Timing of birth and infant and early neonatal mortality in Sweden 1973-95: longitudinal birth register study

Z C Luo, J Karlberg

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Abstract

Objective To assess the impact of time of birth on infant mortality and early neonatal mortality in full term and preterm births.
Design Analysis of data from the Swedish birth register, 1973-95.
Participants 2 102 324 spontaneous live births of infants without congenital malformation.
Outcome measurements Absolute and relative risk of infant mortality, early neonatal mortality, and early neonatal mortality related to asphyxia.
Results Infant mortality, early neonatal mortality, and early neonatal mortality related to asphyxia were higher in infants who were born during the night (9 pm to 9 am) compared with those born during the day for 1973-9, 1980-9, and 1990-5. The difference was more dramatic for preterm infants. The largest difference was observed during 1990-5, when there was a 30% increase in early neonatal mortality (relative risk 1.31, 95% confidence interval 1.10 to 1.57) and a 70% increase in early neonatal mortality related to asphyxia (1.70, 1.22 to 2.38) in preterm infants born during the night compared with rates for preterm infants born during the day. A detailed analysis over 24 hours revealed two "high risk" periods: between 5 pm and 1 am and around 9 am.
Conclusions Infants born during the night have a greater risk of infant and early neonatal mortality and early neonatal mortality related to asphyxia than those born during the day. There has been no improvement over the past two decades. The problem is more serious for preterm births and was even worse in the 1990s. Shift changes and the hours immediately after such changes are high risk periods for neonatal care.

Introduction

In recent years several studies have reported a higher early neonatal mortality, particularly mortality related to asphyxia, in infants born during the night than in those born in the day.[1–3] This has important implications for health care as millions of births take place at night throughout the world. An exploration of the time of birth in relation to such mortality will help us to assess the importance of this problem in preterm infants—those most at risk. We assessed whether infant mortality and early neonatal mortality is related to the time of birth in both full term and preterm infants born in Sweden.

Methods

We used data from the Swedish birth register, 1973-95. The register covers virtually all the births in the country.[4–6] The data include records on the exact time of birth. The inputs include standardised sets of forms used in all antenatal clinics and delivery units and during paediatric examinations of newborn infants. The records are linked to the registry of population that includes the death registry.[5 6] There were 2 392 263 valid births recorded by the registry during 1973-95. To assess the effect of the time of birth in comparison with the recent result by Heller[1] we retained only those data on spontaneous live births of infants without considerable congenital malformation (2 102 324 infants). We also assessed which hours of birth over 24 hours were "high risk" periods for infant and early neonatal mortality and early neonatal mortality related to asphyxia.

During the study period there were no alterations in routines surrounding staff shift changes in Sweden. The obstetric nurses change shifts at 7 am, and the nurses have full responsibilities for each delivery. The obstetricians and neonatalogists change shifts at 8 am. Larger hospitals have a neonatalogist on-call 24 hours; medium and small hospitals have a senior paediatrician on-call 24 hours. The general principle is that all complicated deliveries will have a neonatalogist present, and premature and sick babies will be cared for in special neonatal wards. Early neonatal mortality was similar in babies born in large cities and those born elsewhere (1.57 *v* 1.53 per 1000, P = 0.51), an indication of homogeneity of neonatal care across the country.

Night time births refers to births that occurred in the hours from 9 pm to 7 am.[1] Early neonatal death refers to death in the first six days of life.[1 7] We computed the absolute and relative risks to evaluate the impact of the time of birth on the risk of infant and early neonatal mortality and early neonatal mortality related to asphyxia. We assessed preterm and term births separately in the analysis of infant and early neonatal mortality. The analyses were done for 1973-9, 1980-9, and 1990-5 separately so that we could make

Clinical Trials Centre, University of Hong Kong, Hong Kong SAR, People's Republic of China
Z C Luo
research associate
J Karlberg
professor
Correspondence to:
J Karlberg
jpekarl@hkucc.hku.hk

