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Decreasing perinatal mortality in The Netherlands, 2000–2006: a record linkage study

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ABSTRACT

Background: The European PERISTAT-1 study showed that, in 1999, perinatal mortality, especially fetal mortality, was substantially higher in The Netherlands than in other European countries. The aim of this study was to analyse the recent trend in Dutch perinatal mortality and the influence of risk factors.

Methods: A nationwide retrospective cohort study of 1 246 440 singleton births in 2000–2006 in The Netherlands. The source data were available from three linked registries: the midwifery registry, the obstetrics registry and the neonatology/paediatrics registry. The outcome measure was perinatal mortality (fetal and early neonatal mortality). The trend was studied with and without risk adjustment. Five clinical distinct groups with different perinatal mortality risks were used to gain further insight.

Results: Perinatal mortality among singletons declined from 10.5 to 9.1 per 1000 total births in the period 2000–2006. This trend remained significant after full adjustment (odds ratio 0.97; 95% CI 0.96 to 0.98) and was present in both fetal and neonatal mortality. The decline was most prominent among births complicated by congenital anomalies, among premature births (32.0–36.6 weeks) and among term births. Home births showed the lowest mortality risk.

Conclusions: Dutch perinatal mortality declined steadily over this period, which could not be explained by changes in known risk factors including high maternal age and non-western ethnicity. The decline was present in all risk groups except in very premature births. The mortality level is still high compared with European standards.

Perinatal mortality is an indicator of reproductive health and quality of obstetric health care.[1–3] The European PERISTAT-1 study showed that, in 1999, perinatal mortality, especially fetal mortality, was substantially higher in The Netherlands than in other European countries.[4] Dutch civil registration issued crude perinatal mortality data showing a decline in perinatal mortality since 2000; however, the civil registration has a limited set of risk factors for detailed analysis.[5]

Trends in perinatal mortality can be explained by changes in the prevalence of risk factors or by changes in the impact of risk factors.[6 7] The effect of risk factors on the outcome can be influenced by healthcare factors. Perinatal mortality is known to be higher among teenage and older mothers, first and multiple births and births to non-western women.[8 9] Several changes in risk and healthcare factors have taken place in recent years. Maternal age increased further. The obstetric management of term breech presentation has changed since the Term Breech Trial.[10] The number of midwives has increased, and neonatal intensive care unit (NICU) capacity has been extended.

The objective of this paper is to describe the 7-year crude and risk-adjusted trends in Dutch perinatal mortality based on linked, detailed, nationwide, perinatal registry data.

MATERIALS AND METHODS

Data sources

The Dutch Perinatal Registry (PRN) contains detailed population-based information on pregnancies, deliveries and (re)admissions occurring until 28 days after delivery, collected by caregivers. Source data are available from three independent registries: the midwifery registry (LVR1), the obstetrics registry (LVR2) and the neonatology/paediatrics registry (LNR).The midwifery and obstetrics registries start at the booking visit and contain complete perinatal data from 20.0 gestational weeks onwards. The neonatology registry contains only data on hospital admissions of newborns. The completeness of the PRN registry is 96% of all births in The Netherlands.[11] The cohort dataset has been created by a validated probabilistic record linkage algorithm of the three healthcare registries without a personal identifier.[12 13] For this study, the years 2000–2006 have been combined. To accommodate World Health Organization (WHO) reporting criteria, we included all pregnancies from 22.0 gestational weeks onwards.[14] If gestational age was unknown, births with a birthweight below 500 g were excluded. The study was limited to singleton pregnancies.

Outcome measurements and determinants

The primary outcome measurement was perinatal mortality, defined as the number of fetal deaths (stillbirths) and neonatal deaths in the first week of life per 1000 total births. Fetal mortality was defined as the number of fetal deaths per 1000 total births. Early neonatal mortality was defined as neonatal deaths in the first week of life per 1000 live births, and late neonatal mortality as deaths between 7 and 27 days of life per 1000 live births.

