Research

No cry at birth: global estimates of intrapartum stillbirths and intrapartum-related neonatal deaths

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Objective Fewer than 3% of 4 million annual neonatal deaths occur in countries with reliable vital registration (VR) data. Global estimates for asphyxia-related neonatal deaths vary from 0.7 to 1.2 million. Estimates for intrapartum stillbirths are not available. We aimed to estimate the numbers of intrapartum-related neonatal deaths and intrapartum stillbirths in the year 2000.

Methods Sources of data on neonatal death included: vital registration (VR) data on neonatal death from countries with full (> 90%) VR coverage (48 countries, $n = 97\,297$); studies identified through literature searches (> 4000 abstracts) and meeting inclusion criteria (46 populations, 30 countries, $n = 12\,355$). A regression model was fitted to cause-specific proportionate mortality data from VR and the literature. Predicted cause-specific proportions were applied to the number of neonatal deaths by country, and summed to a global total. Intrapartum stillbirths were estimated using median cause-specific mortality rate by country (73 populations, 52 countries, $n = 46\,779$) or the subregional median in the absence of country data.

Findings Intrapartum-related neonatal deaths were estimated at 0.904 million (uncertainty 0.65–1.17), equivalent to 23% of the global total of 4 million neonatal deaths. Country-level model predictions compared well with population-based data sets not included in the input data. An estimated 1.02 million intrapartum stillbirths (0.66–1.48 million) occur annually, comprising 26% of global stillbirths.

Conclusion Intrapartum-related neonatal deaths account for almost 10% of deaths in children aged under 5 years. Intrapartum stillbirths are a huge and invisible problem, but are potentially preventable. Programmatic attention and improved information are required.

Keywords Infant mortality; Pregnancy outcome; Labor complications/epidemiology; Asphyxia neonatorum/epidemiology; Hypoxia-ischemia, Brain/epidemiology; Cause of death; Infant, Newborn; Infant, Premature; Regression analysis; Forecasting (*source: MeSH, NLM*).

Mots clés Mortalité nourrisson; Issue grossesse; Accouchement compliqué/épidémiologie; Asphyxie néonatale/épidémiologie; Hypoxie-ischémie cérébrale/épidémiologie; Cause décès; Nouveau-né; Prématuré; Analyse régression; Prévision (*source: MeSH, INSERM*).

Palabras clave Mortalidad infantil; Resultado del embarazo; Complicaciones del trabajo de parto/epidemiología; Asfixia neonatal/epidemiología; Hipoxia-isquemia del cerebro/epidemiología; Causa de muerte; Recién nacido; Prematuro; Análisis de regresión; Predicción (*fuente: DeCS, BIREME*).

Arabic

Bulletin of the World Health Organization 2005;83:409-417.

Voir page 415 le résumé en français. En la página 416 figura un resumen en español.

Background

The Millennium Development Goals (MDGs) and *The world health report 2005* are fuelling attention to maternal and child health (*1*). Improved information is required at the global and programme levels to prioritize use of resources to achieve the maximum effect. Almost 40% of deaths in children aged under 5 years occur in the neonatal period and this proportion is increasing as the numbers of post-neonatal deaths fall more rapidly (*2*). Yet neonatal deaths receive limited attention — partly due to the lack of robust estimates of cause of death (*3*). To meet MDG-4, which calls for mortality in under-5-year-olds to be reduced by two-thirds, more rapid reduction is required particularly in the risk of early neonatal death (death in the first week of life), which has shown the least decline (*4*). Birth asphyxia is a major cause of early neonatal deaths. Although the estimated numbers of disability-adjusted life years (DALYs)

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Ref. No. **04-014506**

(*Submitted: 4 May 2004 – Final revised version received: 31 March 2005 – Accepted: 4 April 2005*)

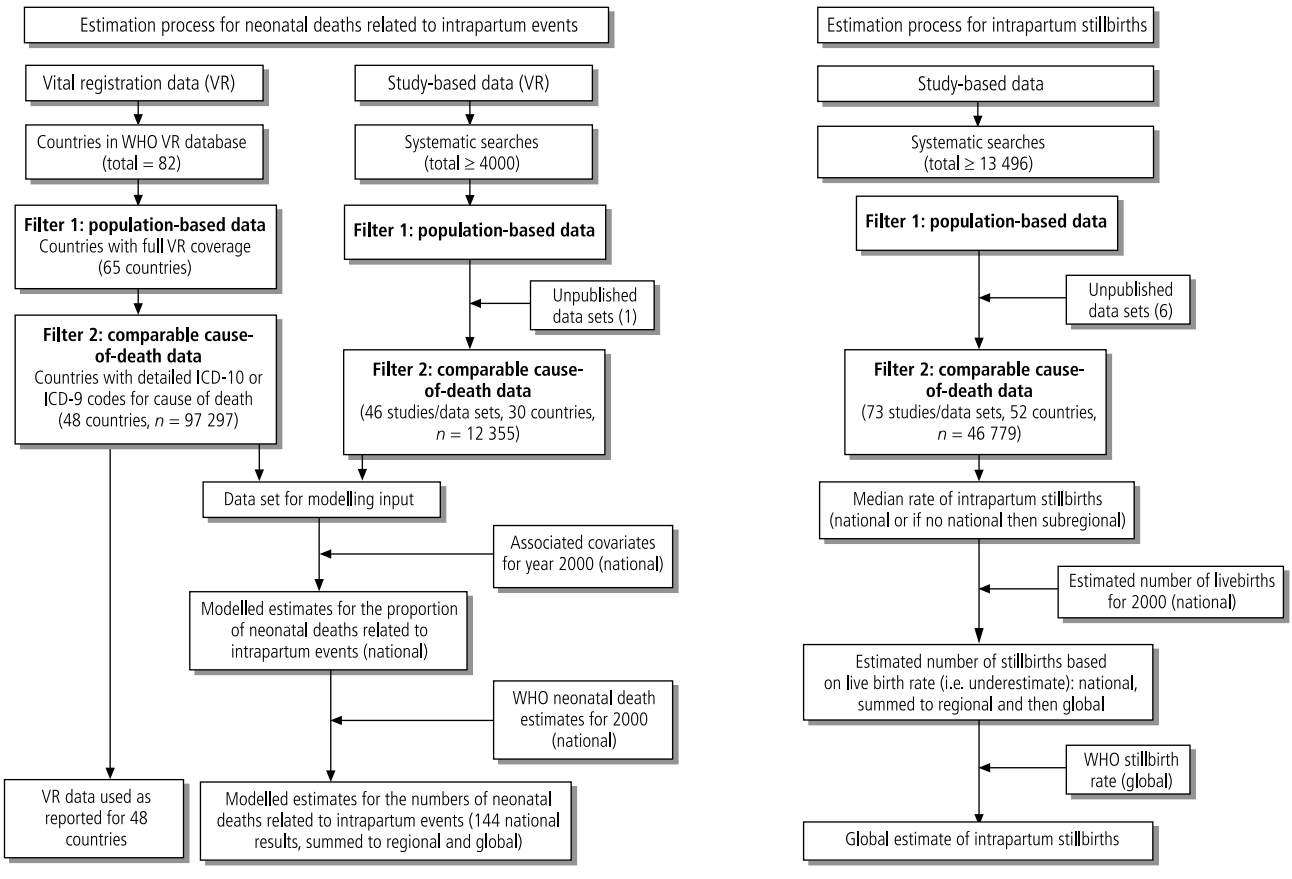
for birth asphyxia exceed those due to all childhood conditions preventable by immunizations (*5*), birth asphyxia does not feature on most lists of childhood "killers" and is not a policy or funding priority. Associated stillbirths (late fetal deaths after 28 weeks of gestation) are virtually invisible at policy level.

Tension between the increasing demand for data for decision-making, and the reality of health information gaps has been described as a "gathering storm" (*6*). Information regarding the cause of death for more than 97% of neonatal deaths is scanty in countries without full coverage of vital registration (VR). The majority of the world's stillbirths and neonatal deaths occur where no information is available to guide programmes. Thus, modelling and other estimation approaches are necessary while working to improve coverage and quality of new data. Systematic global estimates for intrapartum stillbirths — babies who die during labour — have never been published. Reported global totals of neonatal deaths due to the non-specific condition of birth asphyxia vary from 0.7 million (*7*) to 1.6 million (*8*) although the data inputs and methods for obtaining these estimates are not available.