BMJ 2001;323:1327–30

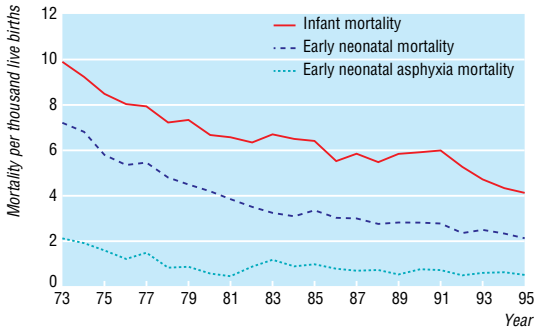

Fig 1 Infant mortality for spontaneous live births of infants without congenital malformation, Sweden 1973-95 (Cochran-Armitage test for trend, P<0.0001 for different rates during 1973-95)

comparisons with results from other countries for 1990-5[1 7 8] and assess changes over decades.

Results

Early neonatal deaths (in the first six days) accounted for more than half of all deaths during the first year of life. A steady decline in infant mortality and early neonatal mortality was observed from 1973 to 1995 (fig 1). There was a slight increase in early neonatal mortality related to asphyxia during 1982-3, but otherwise there was a general downward trend from 1973 to 1995.

There was a higher risk of infant mortality and mortality related to asphyxia during the first year of life in infants born during the night than in those born during the day (table 1). The difference was mostly small but was greater for preterm infants. The most striking difference was in 1990-5, with an increase of about 60% in the risk of mortality related to asphyxia in preterm infants born during the night compared with preterm infants born during the day. The results for early neonatal mortality—that is, in the first six days—were similar to those for mortality in the first year (table 2). The increase of such mortality in 1990-5 was about 30% for early neonatal mortality (relative risk 1.31, 95% confidence interval 1.10 to 1.57) and about 70% for early neonatal mortality related to asphyxia (1.70, 1.22 to 2.38) for preterm infants born at night.

Figure 2 shows the changes in mortality over 24 hours in the time of birth in one and two hour intervals. A high risk period occurred between 5 pm and 1 am, with another short high risk period around 9 am. There was a low risk period between 2 am and 4 pm, except for the short peak around 9 am. The largest difference was in early neonatal mortality related to asphyxia: infants born during the hours of highest risk (around 9 am and 9 pm) had almost double the risk of such mortality compared with infants born during the hours of lowest risk (around 4 am and 3 pm).

Table 1 Infant mortality and mortality related to asphyxia (number of deaths per 1000 live births) during first year of life for spontaneous live births of infants without congenital malformation according to time of birth, Sweden 1973-95