Sociodemographic risk factors were: maternal age, parity (0, first birth; 1, second birth; 2–3, third and fourth birth; 4+, fifth or higher birth), ethnicity and urbanisation. Ethnicity was classified by the healthcare provider and combined in western (ethnic Dutch and other western) and non-western (ethnic groups of Surinamese Creole, Surinamese Hindustani, Moroccan, Turkish and

other non-western countries). Urbanisation was based on the number of households per postal area: very urban (>2500 households per square kilometre), urban/rural (between 500 and 2500 households) and very rural (<500 households).

Obstetric risk factors were: assisted conception, maternal medical condition and male gender. Assisted conception covered all non-spontaneous conceptions. Maternal medical condition is the combination of existing medical disorders (essential hypertension, diabetes, cardiac disease and endocrine disease) and medical complications developed during gestation, such as gestational diabetes and hypertensive pregnancy complications (pregnancy-induced hypertension, pre-eclampsia and HELLP).

Gestational age, birthweight and congenital anomalies are intermediate indicators of perinatal mortality and are highly interrelated. The presence of congenital anomalies was based on the information at or shortly after birth. Based on the gestational age and the presence of congenital anomalies, we defined five clinically relevant groups with different perinatal mortality risk. These groups were: very preterm births (22.0–25.6 weeks), births with congenital anomalies (≥26.0 weeks), preterm births (26.0–31.6 weeks) without congenital anomalies, preterm births (32.0–36.6 weeks) without congenital anomalies and term births (≥37.0 weeks) without congenital anomalies. According to Dutch national obstetrics/neonatology guidelines, women with a gestational age below 32.0 weeks should deliver in a tertiary hospital. Within the term group (≥37.0 weeks), low-risk women can start labour under the supervision of an independent midwife (with a choice between home birth or hospital). High-risk women start labour under the supervision of an obstetrician in hospital. Selection of high risk is based on national guidelines for referral.[15]

Statistical analysis

The incidence of perinatal mortality was analysed for the years 2000–2006, and a χ^2 test was used to test the presence of a trend. Logistic regression modelling was used to determine the effect of year of birth in combination with other risk factors on perinatal mortality expressed as odds ratios (OR) with 95% confidence intervals (95% CI). Interaction between year and risk factor was tested for each factor separately. In addition, we calculated the population-attributive risk (PAR) percentage based on the prevalence (P) and relative risk (RR) {PAR % = [P*(RR−1)/(P*(RR−1)+1)]*100} for each factor.[16] Subsequently, the prevalence and mortality risk for the five risk groups were analysed. The change in prevalence and mortality risk from 2000 to 2006 was determined for the five risk groups. SAS software version 9.1 was used (SAS Institute Inc., Cary, NC, USA).

RESULTS

Between 2000 and 2006, the perinatal mortality among singletons declined from 10.5 to 9.1 per 1000 total births (14%, χ^2 $p<0.001$). This was an average decline of 2.0% a year (table 1). Both fetal and early neonatal mortality declined: fetal mortality from 7.5 to 6.4 per 1000 total births (15%, χ^2 $p<0.001$) and early neonatal mortality from 3.1 to 2.7 per 1000 live births (13%, χ^2 $p<0.02$). There was no decline in late neonatal mortality (0.5 to 0.5 per 1000 live births, χ^2 $p = 0.69$). The decline in perinatal mortality was also present among multiple pregnancies from 37.1 to 28.9 per 1000 births (data not shown).

Year effect and risk factors for perinatal mortality

The effect of the calendar year of birth was OR 0.97 (95% CI 0.96 to 0.98), both crude and adjusted for risk factors (see table 2). None of the risk factors showed a significant interaction with year. The risk factors maternal age and parity were U-shaped in relation to perinatal mortality with age category 25–34 years and parity 1 as optimal categories. The PAR of nulliparity was 14.8%. The mean age of nulliparous women was 28.8 years. Sixteen percent of the pregnant women were of non-western origin; the ethnic effect on perinatal mortality was OR 1.4 (95% CI 1.3 to 1.5) and the PAR was 6.6%. Assisted conception and the presence of a maternal medical condition increased the risk of perinatal mortality (ORs of 1.7 and 1.6 respectively).