Clarifying the language relating to birth asphyxia is necessary for improved measurement, especially if the deaths counted are to be relevant to programme action. Previous estimates have referred to the nonspecific condition of birth asphyxia, or not breathing at birth, which has several causes, including preterm birth, although historically the term birth asphyxia has implied a causal link with intrapartum hypoxia. There is no gold standard test for birth asphyxia — fetal distress, acidaemia, Apgar scores and other clinical markers of the process of potential intrapartum injury have low positive predictive values (*9*). Furthermore, such measurements are not feasible for many of the 99% of neonatal deaths occurring in low- and middle-income countries because half of these deliveries take place without a skilled attendant and a minority has access to assessment of acid–base status.

Epidemiological measurement of intrapartum injury has moved from *process-based* (e.g. long labour) and *symptom-based* (e.g. Apgar score) definitions to multiple indicator *outcomes* particularly neonatal encephalopathy, which refers to an abnormal neurobehavioural state in the first few days of life and is most commonly related to intrapartum insult (*10*). Such outcomes are more feasible to measure consistently and have direct programme relevance (*11*, *12*). Recent developments in early cooling therapy for babies with neonatal encephalopathy are potentially applicable more widely and require early and specific identification of babies with acute intrapartum brain injury (*13*). If babies with extreme preterm birth or congenital malformations continue to be misclassified as having intrapartum asphyxia, aside from the issue of litigation in rich countries, expected population-level programmatic solutions may be based on misinformation, as different interventions are required to prevent deaths due to these other causes. Improved global estimates necessitate tighter case definitions; detailed data inputs with explicit inclusion criteria; methods and assumptions described; and provision of associated uncertainty estimates.

Fig. 1. **Overview of the vital registration and study-based data screened and included in the estimation of the global numbers of neonatal deaths related to intrapartum events and intrapartum stillbirths**



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Objective and case definitions

The objective of the present study was to provide estimates for 192 countries around the year 2000 for the following mortality outcomes:

- *Neonatal deaths related to intrapartum events*, including neonatal deaths resulting from neonatal encephalopathy, neonates born at term who could not be resuscitated (or for whom resuscitation was not available) or specific birth trauma. Where possible, other causes such as lethal congenital malformations and extreme preterm birth (less than 34 completed weeks of gestation (or birth weight < 1500 g) should have been excluded.
- *Stillbirths occurring intrapartum* or fresh stillbirths (skin still intact, implying death less than 12 hours before delivery), weighing more than 1000 g or after more than 28 weeks of gestation, but excluding those with severe lethal congenital abnormalities.

Methods and data sources

Fig. 1 provides an overview of the methods applied. For the proportion of neonatal deaths related to intrapartum events if full coverage (> 90%) VR data were available with data on cause of neonatal death, we analysed and used these data. For countries where full coverage VR data were not available, a regression (logit) model based on VR and study data was fitted, and the predicted proportion applied to the WHO estimates of number of neonatal deaths by country. The cause-specific rate of stillbirths occurring intrapartum by country was estimated from the median rate using studies that met the inclusion criteria.

Search Strategy

Systematic searches were performed of the MEDLINE, POPLINE, Latin American and Caribbean Health Sciences (LILACS), BioMed Central, African Index Medicus and WHO Regional Office for the Eastern Mediterranean (EMRO) databases. Searches were conducted, without restrictions regarding language, on publications since 1985 for various terms, including all-cause mortality terms (e.g. neonatal/perinatal mortality, stillbirths and fetal deaths) and cause-specific terms related to acute intrapartum events (e.g. birth asphyxia, hypoxic ischaemic encephalopathy, neonatal encephalopathy, birth trauma, fresh stillbirths and intrapartum stillbirths). Extensive attempts were made to identify unpublished databases. Over 4000 documents of potential relevance were identified through these search techniques for neonatal deaths, and almost 14 000 for stillbirths (Fig. 1). After screening the abstracts, the selected publications were examined in detail to determine whether they met the inclusion criteria using two screening filters (Table 1).

Neonatal deaths related to acute intrapartum events

The case definition is given above.

Vital registration data

Original analysis was performed on the data for all neonatal deaths from 83 countries that had recorded VR data within the last 10 years, as reported to WHO up to March 2004 (Personal communication, D. Ma Fat, Evidence for Information and Policy Cluster, WHO, June 2003). Data from 48 countries met the inclusion criteria, with the median year being 2000 (Table 1). The proportion of intrapartum-related deaths was derived from analysis using the relevant International Classification of Diseases (ICD)-10 or ICD-9 codes relevant to the case definition, and analysed in Stata version 8 (Stata Corporation, College Station, Texas, USA). For countries with suitable VR data (48 countries) the proportion of intrapartum-related neonatal deaths was used. For countries with less than 500 neonatal deaths per year, a weighted average proportion of the most recent 3 years was used.

Model-based estimates

For the remaining 145 countries, a random effects model was used to predict the proportion of neonatal deaths related to intrapartum events. The dependent variable was the logit of the proportion of intrapartum-related neonatal mortality from VR (48 countries) and from 46 published and unpublished studies that met the inclusion criteria specified (Table 1). A variety of potential independent variables, using national-level data for the year 2000, were tested for fit. These were mortality rate in under-5-year-olds; neonatal mortality rate (NMR); gross domestic product; health expenditures; dummy variable for type of data (VR or others); WHO subregions and mortality levels; and coverage of interventions such as vaccination, skilled birth attendance and antenatal care. These data were obtained from the World Bank, WHO, and the United Nations Children's Fund (UNICEF), and refer to the year 2000. A random effects model was fitted using a parsimonious approach, adding predicators if they reached significance at a level of 5%. The final model was used to predict the proportion of neonatal deaths related to intrapartum events for the 145 countries without VR data. The proportion derived was then applied to the number of neonatal deaths in the country according to WHO estimates to produce an estimate of the number of intrapartum-related neonatal deaths. External validity of the estimates was examined by comparing model predictions to unpublished, population-based data sets.

Intrapartum stillbirths

The case definition applied is detailed above. A "fresh stillbirth" is a baby born dead without signs of skin disintegration or maceration and the death is assumed to have occurred < 12 hours prior to delivery (*12*, *14*). For obstetric classifications such as Aberdeen, acute intrapartum events causing death such as antepartum haemorrhage and obstructed labour were considered equivalent.

Studies meeting the inclusion criteria specified were abstracted (Table 1). If more than one study was included per country, then the median rate was applied. The median was selected in preference to the mean in keeping with approaches used for estimations in the Child Health Epidemiology Reference Group (*15*). If no data were available for a country then the median cause-specific rate for the subregion was used. The correct denominator for the rate of stillbirths is total number of births. Estimates of rates of stillbirth are not currently available by country and therefore total numbers of births at country level are unknown. Hence the derived cause-specific rates were applied to the estimated live births for each country for the year 2000 (UN Population Division, 2001 revision (*16*)) and summed to a global total which was then corrected to allow for the missing stillbirths by multiplying by 1.03, based on a global stillbirth rate of 30 per 1000 total births previously estimated by WHO (*7*).

Table 1. **Summary of the inclusion criteria applied to the data inputs**

Method	Inclusion criteria for data inputs
Neonatal deaths Vital registration (VR) data	• Filter 1 – population-based data: full coverage of vital registration (> 90%) as defined by WHO estimates based on adult mortality coverage[a] • Filter 2 – comparable cause-of-death data available: detailed ICD-10 or ICD-9 codes reported to WHO as of March 2004
Neonatal deaths Multiple regression model	• Filter 1 – population based data: population-based study (either in the community, or in an institution if not a tertiary referral centre, and over 90% of deliveries in the area were institutional); neonatal and/or early NMR reported or could be calculated • Filter 2 – comparable cause of death data available: cause-of-death data cover at least 12 months; percentage of unknown deaths was less than 30% and at least 20 deaths with known cause of death were reported; method used was skilled clinical investigation, postmortem or verbal autopsy. Comparable case definition of acute intrapartum events was possible and the cause-specific proportion of interest was specified or could be calculated from the information given. Single cause-of-death studies excluded
Intrapartum stillbirths Literature-based median cause-specific rate	• Filter 1 – population-based data: population-based study (either in the community, or in an institution if not a tertiary referral centre, and over 90% of deliveries in the area were institutional); stillbirth rate (fetal death rate after 28 weeks gestation/birth weight > 1000 g) was reported or could be calculated;[b] • Filter 2 – comparable cause of death data available: percentage of unknown deaths was less than 40%, and at least 20 deaths with known cause of death were reported; method used was skilled clinical investigation, postmortem or verbal autopsy. Comparable case definition of acute intrapartum events was possible and the intrapartum cause-specific rate was specified or could be calculated from the information given

ICD, International Classification of Disease; NMR, neonatal mortality rate.
[a] WHO draft coverage estimates (D. Ma Fat, personal communication, June 2003).
[b] Definition varying from 28 weeks gestation was accepted for a few countries in which mortality was low and no data were available using the 28 week definition (Table A.1, web version only, available at http//www.who.int/bulletin).

