the idea for the study. RC, PD, RR and CW selected the variables for the analysis. RC, PD and NS were responsible for preparing and collating the data from available routine information in the three participating hospital trusts. NS prepared the data files and carried out the analysis. NS and RR drafted the paper. All authors contributed to and approved the final manuscript.

Competing interests

None declared.

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