Risk groups

Table 3 shows the prevalence and perinatal mortality risks for the five risk groups. Almost one-third (29%) of all perinatal deaths occurred among the very preterm births, and 26% of the perinatal deaths occurred among births from 37.0 weeks' gestation onwards. Overall, there were relatively 270 fewer mortality cases observed in 2006 than would be expected based on the prevalence and mortality risks in 2000. The perinatal mortality risk declined and was most prominent among births with congenital anomalies (45% decline), among preterm births with 32.0–36.6 weeks' gestation (30% decline) and among term births (25% decline).

Healthcare factors

The percentage of elective caesarean sections in term pregnancies complicated by breech presentation nearly doubled from 30% in 2000 to 58% in 2006. The perinatal mortality risk in term breech presentation decreased from 5.6‰ to 3.0‰. Fifty-two per cent of the term women were selected as low risk at the start of the delivery and 48% as high risk. The perinatal mortality risk of the low-risk group was 1.3 and of the high-risk

Table 1 Fetal, neonatal early/late and perinatal mortality rates of singletons from 22.0 weeks in The Netherlands in 2000–2006

Singleton	Total children born	Total live born	Fetal mortality 22.0 weeks	Early neonatal mortality 0–6 days	Late neonatal mortality 7–27 days	Perinatal mortality 22.0–6 days
Year	n	n	n (‰)	n (‰)	n (‰)	n (‰)
2000	183627	182246	1381 (7.5)	556 (3.1)	92 (0.5)	1937 (10.5)
2001	182156	180750	1406 (7.7)	539 (3.0)	88 (0.5)	1945 (10.7)
2002	181702	180360	1342 (7.4)	537 (3.0)	86 (0.5)	1879 (10.3)
2003	183550	182301	1249 (6.8)	551 (3.0)	76 (0.4)	1800 (9.8)
2004	175117	173956	1161 (6.6)	441 (2.6)	71 (0.4)	1602 (9.1)
2005	170677	169559	1118 (6.6)	500 (3.0)	85 (0.5)	1618 (9.5)
2006	169611	168525	1086 (6.4)	449 (2.7)	85 (0.5)	1535 (9.1)
2000–2006	1246440	1237697	8743 (7.1)	3573 (2.9)	583 (0.5)	12316 (9.9)

Table 2 Unadjusted and adjusted odds ratios and PAR % of risk factors for perinatal mortality (22.0 weeks–6 days) of singletons in 2000–2006

Risk factor	Prevalence risk factor, %	Absolute mortality mean/year n	Unadjusted perinatal mortality Odds ratio (95% CI)	Adjusted* perinatal mortality Odds ratio (95% CI)	Adjusted† perinatal mortality Odds ratio (95% CI)	PAR%
Year effect	100.0	1759	0.97 (0.96 to 0.98)		0.97 (0.96 to 0.98)	NA
Maternal age (years)						
<20	1.8	50	1.80 (1.62 to 2.00)	1.58 (1.41 to 1.76)	1.57 (1.41 to 1.75)	1.4
20–24	10.2	214	1.32 (1.25 to 1.40)	1.22 (1.15 to 1.29)	1.22 (1.15 to 1.29)	3.1
25–34	68.6	1096	1.00	1.00	1.00	
35–39	17.0	332	1.22 (1.17 to 1.28)	1.20 (1.14 to 1.26)	1.21 (1.15 to 1.27)	3.6
⩾40	2.5	68	1.75 (1.59 to 1.92)	1.51 (1.38 to 1.67)	1.53 (1.39 to 1.68)	1.8
Parity						
0 Nulliparous	46.3	895	1.38 (1.32 to 1.44)	1.31 (1.25 to 1.37)	1.31 (1.25 to 1.36)	14.8
1	35.8	504	1.00	1.00	1.00	
2–3	16.0	294	1.31 (1.24 to 1.38)	1.24 (1.18 to 1.31)	1.24 (1.18 to 1.31)	4.6
4+	2.5	66	2.42 (2.20 to 2.67)	1.98 (1.79 to 2.19)	1.97 (1.78 to 2.18)	2.7
Non-western ethnicity	16.2	382	1.45 (1.38 to 1.51)	1.39 (1.33 to 1.46)	1.40 (1.33 to 1.47)	6.6
Level of urbanisation						
Very urban	19.5	374	1.12 (1.07 to 1.17)	0.99 (0.94 to 1.03)	0.99 (0.94 to 1.03)	2.3
Medium urban/rural	62.6	1074	1.00	1.00	1.00	
Very rural	17.9	311	1.01 (0.97 to 1.06)	1.05 (1.00 to 1.10)	1.05 (1.00 to 1.10)	0.2
Assisted conception	1.7	53	1.79 (1.62 to 1.99)	1.71 (1.54 to 1.90)	1.71 (1.54 to 1.90)	1.3
Maternal medical condition	9.5	255	1.63 (1.55 to 1.71)	1.59 (1.51 to 1.67)	1.59 (1.52 to 1.68)	5.7
Male gender child	51.4	935	1.07 (1.04 to 1.11)	1.07 (1.04 to 1.11)	1.07 (1.04 to 1.11)	3.6