Uncertainty analysis

In countries with full VR coverage, 95% uncertainty levels were derived from the reported data. For modelled estimates, uncertainty bounds were generated using the standard error of the prediction of the logit and running 10 000 Monte Carlo simulations. For stillbirths, the upper and lower bounds of uncertainty for each subregion were taken as the highest and lowest rates for intrapartum stillbirth in the data entered for that subregion. These methods did not take into account uncertainty in the birth cohort or in the WHO estimates for neonatal deaths by country.

Results

Neonatal deaths related to acute intrapartum events

A total of 46 study populations from 30 countries met the inclusion criteria, with a cumulative sample size of 12 355 neonatal deaths (Table A.2, web version only, available at http//www.who.int/bulletin). VR data from 48 countries were included (97 297 neonatal deaths). The data entered (Fig. 2) suggest that in countries with a lower NMR (< 15 per 1000 live births), the proportion of neonatal deaths related to acute intrapartum events is mainly between 10% and 20%. For NMRs between 15 and 30 per 1000, intrapartum events are reported to cause a higher proportion of neonatal deaths, ranging from 23% to 37%. However at higher NMRs (above 30 per 1000 live births), the cause-specific proportion falls to 15–25% of neonatal deaths.

The final regression model applied to predict the proportion of neonatal deaths related to acute intrapartum events was (standard errors in parentheses):

$$\text{logit (\% asphyxia deaths)} = -1.53 + \underset{(0.93)}{1.83}*(\text{lnq5}) - \underset{(0.62)}{0.28}*(\text{lnq5})^2 - \underset{(0.09)}{0.30}*(\text{lnGDP}) - \underset{(0.13)}{0.13}*\text{logit}\,(\%DPT_3) - \underset{(0.05)}{0.05}*\text{logit (\% skilled birth attendants)} + \underset{(0.07)}{0.23}*(\text{data type})$$

Where lnq5 is the natural logarithm of the national risk of dying between birth and 5 years of age, lnGDP is the natural logarithm of gross domestic product in purchasing power parity, logit (%DPT_3) is the logit of national coverage of immunization with three doses of diphtheria, pertussis and tetanus toxoid immunization, and data type is a dummy variable for data input type (VR or literature). The goodness-of-fit was satisfactory, as reflected by *R*-square (0.61). There was no systematic deviation among the residuals. National data for coverage of emergency obstetric care were not available. Other covariates such as antenatal care were not found to be statistically significant.

The predicted proportion of neonatal death due to intrapartum events in each country was then applied to the WHO estimations of neonatal deaths by country. The model results, combined with full coverage VR data for 48 countries, predicted a global total of 0.904 million (0.65–1.17 million) deaths. Table 2 compares model predictions with unpublished

population-based data from four countries with high mortality levels. These data sets met the inclusion criteria (Table 1), but were not included in modelling. A paired *t*-test did not detect a statistically significant difference between observed and predicted proportions ($P = 0.76$). The average absolute difference between observed and predicted proportionate mortality was only 4%.

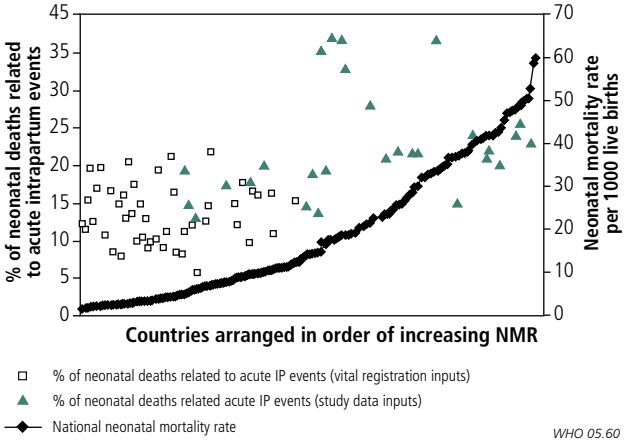
Intrapartum stillbirths

Studies meeting inclusion criteria included 73 populations in 52 countries with a cumulative sample size of 46 779 stillbirths (Table A.1, web version only, available at: http//www.who.int/bulletin). Approximately 84% were reported in peer-reviewed papers, four were national reports and two were unpublished data sets. Table 3 summarizes the estimates of rates of intrapartum stillbirth by subregion, summing to a global total of 1.02 million (uncertainty 0.66–1.48 million). The incidence varied markedly, with a rate of less than 1 per 1000 total births in the richest regions, to more than 15 times higher in the Eastern Mediterranean regions, South Asia and sub-Saharan Africa. The disparity reached 50-fold when comparing the lowest (0.33 per 1000 total births) (*17*) and highest (17.4 per 1000) (*18*) reported rates.

Discussion

The figures presented here are the first systematic global estimates quantifying intrapartum stillbirths, and the first estimates of intrapartum-related neonatal deaths using a more specific case definition. We estimated that 0.904 million neonatal deaths were associated with acute intrapartum events, approximately 23% of all neonatal deaths globally, and an additional 1.02 million intrapartum stillbirths accounted for 26% of 3.9 million stillbirths. This total of close to 2 million deaths occurring immediately around the time of birth is largely invisible in terms of the priorities of either safe motherhood or child survival programmes. Improving health systems at the time of childbirth potentially offers a triple benefit: reducing not only neonatal mortality and intrapartum stillbirths, but also averting many of the estimated 0.5 million maternal deaths a year.

Fig. 2. **Input data by country from vital registration (48 countries, *n* = 97 297) and studies (46 populations, 30 countries, *n* = 12 355).** Countries are arranged in order of increasing neonatal mortality rate (NMR) and the reported proportion of neonatal deaths related to intrapartum (IP) events is plotted



Extensive efforts were made to systematically identify and use the best information available. Comparison of the model predictions with unpublished data sets (Table 2) showed reasonable agreement in four countries. However, only 48 countries had suitable VR data. Stillbirth data are not routinely collected by WHO. Given the numerous approaches to classification of perinatal deaths and variable case definitions, the data are intrinsically uncertain, even within Europe (*19*). Improving the quantity, quality and comparability of data collected in the future is the only way to reduce this uncertainty. Trend analysis with previous global estimates of neonatal deaths due to "birth asphyxia" should be made with caution, because the case definitions here are more specific (*9*).

Table 2. **Consistency of estimates with unpublished data from population-based data sets**

Country	Study site	Percentage of neonatal deaths related to acute intrapartum events	
		Unpublished population-based data (number of neonatal deaths)	National estimate predicted by model
Gambia[a]	Rural community with primary health care and some access to emergency obstetric care	19% (78)	22
United Republic of Tanzania[b]	Urban (Dar es Salaam) Rural (Hai) Rural (Morogoro) National weighted result	18% (91) 25% (142) 33% (158) 29%	26
Bangladesh[c]	Periurban community in Dhaka with potential access to emergency obstetric care	24% (124)	30
Pakistan[d]	Rural site with limited access to basic and emergency obstetric care	26% (154)	23

No significant difference detected between observed and predicted proportions. Paired *t*-test 0.76.

[a] Walraven G, personal communication, March 2004.

[b] Settel P, Whiting D, Hemed Y, personal communication, March 2004. National result derived from three sites using *P*-weights based on census data for 2002.

[c] Perry H, personal communication, March 2004.

[d] Bhutta Z, personal communication, April 2004.