		Infant mortality					Infant mortality related to asphyxia				
	No of births	No	Rate	Absolute risk*	Relative risk (95% CI)	P value	No	Rate	Absolute risk*	Relative risk (95% CI)	P value
Gestation ⩾37 weeks											
1973-9:	602 202	1407	2.34				142	0.24			
Day	366 877	813	2.21				81	0.22			
Night	235 325	594	2.52	0.31	1.14 (1.02 to 1.27)	0.02	61	0.26	0.04	1.17 (0.84 to 1.64)	0.34
1980-9:	823 411	1682	2.04				122	0.15			
Day	491 545	997	2.03				72	0.15			
Night	331 866	685	2.06	0.03	1.02 (0.92 to 1.12)	0.72	50	0.15	0.005	1.03 (0.72 to 1.48)	0.88
1990-5:	580 180	957	1.65				61	0.11			
Day	338 432	557	1.65				32	0.09			
Night	241 748	400	1.66	0.009	1.00 (0.88 to 1.14)	0.94	29	0.12	0.03	1.27 (0.77 to 2.10)	0.35
1973-95:	2 005 793	4046	2.02				325	0.16			
Day	1 196 854	2367	1.98				185	0.15			
Night	808 939	1679	2.08	0.10	1.05 (0.99 to 1.12)	0.13	140	0.17	0.02	1.12 (0.90 to 1.39)	0.31
Gestation <37 weeks											
1973-9:	26 715	1911	71.53				637	23.84			
Day	16 448	1160	70.53				386	23.84			
Night	10 267	751	73.15	2.62	1.04 (0.95 to 1.13)	0.42	251	24.45	0.98	1.04 (0.89 to 1.22)	0.61
1980-9:	37 120	1060	28.56				268	7.22			
Day	22 941	637	27.77				157	6.84			
Night	14 179	423	29.83	2.06	1.07 (0.95 to 1.21)	0.25	111	7.83	0.99	1.14 (0.90 to 1.46)	0.28
1990-5:	25 449	661	25.97				169	6.64			
Day	15 415	366	23.74				83	5.38			
Night	10 034	295	29.40	5.66	1.24 (1.06 to 1.44)	0.006	86	8.57	3.19	1.59 (1.18 to 2.15)	0.002
1973-95:	89 284	3632	40.68				1074	12.03			
Day	54 804	2163	39.47				626	11.42			
Night	34 480	1469	42.60	3.13	1.08 (1.01 to 1.15)	0.02	448	12.99	1.57	1.14 (1.01 to 1.28)	0.04
All spontaneous live births											
1973-95	2 102 324	7809	3.71				1430	0.68			
Day	1 255 675	4584	3.65				820	0.65			
Night	846 649	3225	3.81	0.16	1.04 (1.00 to 1.09)	0.06	610	0.72	0.07	1.10 (0.99 to 1.23)	0.07

*No of deaths per 1000 births.

Table 2 Early neonatal mortality and mortality related to asphyxia (number of deaths per 1000 live births) during first six days for spontaneous live births of infants without congenital malformation according to time of birth, Sweden, 1973-95, compared with data from Germany, 1990-5[1]

		Early neonatal mortality					Early neonatal mortality related to asphyxia				
	No of births	No	Rate	Absolute risk*	Relative risk (95% CI)	P value	No	Rate	Absolute risk*	Relative risk (95% CI)	P value
Sweden, gestation ⩾37 weeks											
1973-9:	602 202	520	0.86				132	0.22			
Day	366 877	305	0.83				75	0.20			
Night	235 325	215	0.91	0.07	1.10 (0.92 to 1.31)	0.29	57	0.24	0.04	1.18 (0.84 to 1.67)	0.33
1980-9:	823 411	403	0.49				102	0.12			
Day	491 945	236	0.48				60	0.12			
Night	331 866	167	0.50	0.02	1.05 (0.86 to 1.28)	0.64	42	0.13	0.005	1.04 (0.64 to 1.42)	0.82
1990-5:	580 180	184	0.32				46	0.08			
Day	338 432	98	0.29				21	0.06			
Night	241 748	86	0.36	0.07	1.23 (0.92 to 1.64)	0.16	25	0.10	0.04	1.67 (0.93 to 2.98)	0.08
1973-95:	2 005 793	1107	0.55				280	0.14			
Day	1 196 854	639	0.53				158	0.13			
Night	808 939	468	0.58	0.05	1.08 (0.96 to 1.22)	0.19	122	0.15	0.02	1.14 (0.90 to 1.45)	0.27
Sweden, gestation <37 weeks											
1973-9:	26 715	1712	64.08				614	22.98			
Day	16 448	1035	62.93				371	22.56			
Night	10 267	677	65.94	3.01	1.05 (0.95 to 1.15)	0.33	243	23.67	1.11	1.05 (0.89 to 1.23)	0.56
1980-9:	37 120	810	21.82				228	6.14			
Day	22 941	482	21.01				135	5.88			
Night	14 179	328	23.13	2.12	1.10 (0.96 to 1.26)	0.17	93	6.56	0.68	1.11 (0.86 to 1.45)	0.42
1990-5:	25 449	478	18.78				137	5.38			
Day	15 415	258	16.74				65	4.22			
Night	10 034	220	21.93	5.19	1.31 (1.10 to 1.57)	0.003	72	7.18	2.96	1.70 (1.22 to 2.38)	0.002
1973-95:	89 284	3000	33.60				979	10.97			
Day	54 804	1775	32.39				571	10.42			
Night	34 480	1225	35.53	3.14	1.10 (1.02 to 1.18)	0.01	408	11.83	1.41	1.14 (1.00 to 1.29)	0.048
Germany, gestation ⩾37 weeks											
1990-5:	380 930	57	0.15				21	0.06			
Day	231 939	26	0.11				6	0.03			
Night	148 991	31	0.21	0.10	1.86 (1.1 to 3.13)	NS	15	0.10	0.07	3.89 (1.51 to 10.03)	NS