*Adjusted for maternal age, parity, ethnicity, urbanisation, assisted conception, medical condition and male gender.
†Adjusted for maternal age, parity, ethnicity, urbanisation, assisted conception, medical condition, male gender and year.
PAR, population-attributable risk.
NA, not applicable.

group 4.5 per 1000 births. Perinatal mortality declined in both low- and high-risk term groups; from 1.7‰ to 1.0‰ for the low-risk group and from 5.0‰ to 3.8‰ for the high-risk group. Within the low-risk group, the perinatal mortality risk declined from 0.5 to 0.4 for home deliveries, from 2.8 to 0.9 for hospital deliveries under the supervision of an independent midwife and from 3.2 to 2.4 for transferrals to high risk during delivery.

DISCUSSION

Perinatal mortality declined from 10.5 per 1000 total births in 2000 to 9.1 per 1000 total singleton births in 2006. The decline remained significant after adjustment for important significant risk factors such as teenage pregnancy, maternal age ⩾40 years, nulliparity, parity ⩾4, non-western ethnicity, urbanisation, assisted conception and maternal medical condition. The decline was most prominent among births with congenital anomalies, preterm births (32.0–36.6 weeks) and among term pregnancies, but was absent in very premature births.

Strengths and weaknesses

The large dataset with national coverage and many available variables allowed for a detailed analysis of both risk and healthcare factors. National databases usually lack information at this level. The combined information from midwives, gynaecologists and neonatologists could be used for analyses due to the application of a probabilistic linking algorithm. Validation of this algorithm showed less than 1% errors.[12 13] Discrepancies on important risk factors among linked records were less than 2%. In general, in the case of discrepancies, the value of the healthcare provider involved at the moment of occurrence was used. If congenital anomalies or mortality had been registered by one of the involved caregivers, it was

Table 3 Prevalence and mortality risk of risk groups and the relative difference in prevalence and mortality risk of singletons for 2006 compared with 2000

Risk groups	Prevalence n (%)	Perinatal mortality n (‰)	Contribution %	Prevalence 2000 %	Prevalence 2006 %	Prevalence Difference %	Mortality risk 2000 ‰	Mortality risk 2006 ‰	Mortality risk Difference %
Very premature 22.0–25.6 weeks	3865 (0.31)	3614 (935)	29	0.28	0.36	27	931	912	−2
⩾26.0 weeks and congenital anomalies	29228 (2.34)	1937 (66)	16	2.25	2.78	24	84	46	−45
26.0–31.6 weeks and no congenital anomalies	8775 (0.70)	1953 (223)	16	0.72	0.69	−4	232	195	−16
32.0–36.6 weeks and no congenital anomalies	58864 (4.72)	1562 (27)	13	5.01	4.61	−8	27	19	−30
⩾37.0 weeks no congenital anomalies	1145708 (91.9)	3250 (2.8)	26	91.74	91.56	0	3.3	2.4	−25
Total	1246440 (100)	12316 (9.9)	100	100.00	100.00		10.5	9.1	

assumed to have occurred. When the registry data were compared with civil registration data, the quality of the outcome measurements was high; fetal deaths were more often registered in the PRN registration, especially very preterm fetal deaths. The risk factors age, parity, ethnicity and postal area showed fewer than 1% missing values. The prevalence of a maternal medical condition before and during pregnancy could be underestimated, as this variable is not required by the registry, but there is no indication that changes occurred in registering this information during the studied period. The analyses of perinatal mortality in five risk groups with different patterns of care allowed for analyses of changes in perinatal mortality in relation to daily (clinical) practice.