Table 3. **Summary of the estimated numbers of stillbirths and neonatal deaths related to acute intrapartum events for 192 countries according to the 14 subregions of the World Health Organization**

Subregion[a] (in order of increasing neonatal mortality rate)	Neonatal deaths related to acute intrapartum events			Estimated intrapartum stillbirth rate per 1000 total births[c]
	Cause-specific percentage of neonatal deaths[b]	Estimated cause-specific number of neonatal deaths (thousands)[b]	Uncertainty bounds	
Wpr A	15	0.51	0.4–0.6	0.95
Euro A	14	2.0	1.7–2.3	0.66
Amr A	12	2.4	2.2–2.5	0.95
Euro C	15	3.2	2.4–5.1	1.2
Euro B	24	15.1	10.7–19.6	2.0
Amr B	24	31.7	29.4–34.2	3.7
Emr B	13	6.8	4.7–8.8	4.5
Sear B	24	24.8	17.5–32.3	3.9
Wpr B	26	128.4	91.0–167.5	5.8
Amr D	22	9.6	6.8–12.5	6.3
Sear D	24	316.0	223.0–410.3	10.2
Afr D	23	118.2	83.6–151.0	10.6
Afr E	20	116.7	82.1–151.0	10.8
Emr D	23	129.0	90.3–166.8	11.2
Global estimate for numbers of deaths (thousands)		**904.4**		**1021**
(Uncertainty bounds)		(646–1170)		(660–1480)
Percentage of global neonatal deaths or stillbirths		**23%**		**27%**

Wpr, WHO Western Pacific Region; Euro, WHO European Region; Amr, WHO Region of the Americas; Emr, WHO Eastern Mediterranean Region; Sear, WHO South-East Asia Region; Afr, WHO African Region.

[a] Countries in the 14 subregions of the Global Burden of Disease listed in Table A.3 (web version only, available at http//www.who.int/bulletin). A list of individual countries in this classification can be found at: http://www.who.int/whr/2001/main/en/memberstates.htm

[b] Based on the vital registration data for 48 countries and multiple regression model as described for 143 countries.

[c] Based on median cause-specific rate as described.

Neonatal deaths related to acute intrapartum events

There are several potential sources of bias in the proportion of neonatal deaths related to acute intrapartum events. Early neonatal deaths may be misregistered as stillbirths (*20*). Misclassification of cause of death occurs, and is more likely with simpler verbal autopsy tools using unspecified algorithms, particularly in distinguishing between intrapartum causes and prematurity, or undetected congenital abnormalities. Furthermore, comorbidity may be complex; for example, infection and acute intrapartum events are synergistic and the direct cause of death may be debatable (*21*). In litigious societies, there may be systematic avoidance of the diagnosis of "birth asphyxia" on death certificates. Despite higher NMRs, the subregional average percentage of neonatal deaths related to intrapartum events is lower in North America (12%) than in Australia and Europe (14% and 15%, respectively) (Table 2). Industrialized countries tend to restrict the definition of intrapartum-related neonatal deaths to deaths subsequent to neonatal encephalopathy with multi-organ dysfunction, documented acidosis and proven intrapartum insults (*9*). The use of this definition is not feasible in developing countries and omits an important group, namely, those infants who die immediately after birth if resuscitation is unavailable or fails. Relevant and practical case definitions require validation especially within verbal autopsy tools, as this is the major source of cause-specific mortality information on most of the world's neonatal deaths.

There are several plausible explanations for the variation in the proportion of intrapartum-related neonatal deaths with NMR (Fig. 2). In countries with high NMRs, the lower proportion of neonatal deaths may be due to a higher proportion of deaths being caused by infections and tetanus. Additionally, in the settings with the highest mortality rates, access to obstetric care is limited, and acute intrapartum events more frequently result in stillbirth than in neonatal death. It is also possible that the measurement tools used in the settings where mortality is highest, particularly the simplest verbal autopsy tools, underestimate intrapartum-related neonatal deaths, misclassifying these as stillbirths or as due to other causes of death such as infection. The higher proportion of intrapartum-related deaths reported in transitional countries may be a real result, perhaps because infectious causes are less frequent in the countries shown (China and Latin America), leaving intrapartum causes as leading to a high proportion of deaths — or there may be systematic misclassification of cause of neonatal death, for example misclassifying preterm birth as intrapartum-related death if Apgar-based definitions are still used. Population-based studies using validated measurement tools are necessary to improve understanding of this apparent variation, and to address any avoidable factors.

In the final model, the strength of association of the outcome with coverage of vaccination with triple doses of diphtheria, pertussis and tetanus, which is considered a good marker for health system functioning, may suggest that improving coverage by skilled birth attendants alone is insufficient to address

intrapartum complications. Coverage of emergency obstetric care could not be tested for fit due to lack of comparable national data. Models able to simultaneously predict a number of causes of neonatal death would be an alternative approach (*2*, *16*).

Intrapartum stillbirths

Stillbirths are invisible in many societies, except for the estimated 4 million women who lose their baby in the last 3 months of pregnancy (*7*). Intrapartum stillbirths are more frequent than intrapartum-related neonatal deaths, especially in settings with limited emergency obstetric care (*22*). A mature fetus dying during childbirth is usually defined as a preventable death (*23–25*). Hospital-based studies suggest that 25–62% of intrapartum stillbirths could be avoided with better obstetric care and more rapid responses to intrapartum complications, including reducing delays in recognition of complications at home, and reducing delays in transportation to hospital (*25–27*).

Fresh stillbirth is a proxy for stillbirth due to acute intrapartum insult, but probably underestimates the true rate of stillbirths due to acute intrapartum events because a duration of labour in excess of 12 hours usually results in a macerated stillbirth and in settings with poor access to obstetric care, labour lasting more than 24 hours is not infrequent (*28*). Conversely, a small proportion of fresh stillbirths may be due to non-hypoxic causes (undetected congenital abnormalities or severe infection). The extent of such misclassification biases cannot be quantified without further study.

Conclusion

Intrapartum stillbirths and intrapartum-related neonatal deaths are a huge and potentially preventable burden, yet receive limited policy and programmatic attention. Intrapartum-related neonatal deaths account for 9% of all deaths in children aged under 5 years, a proportion comparable to the estimated number of children who die from malaria. The risks of intrapartum-related stillbirths and neonatal deaths are much higher in poor countries, yet the coverage of care is lower, a modern example of the inverse care law (*2*, *29*). Innovative approaches are required to increase information for decision-making and improve care in settings where far too many babies do not cry at birth. ■

Acknowledgements

We are grateful to Gary Darmstadt for input on the scope of the study and for reviewing the manuscript, and Anne Tinker (Save the Children Federation, USA) for support. We thank Simon Cousens for assistance in analysing the VR data and the Child Health Epidemiology Reference Group based in Child and Adolescent Health at WHO for critical review of the methods. We appreciate the help given by Kate Wilczynska-Ketende with literature searches. We thank Doris Ma Fat, Colin Mathers and Mie Inoue for providing data related to the WHO mortality database. We acknowledge the following for supplying unpublished data sets: Adult Morbidity and Mortality Project, Ministry of Health, United Republic of Tanzania, particularly Philip Setel, Dave Whiting and Yusuf Hemed; Ana Maria Aguilar (BASICS II, Bolivia); Zulfiqar Bhutta (Aga Khan University, Karachi, Pakistan); Fariyal Fikree (Population Council, New York, USA); Professor Henry Perry (Future Generations, Franklin West, Virginia, USA, formerly of Hopital Albert Schweitzer, Haiti); Gils Walraven (Aga Khan Foundation, Paris, formerly of Farafenni Field Site, Gambia); and David Woods (University of Cape Town, South Africa).

Funding: Joy Lawn was supported by the Bill & Melinda Gates Foundation through a grant to Save the Children/USA for the Saving Newborn Lives initiative.

Competing interests: none declared.

Résumé

Enfants mort-nés : estimation de la mortinatalité per-partum et du nombre de décès néonataux liés à des problèmes per-partum dans le monde

Objectif Moins de 3 % des 4 millions de décès néonataux annuels se produisent dans des pays disposant de données d'état civil fiables. Les estimations pour l'ensemble du monde du nombre de décès néonataux liés à une asphyxie vont de 0,7 à 1,2 million. On ne dispose pas d'estimations de la mortinatalité per-partum. L'objectif de l'étude est d'évaluer le nombre de décès per-partum et de décès néonataux liés à des problèmes per-partum survenus en l'an 2000.