*No of deaths per 1000 births.

The changes in mortality followed similar trends over 24 hours during weekdays (Monday-Friday) and at the weekend (Saturday and Sunday).

Discussion

Our observations confirm the previous reports from Germany and the United Kingdom that infants born at night have a higher risk of early neonatal mortality and mortality related to asphyxia than infants born during the day.[1–3] The new message from our observation is that this problem is much more serious for preterm infants and that shift changes and the hours immediately after are high risk periods. Furthermore, there was no improvement in the quality of neonatal health care in the night compared with that in the day over the decades we studied. There was an even greater relative risk of early neonatal mortality and mortality related to asphyxia for infants born at night during the 1990s.

Strengths and weaknesses in relation to other studies

Quality of data is an important consideration for studies on neonatal mortality. There is a large difference in early neonatal mortality reported within developed countries.[1 7 8] This may be due to true differences among populations but could also be due to a lack of consistency in collecting, recording, and coding data on births and deaths in different countries. The data from the Swedish birth registry are of high quality.[4] As virtually all births were recorded there is no problem with sample error, therefore all parameters estimated here represent the true value of the population.

Sweden is a typical developed country with good social welfare and health care. The observed results would probably apply elsewhere, such as in Canada, Japan, Singapore, Hong Kong, and European countries, but may not be applicable to developing or underdeveloped regions or countries without such social welfare and healthcare systems. However, we would expect to see more dramatic differences in infant and early neonatal mortality between infants born during the night and day in less developed regions or in countries with a less effective healthcare system.

Possible mechanism and implications

Even with the improvements in health care the greatest difference between mortality in infants born day or night was during 1990-5. There was about 30% higher early neonatal mortality and 70% higher neonatal mortality related to asphyxia in preterm infants born at night compared with preterm infants born during the day. There was also a large increase in absolute and relative risk of early neonatal mortality for preterm infants born at night in the 1990s compared with the 1980s. To some extent, there was no improvement or even a worsening in the quality of night time neonatal care compared with the daytime neonatal care in the 1990s. This certainly raises our concern, and efforts