Some important risk factors for perinatal mortality such as level of education, smoking during pregnancy, maternal body mass index and food and folic acid intake were not captured in the current registry. Severe smoking during pregnancy is an item in the registry, but this information was not used because of the low prevalence (0.5%) due to underreporting. In general, about 10–15% of pregnant women smoke during pregnancy in The Netherlands.[17] When severe smoking (OR 1.5, 95% CI 1.2 to 1.9) was included in the adjusted model, no effect on the trend OR was visible. It is unknown whether the prevalence and perinatal mortality risk of the unmeasured risk factors changed during the study period and contributed to the decline.

The high level of Dutch perinatal mortality in 1999 compared with other European countries was explained by several risk factors: the restrictive policy to resuscitate and to perform intensive treatment on very preterm infants, the absence of a prenatal screening programme for congenital anomalies and substandard care including home birth. Other risk factors mentioned were multiple births, advanced maternal age, high parity, non-western ethnicity, smoking, maternal obesity, increased birthweight and more complete registration through professional instead of civil registrations.[5 18] The present study showed that the changes in prevalence of women with advanced maternal age and of women of non-western origin did not play an important role in the trend in perinatal mortality. We also showed that the prevalence of home deliveries in term infants (27%) is paired with a very low perinatal mortality risk (0.4 per 1000 births).

What is already known on this subject

- Perinatal mortality, especially fetal mortality, is substantially higher in The Netherlands than in other European countries (PERISTAT study).
- The effect of different risk factors, such as maternal age and ethnicity, on recent Dutch perinatal mortality is unknown.

What this study adds

- Since 2000, there has been a steady decline in both fetal and neonatal mortality in The Netherlands, which could not be explained by changes in known risk factors.
- Population-attributive risk for different risk factors of perinatal mortality showed that non-western ethnicity is important and nulliparity even more so.
- Home births showed the lowest mortality risk.

Our study confirmed the large share of very preterm infants in perinatal mortality; 29% of total perinatal mortality. The Dutch restricted resuscitation policy in spontaneous very preterm births did not change during the period 2000–2006.[19 20] The prevalence of very preterm infants, however, increased, especially from 2005 to 2006. The proportion of congenital anomalies within the very premature birth group increased from 15% to 26%. Termination of pregnancy after the detection of structural anomalies in late second-trimester screening influences the prevalence of very preterm births and the mortality rate.[19 21 22] Termination of pregnancy is not an explicit item in the registry, but a high percentage of induction was found among births of 22.0–25.6 weeks' gestation (48% in 2000 and 57% in 2006), indicating late terminations of pregnancy. This is most likely the result of the start of the national prenatal ultrasound screening programme for structural abnormalities (around 20 weeks of gestation) in the period 2004/2005, which was consolidated in 2006.

The decline in perinatal mortality risk in term breech presentations illustrates the rapid and successful implementation of the Hannah trial results.[10] However, because of the low prevalence of breech presentation, the contribution to the overall decline in perinatal mortality was minimal. The perinatal mortality decline in both low- and high-risk women at term is remarkable and might indicate the influence of care factors such as more and better trained perinatal health professionals and the better use of facilities including NICU beds.

The decline in perinatal mortality after 2000 has been described in other countries as well.[23–25] Detailed analyses separately for fetal and neonatal mortality can give further insight into the role of risk factors.[26] The elevated perinatal mortality risk among ethnic groups, also after adjustment, is a matter for concern. A national audit of perinatal mortality cases is essential to define substandard care factors in relation to the cause of death.

In conclusion, Dutch perinatal mortality declined from 2000 to 2006; this could not be explained by changes in known risk factors. The decline was present in all risk groups except in very premature births.

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