Méthodes L'étude a notamment utilisé les sources de données relatives aux décès néonataux suivantes : statistiques d'état civil indiquant des décès néonataux fournies par des pays totalement couverts (couverture > 90 %) par des registres d'état civil (48 pays, n = 97 297), études sélectionnées par des recherches bibliographiques (> 4000 sommaires) et remplissant les critères de prise en compte (46 populations, 30 pays, n = 12 355). Un modèle de régression a été adapté pour établir les proportions par causes des décès signalés par les statistiques d'état civil et par les données de mortalité tirées de la littérature. Les proportions par causes prévues ont été appliquées au nombre de décès néonataux par pays et les résultats de ces opérations ont été ajoutés pour obtenir un total mondial. La mortinatalité per-partum a été estimée à partir des taux de mortalité par cause médians dans chaque pays (73 populations, 52 pays, n = 46 779) ou à partir de la médiane subrégionale en l'absence de données nationales.

Résultats Le nombre de décès néonataux liés à des problèmes per-partum a été évalué à 0,904 million (intervalle d'incertitude : 0,65 - 1,17 million), ce qui correspond à 23 % de la mortalité néonatale mondiale totale (4 millions de décès). Les prédictions par pays fournies par le modèle sont en bon accord avec des jeux de données en population non intégrés aux données d'entrée du modèle. La mortinatalité per-partum mondiale annuelle est estimée à 1,02 millions de décès (intervalle d'incertitude : 0,66 - 1,48 million), soit 26 % de la mortinatalité mondiale.

Conclusion Les décès néonataux liés à des problèmes per-partum représentent près de 10 % des décès chez les enfants de moins de 5 ans. La mortinatalité per-partum constitue un problème énorme et peu visible, dont la prévention est cependant possible. Une telle prévention nécessiterait que les responsables de programmes s'intéressent à ce problème et que les décideurs soient mieux informés.

Resumen

Silencio en el parto: estimaciones mundiales de la mortalidad intraparto y de las defunciones neonatales relacionadas con el parto

Objetivo Menos del 3% de los 4 millones de defunciones neonatales anuales se producen en países con datos de registro civil (RC) fiables. Las estimaciones mundiales de las defunciones neonatales relacionadas con problemas de asfixia oscilan entre 0,7 y 1,2 millones. No se dispone de estimaciones sobre la mortalidad intraparto. Decidimos estimar el número de muertes neonatales relacionadas con el parto y el número de nacidos muertos en el año 2000.

Métodos Las fuentes de los datos sobre las defunciones neonatales fueron las siguientes: datos del registro civil (RC) sobre las muertes neonatales en países con cobertura plena (90%) de RC (48 países, $n = 97\,297$); estudios identificados mediante búsquedas en la literatura (> 4000 resúmenes), y cumplimiento de los criterios de inclusión (46 poblaciones, 30 países, $n = 12\,355$). Se estableció un modelo de regresión para los datos de mortalidad proporcional por causas específicas extraídos del RC y de la literatura. Las proporciones proyectadas por causas específicas se aplicaron al número de defunciones neonatales por país, y finalmente éstas se sumaron para obtener un total mundial. La mortalidad intraparto se estimó utilizando la mediana de la tasa de mortalidad por causas por país (73 poblaciones, 52 países, $n = 46\,779$), o la mediana subregional a falta de datos del país.

Resultados Las defunciones neonatales relacionadas con el parto se estimaron en 0,904 millones (incertidumbre: 0,65–1,17), lo que equivale al 23% del total mundial de 4 millones de defunciones neonatales. Las predicciones del modelo a nivel de país fueron razonablemente coherentes con conjuntos de datos basados en la población no incluidos en el input utilizado. Cada año se registran 1,02 millones de mortinatos intraparto (0,66–1,48 millones), lo que supone el 26% de la mortinatalidad mundial.

Conclusión Las defunciones neonatales relacionadas con el parto representan casi el 10% de las defunciones de menores de 5 años. La mortalidad intraparto es un inmenso problema oculto, pero es potencialmente prevenible. Se requiere atención programática y una mejor información.

Arabic

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Table A.1. **Summary of 73 populations studied from 52 countries that provided information for rate of intrapartum stillbirths (cumulative sample size 46 779 stillbirths)**

Region *GBD subregion*	Place	Data collection and attribution of cause of death	Stillbirth definition abstracted	Case definition of intrapartum stillbirths abstracted	Number of still-births	Stillbirth rate for birth weight ⩾ 1000 g unless noted	Intrapartum stillbirth rate per 1000 live births for birth weight ⩾ 1000 g unless noted
Sub-Saharan Africa *Afro D*	Cape Verde, county of Praia, including the capital city, Praia (*1*)	Prospective through birth and deaths registry. Complete VR, March 1992–February 1993	Gestational age ⩾ 28 weeks	APH and non-cephalic presentation	49	19	3.2
	Senegal, peripheral maternity clinics of Pikene district (*2*)	Health system records. Median year of data collection 1990	Birth weight ⩾ 1000 g	Fresh intrapartum stillbirths	35	36	8.5
	Burkina Faso (*3*, *4*) Mali (*3*, *4*) Mauritania (*3*, *4*) Niger (*3*, *4*) Senegal, 2 sites (*3*, *4*)	Population-based survey in 7 sites in West Africa (6 urban capital cities, 1 semi-urban), Dec. 1994 – June 1996. Verbal autopsy	Birth weight ⩾ 500 g or 22 weeks of gestation but reports only "late stillbirths" after 8-month antenatal visit	Full-term intrapartum death excluding congenital abnormalities ("viable")	513 total	26 24 30 20 23	10.9 10.0 12.6 10.9 9.6
Sub-Saharan Africa *Afro E*	Côte d'Ivoire (*3*, *4*)	Population-based survey in 7 sites in West Africa (6 urban capital cities, 1 semi-urban), Dec. 1994 – June 1996. Verbal autopsy	Birth weight ⩾ 500 g or 22 weeks of gestation but reports only "late stillbirths" after 8-month antenatal visit	Full-term intrapartum death excluding congenital abnormalities ("viable")	513 total	34	14.2
	Kenya, Nairobi (*5*)	Prospective hospital-based perinatal surveillance in 1 hospital and 12 health clinics	Not specified	Intrapartum fetal deaths	404	18	6.5
	Malawi, rural (*6*, *7*)	Community-based cohort. Verbal autopsy	Not specified	Applied obstetric classification, adapted Wigglesworth	36	45	10.0
	Mozambique, Maputo (at least 90% of stillbirths) (*8*, *9*)	Prospective hospital-based perinatal surveillance. 10-week period in 1984	Gestational age ⩾ 20 weeks. None weighed ⩽ 1500 g	Specific direct cause including cord complications, uterine rupture, intrauterine asphyxia, APH	169	39	10.2
	South Africa. Peninsular maternal and neonatal service, South Africa (*10*)	Surveillance database, expert opinion, postmortems, 2001	Birth weight ⩾ 1000 g	Intrapartum stillbirths, congenital abnormalities excluded	573	21	4.2
	South Africa. Hospital-based perinatal surveillance in 33 sites (*11*, *12*)	Surveillance database, expert opinion, postmortems, 2000	Birth weight ⩾ 1000 g	Intrapartum hypoxia, APH, cord prolapse with intrapartum death	1985	–	Metropolitan 10.6 Cities/towns 11.9 Rural 8.7

(Table A.1, cont.)