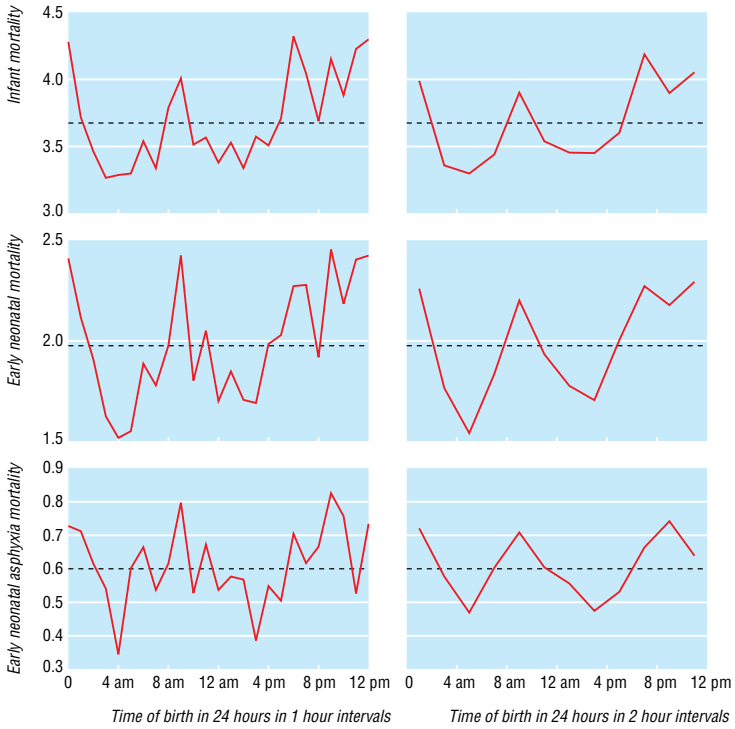

Fig 2 Changes in mortality over 24 hours according to time of birth by one or two hour intervals for spontaneous live births of infants without congenital malformation, Sweden 1973-95. Dashed lines represent reference mean values over 24 hours (χ^2 test for difference over 24 hours, P<0.0001 for infant mortality and early neonatal mortality by both one and two hour intervals; P=0.005 and 0.007 for early neonatal mortality related to asphyxia by one and two hour intervals, respectively)

should be made to eliminate this difference. The benefit would be enormous considering the millions of births worldwide. The underlying causes are not clear and may be due to excess workloads, inadequate or less experienced staff on night shifts, or out of date systems for managing shift changes within hospitals.

A more in depth analysis over 24 hours showed that there were actually two high risk periods for neonatal care: 5 pm to 1 am and around 9 am. The first risk period started from the end of the normal day shift and extended to the midnight shift. The second one, around 9 am, was immediately after day shift staff were taking over responsibilities. This pattern indicates that shift changes and the periods immediately after are high risk periods for neonatal care. The exact answers to the mechanisms and causes should be identified by further investigations.

What is already known on this topic

Infants born at night have a greater risk of early neonatal mortality and early neonatal mortality related to asphyxia than those born during the day

The causes are unclear but may be related to insufficient or less experienced staff or excess workload during the night

What this study adds

In Sweden the relative risks of infant and early neonatal mortality and mortality related to asphyxia for infants born during the night compared with during the day did not diminish during 1973-95, are greater for preterm infants, and were greater in the 1990s

There are two "high risk" periods for early neonatal mortality: 5 pm to 1 am and around 9 am

The exact reasons are unclear but better vigilance and an improvement in shift changes may be required to improve neonatal health care further

We thank all hospital staff for their work in collecting and filing data for the Swedish birth register, and the Children's Hospital of the University of Goteborg for providing access to the data.

Contributors: See bmj.com

Funding: Clinical Trials Centre and the Department of Pediatrics, University of Hong Kong.

Competing interest: None declared.

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(Accepted 29 August 2001)

One hundred years ago

The war in South Africa

Sir Walter Foster called attention to the grave loss from disease sustained by the forces in South Africa, and quoted figures to show that up to the end of last year more than 7,500 had died of disease and more than 30,000 had been sent home as invalids. Up to the end of September, 3,642 had died of enteric fever and 15,655 had been affected by this very preventable disease. He quoted extracts from the Report of the Commission which recommended the appointment of sanitary officers to select camps and supervise the health of the army, and asked why when such a course had been proposed at the beginning of the war the War Office had refused to listen to the suggestion. He contended that in spite of the endeavour of the Commission not to find fault, the report practically admitted the case raised against the hospitals at Bloemfontein and other places. He wanted to know what steps the Government were taking now to prevent disease, and what kind of a Committee they would appoint to consider reforms in the R.A.M.C.

(*BMJ* 1901;i:469)