Region *GBD subregion*	Place	Data collection and attribution of cause of death	Stillbirth definition abstracted	Case definition of intrapartum stillbirths abstracted	Number of still-births	Stillbirth rate for birth weight ⩾ 1000 g unless noted	Intrapartum stillbirth rate per 1000 live births for birth weight ⩾ 1000 g unless noted
Sub-Saharan Africa *Afro E* (continued)	United Republic of Tanzania, Hanang and Mbulu districts (*13*, *14*)	Cohort of antenatal clinic attendees followed up after delivery. Household survey of subsample, January 1995–March 1996	Gestational age ⩾ 28 weeks	Intrauterine hypoxia, cord compression, breech, APH	60	15	6.3
	United Republic of Tanzania, Kwimba and Missungwi districts (*15*)	Prospective community-based, participatory surveillance. March 2000–February 2001	Not specified but tables show very few fetal deaths ⩽ 1000 g	BABIEs matrix (birthweight by age at death). Intrapartum deaths ⩾1000 g	34	36	17.4
	Zimbabwe, Bulawayo Hospital (*16*)	Prospective hospital-based perinatal surveillance, September 1989–August 1990	Gestational age ⩾ 28 weeks or birth weight ⩾ 1000 g	Adapted Wigglesworth	466	43	15.5
	Zimbabwe, Gweru rural district health care system with 6 rural maternity centres (*17*)	Prospective health system data collection, expert opinion, 1984–1986	From 500 g, although very few stillbirths ⩽ 1000 g	Adapted Wigglesworth	165	15[a]	7.0[a]
North America *Amro A*	Canada, West Central Region of the Province of Ontario (*18*)	Vital statistics system, 1988–1995	Birth weight ⩾ 500 g	ICD-9 codes. Stillbirth due to "birth asphyxia"	1350	6.9	0.41
	USA, Texas (white, black and Hispanic populations) (*19*)	Bureau of Vital Statistics, 1993–1995	Gestational age ⩾ 20 weeks	ICD-9 codes. Fetus affected by placenta, cord, membranes complication[b]	6084	6.2[a]	1.6[a]
Latin America/ Caribbean *Amro B*	Argentina, hospital-based surveillance mainly in urban areas (*20*, *21*)	Prospective hospital-based perinatal surveillance in 308 hospitals in 18 Latin American countries, 1995–1997	Gestational age ⩾ 20 weeks	Intrapartum stillbirths	5366	19[a]	2.3[a]
	Brazil, all births in city of Pelotas (*22*)	Death certificates and hospital surveillance, with high coverage of postmortems, 1993	Gestational age ⩾ 28 weeks or birth weight ⩾ 1000 g	Wigglesworth classification. Asphyxia	55	10	3.9
	Brazil, hospital-based surveillance mainly in urban areas (*23*)	Prospective hospital-based perinatal surveillance in 308 hospitals in 18 Latin American countries, 1995–1997	Gestational age ⩾ 20 weeks	Intrapartum stillbirths	5664	22[a]	2.6[a]
	Brazil, Natal city, 3 hospitals and 2 health centres (*24*)	Prospective hospital-based perinatal surveillance, nested case–control study with postmortem questionnaire. Year not given: published 1990	Gestational age ⩾ 28 weeks or birth weight ⩾ 1000 g	Intrapartum complications	312	27	4.5

(Table A.1, cont.)

Region *GBD subregion*	Place	Data collection and attribution of cause of death	Stillbirth definition abstracted	Case definition of intrapartum stillbirths abstracted	Number of still-births	Stillbirth rate for birth weight ⩾ 1000 g unless noted	Intrapartum stillbirth rate per 1000 live births for birth weight ⩾ 1000 g unless noted
Latin America/ Caribbean *Amro B* (continued)	Jamaica, whole island (*25–27*)	Death certificates, notes review, expert assessment. 50% had postmortems, 1986–1987	Gestational age ⩾ 28 weeks	Wigglesworth classification. Intrapartum hypoxia	1119	21	9.2
	Paraguay hospital-based surveillance mainly in urban areas (*20, 21)*	Prospective hospital-based perinatal surveillance in 308 hospitals in 18 Latin American countries, 1995–1997	Gestational age ⩾ 20 weeks	Intrapartum stillbirths	1252	34[a]	4.1[a]
	Trinidad and Tobago, St Augustine city (*28*)	Prospective audit in hospital, 1993–1998	Gestational age ⩾ 28 weeks or birth weight ⩾ 1000 g	Modified Wigglesworth. Obstetric complications in labour such as cord complications, "fetal distress", APH	151	15[a]	6.0[a]
	Uruguay, hospitals mainly in urban areas (*20, 21*)	Prospective hospital-based perinatal surveillance in 308 hospitals in 18 Latin American countries, 1995–1997	Gestational age ⩾ 20 weeks	Intrapartum stillbirths	1450	26[c]	3.1 (⩾ 20 weeks)
	Venezuela, hospitals mainly in urban areas (*20, 21*)	Prospective hospital-based perinatal surveillance in 308 hospitals in 18 Latin American countries, 1995–1997	Gestational age ⩾ 20 weeks	Intrapartum stillbirths	1455	22[c]	2.6 (⩾ 20 weeks)
Latin America *Amro D*	Bolivia, hospitals mainly in urban areas (*20, 21*)	Prospective hospital-based perinatal surveillance in 308 hospitals in 18 Latin American countries, 1995–1997	Gestational age ⩾ 20 weeks	Intrapartum stillbirths	740	44[a]	5.3[a] (⩾ 20 weeks)
	Ecuador, hospitals mainly in urban areas (*20, 21*)	Prospective hospital-based perinatal surveillance in 308 hospitals in 18 Latin American countries, 1995–1997	Gestational age ⩾ 20 weeks	Intrapartum stillbirths	413	20	2.4
	Guatemala, 4 rural, predominantly Indian communities (*29*)	Community-based surveillance. Verbal autopsy and expert opinion, December 1997–May 1998	Gestational age ⩾ 28 weeks	Acute obstetric causes including prolonged labour, cord accidents. Excluding congenital abnormalities and chronic pathology	101	25	12.8
Middle East *Emro B*	Bahrain, whole island (*30*)	Prospective hospital-based perinatal surveillance in 3 hospitals and 3 maternity units, 1985–1987	Gestational age ⩾ 22 weeks	Aberdeen classification. Mechanical causes in labour, APH. Excluding congenital abnormalities	355	12.0[a]	3.6[a]

(Table A.1, cont.)

Region *GBD subregion*	Place	Data collection and attribution of cause of death	Stillbirth definition abstracted	Case definition of intrapartum stillbirths abstracted	Number of stillbirths	Stillbirth rate for birth weight ⩾ 1000 g unless noted	Intrapartum stillbirth rate per 1000 live births for birth weight ⩾ 1000 g unless noted
Middle East *Emro B* (continued)	Jordan, Irbid, North Jordan (*31*)	Prospective hospital-based perinatal surveillance, 1991–1992	Gestational age ⩾ 28 weeks	Intrapartum death, cord prolapse, APH. Congenital abnormalities excluded	124	15.0	4.1
	Jordan, Irbid, North Jordan (*32*)	Prospective hospital-based perinatal surveillance, 1994–1995	Gestational age ⩾ 28 weeks or birth weight ⩾ 1000 g	Intrapartum asphyxia	107	11.0	2.9
	Libyan Arab Jamahiriya, Benghazi City (*33*, *34*)	Prospective hospital-based perinatal surveillance in 3 hospitals, 1984 data	Not specified	Fresh intrapartum stillbirth. Obstetric causes, prolonged labour, cord accidents, APH, hypoxia. Congenital abnormalities excluded	160	12.0	5.4
	Lebanon, South Beirut hospital (*35*)	Prospective hospital-based perinatal surveillance. Year of data collection not given, published 1998	Gestational age ⩾ 28 weeks or birth weight ⩾ 1000 g	Cord prolapse, ruptured uterus, abruption placenta. Congenital abnormalities excluded	72	16	3.5
	Saudi Arabia, Al-Khobar City (*36*)	Prospective hospital-based perinatal surveillance, 1981–1985	Gestational age ⩾ 28 weeks or birth weight ⩾ 1000 g	Aberdeen classification. Intrapartum asphyxia, birth trauma, APH. Congenital abnormalities excluded	77	9.6[a]	3.1[a]
	Saudi Arabia, Al-Majma-ah city, Riyadh region (*37*)	Prospective hospital-based perinatal surveillance, 1986	Birth weight ⩾ 500 g	Cord complications and APH	22	22.0[a]	9.1[a]
	Saudi Arabia, hospital (*38*)	Prospective hospital-based perinatal surveillance, 1979–1980	Gestational age ⩾ 28 weeks	Intrapartum stillbirths	27	18.0	6.6
Middle East *Emro D*	Egypt, investigation of all perinatal deaths identified in national stratified sample for DHS survey (*39*)	Verbal autopsy and committee expert opinion, 2000	Birth weight ⩾ 1000 g	Asphyxial conditions developing in labour, and birth injuries (adapted Wigglesworth)	93	19.0	6.4
	Pakistan, Lahore. Community-based, 4 samples of differing socioeconomic status (*40*, *41*)	Verbal autopsy (2 independent doctors). Median year 1984	Gestational age ⩾ 28 weeks or birth weight ⩾ 1000 g	Labour complications	36	24.0	14.0

(Table A.1, cont.)

Region *GBD subregion*	Place	Data collection and attribution of cause of death	Stillbirth definition abstracted	Case definition of intrapartum stillbirths abstracted	Number of still-births	Stillbirth rate for birth weight ⩾ 1000 g unless noted	Intrapartum stillbirth rate per 1000 live births for birth weight ⩾ 1000 g unless noted
Europe *Euro A*	Denmark, whole country (*42*)	National birth registry data plus detailed audit in European collaborative project 1996 data	Gestational age ⩾ 28 weeks	Nordic-Baltic classification. Intrapartum deaths	378	5.6	0.44
	Norway, Nordland county (*43*)	County perinatal audit committee with high coverage of postmortems, 1986–1996	Gestational age ⩾ 28 weeks	Nordic-Baltic classification. Intrapartum deaths	171	4.7	0.33
	Norway, Troms county (*44*)	County perinatal audit committee with high coverage of postmortems, 1992–1997	Gestational age ⩾ 20 weeks	Intrapartum stillbirths with cross-tabulations allowing restriction to ⩾ 1000 g	282 (for 1992–1997)	4.0	1.1
	Sweden, Stockholm county (*45*)	County perinatal data collection, all fetal deaths, 1998–1999	Gestational age ⩾ 22 weeks	Intrapartal asphyxia, cord complications, APH, allowing infection comorbidity, but not IUGR	188	5.3	1.0
	UK, England, Wales and Northern Ireland (*46*)	Confidential national reporting system with high coverage of postmortems, 1999 data	Gestational age ⩾ 24 weeks, but also reports birth weight ⩾ 1000 g	Intrapartum deaths, birth weight ⩾ 1000 g excluding congenital abnormalities, plus APH, plus mechanical causes	2927	4.5 (4.9 for ⩾ 24 weeks of gestation)	0.62 (1.23 if APH is included)
	UK, Scotland (*47*)	Confidential reporting system with high coverage of postmortems, 1998 data	Gestational age ⩾ 24 weeks, but also reports birth weight ⩾ 1000 g	Intrapartum deaths, birth weight ⩾ 1000 g excluding congenital abnormalities, plus birth trauma	205	3.6 (5.6 for ⩾ 24 weeks of gestation)	0.56 (1.16 if APH is included)
	UK, Wales (*48*)	Perinatal survey of all of Wales, 1993–1995	Gestational age ⩾ 20 weeks	Intrapartum stillbirth with birth weight ⩾ 1500 g	608[c]	5.7[a]	0.58[a] (⩾ 1500 g)
Europe *Euro B*	Turkey, 29 centres in 6 main regions (*49*)	Prospective hospital-based perinatal surveillance, 1999	Gestational age ⩾ 22 weeks	Modified Wigglesworth classification, perinatal asphyxia	1664	18.0[a]	2.0[a]
Europe *Euro C*	Latvia, national perinatal audit (*50*)	National audit based on medical records of all perinatal deaths, 1995–1996 data	Gestational age ⩾ 28 weeks	Nordic-Baltic classification, intrapartum death after admission	257	10.0	1.1
	Lithuania, whole country (*51*)	Obstetric and neonatal records and compared with VR data 1993–1994	Gestational age ⩾ 28 weeks	Nordic-Baltic classification. Intrapartum death after admission	674	11	1.6

(Table A.1, cont.)

Region *GBD subregion*	Place	Data collection and attribution of cause of death	Stillbirth definition abstracted	Case definition of intrapartum stillbirths abstracted	Number of stillbirths	Stillbirth rate for birth weight ⩾ 1000 g unless noted	Intrapartum stillbirth rate per 1000 live births for birth weight ⩾ 1000 g unless noted
Europe *Euro C* (continued)	Ukraine, Donetsk region (*42*)	Ukrainian birth register for stillbirths and early neonatal deaths. Hospital delivery records, 1997–1998 data	Gestational age ⩾ 22 weeks	Nordic-Baltic classification. Intrapartum death after admission	610	8.7	1.2
East Asia/ Pacific *Searo B*	Sri Lanka, Colombo (*52*)	Retrospective hospital-based perinatal surveillance in 3 hospitals, 1993	Not specified	Intrapartum stillbirths excluding congenital abnormalities	137	18	3.4
	Thailand, Bangkok (*53*)	Prospective hospital-based perinatal surveillance, 1983–1987	Birth weight ⩾ 1000 g	Fresh stillbirths excluding congenital abnormalities	165	14	4.1
	Thailand, Chang Rai (*54*)	Prospective hospital-based perinatal surveillance, 1992–1994	Birth weight ⩾ 1000 g	Fresh stillbirths excluding congenital abnormalities	863	8.5	4.4
South Asia *Searo D*	Bangladesh rural ICCDR,B (Matlab) (*55*)	Community-based surveillance, verbal autopsy, 1979–1986	Gestational age ⩾ 28 weeks	Prolonged labour/ malpresentation	2213	37.0	11.8
	Bangladesh rural Manikganj district (*56*, *57*)	Community-based surveillance, verbal autopsy, 1991–1993	Gestational age ⩾ 28 weeks	Acute intrapartum events	53	28.0	8.4
	India rural Maharashtra state (*58*)	Prospective community-based data collection (pre-intervention population reported). Verbal autopsy	Birth weight ⩾ 1000 g	"Asphyxia"	90	28.0	15.0
	India rural Upper Assam (*59*)	Verbal autopsy, 1995	Not specified	Perinatal hypoxia, complicated delivery	46	19.0	8.0
	India, rural, near Patna, Bihar, India (*60*)	Prospective community-based data collection 1993–1995, verbal autopsy (*61*)	Birth weight ⩾ 1000 g	Trauma/ abnormal labour/APH	39	39.0	9.8
	India, rural Uttar Pradesh, Lucknow District (*62*, *63*)	Prospective community-based data collection. Verbal autopsy, 1987–1988	Not specified	Prolonged labour	25	26.0	7.3
	India, rural Vallabhnagar, Udaipur (*64*)	Prospective community-based data collection. Verbal autopsy. Median year 1980	Not specified. Cross-tabulation by weight starts at ⩽ 2000 g	Prolonged second stage, abnormal presentation, birth injury. Congenital abnormalities and low birth weight excluded	14	21.0	10.2

(Table A.1, cont.)

Region *GBD subregion*	Place	Data collection and attribution of cause of death	Stillbirth definition abstracted	Case definition of intrapartum stillbirths abstracted	Number of stillbirths	Stillbirth rate for birth weight ⩾ 1000 g unless noted	Intrapartum stillbirth rate per 1000 live births for birth weight ⩾ 1000 g unless noted
South Asia *Searo D* (continued)	India, 25 Anganwadi centres of urban Lucknow (*63*)	Prospective community-based data collection. Verbal autopsy, 1992–1993	Not specified	Intrapartum hypoxia, excluding toxaemia and anaemia	36	37.0	14.4
	Nepal, rural community, Jumla, (*65*)	Hospital records, plus verbal autopsy if death occurred at home, 1989–1990	Gestational age ⩾ 28 weeks or birth weight ⩾ 1000 g	"Intrapartum asphyxia" based on Aberdeen classification	44	34.0	15
	Nepal, rural Lalitpur (*65*)	Hospital records, plus verbal autopsy if death occurred at home, 1989–1990	Gestational age ⩾ 28 weeks or birth weight ⩾ 1000 g	"Intrapartum asphyxia" based on "Aberdeen classification"	11	40.0	19
Oceania *Wpro A*	Australia, national perinatal data collection (*66*)	National minimum perinatal data set reported directly to perinatal surveillance system, 2000	Birth weight ⩾ 400 g	Intrapartum deaths with documented heart rate before onset of labour	1304[c]	5.2 (8.3 for ⩾ 400 g)	0.62 (1.0 for ⩾ 400 g)
	Australia, State of Victoria (*67*)	State-wide surveillance, 2000	Legal definition ⩾ 400 g, also reported ⩾ 500 g	Hypoxic peripartum death, APH	262	6.4[a]	0.74[a]
	Singapore, Women and Children's Hospital (*68*)	Expert confidential review of all stillbirths for suboptimal care, 1995–1996	Not stated, apparently > 500 g in tables	Mechanical, APH, acute intrapartum event, unexplained intrapartum death	121	4.0[a]	1.5[a]
Pacific *Wpro B*	China, 11 cities in Jiangsu province (*69*)	Prospective hospital-based perinatal surveillance in 66 hospitals, 1981	Gestational age ⩾ 28 weeks	Nanjing perinatal classification. Fetal hypoxia including cord factors, maternal and placental complications	1140	13.0	8.8
	China, urban and rural, Shanghai municipality (*70*)	Prospective hospital-based perinatal surveillance. Stratified random sample of 29 hospitals, 1986–1987	Gestational age ⩾ 28 weeks or birth weight ⩾ 1000 g	Intrapartum death	608	8.0	2.0
	Malaysia, 3 districts in Peninsular Malaysia, 1 from East Malaysia (*71*)	Prospective hospital-based perinatal surveillance, October 1990–1991	Gestational age ⩾ 28 weeks	Adapted Wigglesworth. Stillbirth with "asphyxial conditions"	298	12.0	3.2
	Papua New Guinea, Port Moresby (*72*)	Prospective hospital-based perinatal surveillance, 1995–1997	Gestational age ⩾ 28 weeks or birth weight ⩾ 1000 g	Acute intrapartum events such as cord accidents and APH, "acute intrapartum hypoxia"	249	22.0	4.2

(Table A.1, cont.)

Region *GBD subregion*	Place	Data collection and attribution of cause of death	Stillbirth definition abstracted	Case definition of intrapartum stillbirths abstracted	Number of still-births	Stillbirth rate for birth weight ⩾ 1000 g unless noted	Intrapartum stillbirth rate per 1000 live births for birth weight ⩾ 1000 g unless noted
Pacific *Wpro B* (continued)	Vanuatu, Vila (*73*)	Prospective hospital-based perinatal surveillance, 1992	Birth weight ⩾ 500 g	Asphyxia and cord accidents	23	14.0[a]	5.4[a]
Total	73 populations 52 countries	–	–	–	Cumulative sample size 46 779	–	–

GBD, Global burden of disease; VR, vital registration; APH, antepartum haemorrhage; ICD, International Classification of Diseases; DHS, demographic health surveys; IUGR, intrauterine growth retardation; ICDDR,B, International Centre for Diarrhoeal Disease Research, Bangladesh; Afro, WHO African Region; Amro, WHO Region of the Americas; Emro, WHO Eastern Mediterranean Region; Euro, WHO European Region; Searo, WHO South-East Asia Region; Wpro, WHO Western Pacific Region.

Note: if the publication was not referring to stillbirths after 28 weeks of gestation or applied a case definition different to the standard used for these estimates, then the numbers in the table may differ from the reported rates or proportions as we re-calculated where possible to increase comparability across studies.

[a] Stillbirths number/rate not based on definition of ⩾ 28 weeks of gestation or birth weight ⩾ 1000 g.

[b] This may include some chronic placental conditions as the reported data did not specify their exclusion.

[c] Rate reported in the publication included stillbirths and neonatal deaths attributed to intrapartum events. We have included only the intrapartum stillbirths in our analysis.

Table A.2. **Summary of 46 publications, studies and reports from 30 countries without complete coverage of vital registration (VR) that provided information on the proportion of neonatal deaths due to neonatal encephalopathy and/or related to acute intrapartum events or attributed directly to "birth asphyxia" (cumulative sample size of 12 355)**

Region ***GBD subregion*** (number of countries with VR data included)	**Place and level of data collection**	**Case definition (method of cause attribution)**	**No. of neonatal deaths with cause of death reported**	**NMR per 1000 live births**	**Percentage of NMR related to intrapartum events**
Sub-Saharan Africa *Afro D* (VR, 1 country)	Gambia rural community, upper river division. Nested case–control study (1254 total neonatal deaths) (*74*)	Early neonatal death following complicated labour lasting > 24 hours (VA)	134 (singleton cases)	39.0	13.0[a]
	Guinea, Mandiana prefecture, Haute Guinée (*75*)	Birth asphyxia (VA)	97	50.0	24.0
	Nigeria, Nko rural community, Cross River State (*76*)	Birth asphyxia (VA)	24	38.0	21.0
	Senegal (*77*)	Complications of labour (VA)	33	36.0	12.0
Sub-Saharan Africa *Afro E* (VR, no countries)	Ethiopia, 3 districts in North Gondar Admin. zone, Amhara region (*78*)	Birth injury/asphyxia (VA)	48	53	25.5
	Malawi, Lungwena rural community (*6–8*)	Abnormal delivery (VA)	28	37.0	22.0
	South Africa, Cape Town metropolitan area (*11*)	Hypoxia, birth trauma (perinatal database, medical records, postmortems)	248	10.0	26.0
	South Africa, Cape Town metropolitan area (*79*)	Fetal hypoxia and trauma (perinatal database, medical records, postmortems)	253	12.0	16.0
	United Republic of Tanzania, rural community, Mbulu and Hanang districts (*14*, *15*)	Asphyxia-related conditions excluding congenital malformations and immaturity	71	22.0	24.0
	Zimbabwe, Harare, 3 metropolitan area hospitals, maternity clinics and all registered deaths, police reports accounting for 95% of births (*80*)	Intrapartum asphyxia, birth weight ⩾ 1500 g, excluding congenital abnormalities (hospital and police records, expert opinion)	708	–	22.0[b]
Latin America/ Caribbean *Amro B* (VR, 7 countries)	Brazil, Municipality of Center-West region São Paulo (*81*)	Asphyxia/birth injuries (death certificates/hospital notes)	138	17	33.0
	Jamaica, all births in 1-year period (*82*)	Wigglesworth definition (death certificates/hospital notes. More than 50% had postmortem)	185	18.0	35.0
	Paraguay, Dept de Bioestrdistica data (*83*)	ICD codes (death certificates)	3638	20.0	35.0
Latin America/ Caribbean *Amro D* (VR, no countries)	Bolivia, El Alto community (*84*)	Asphyxia (VA, expert opinion)	79	47.0	36.7
	Guatemala rural community (*29*)	Asphyxia with specified intrapartum event. Prematurity/ congenital abnormalities excluded, comorbidity with infection allowed (VA, expert opinion)	36	37.0	22.0
	Nicaragua, Nicaragua City Hospital (*85*)	Asphyxia (hospital records, expert review)	72	12.0	19.4

(Table A.2, cont.)

Region *GBD subregion* (number of countries with VR data included)	Place and level of data collection	Case definition (method of cause attribution)	No. of neonatal deaths with cause of death reported	NMR per 1000 live births	Percentage of NMR related to intrapartum events
Middle East *Emro B*	Bahrain city, population-based (*30*)	ICD codes (death certificates/ hospital records)	228	7.8	11.4
(VR, 2 countries)	Bahrain city, population-based (*86*)	ICD codes (death certificates/ hospital records)	61	6.4	19.7
	Kuwait, Farwania, hospital (*87*)	Birth asphyxia	–	7.9	18.0
	Lebanon, South Beirut, hospital (*35*)	Parapartum hypoxia	22	–	15.0[b]
	Libyan Arab Jamahiriya, Benhazi city (*33, 34*)	Birth asphyxia and injury	245	–	14.0
	Saudi Arabia, Al Khobar hospital (*36*)	Asphyxia, trauma, antepartum haemorrhage (hospital records)	78	12.0	18.0
	Saudi Arabia, Assir region, hospital (*88*)	Asphyxia (hospital records)	184	9.6	11.4
	United Arab Emirates, Al-Ain district hospitals (*89*)	Asphyxial conditions (hospital records)	54	6.7	13.2
Middle East *Emro D*	Egypt, follow up of perinatal deaths identified in DHS survey sampling whole country (*39*)	Asphyxial conditions developing in labour and birth injuries (VA and expert opinion)	117	250	20.4
(VR, no countries)	Egypt, Beni Suef province, Upper Egypt (*90*)	Mechanical and anoxic trauma during labour/ delivery (VA)	41	49.0	13.0
	Pakistan, Lahore, 4 communities of differing socioeconomic status (*40, 41*)	Asphyxia neonatorum and birth trauma (VA)	80	54.0	28.0
	Pakistan, rural North-West Frontier, Balochisan, FATA provinces (*91*)	Birth asphyxia/birth injuries, convulsions in first day of life (VA)	649	57.0	18.5[c]
East Asia/Pacific *Searo B*	Indonesia, national representative sample (*92*)	ICD coding categories (VA)	180	35.0	28.0
(VR, no countries)	Sri Lanka, 2 hospitals in Colombo (*52*)	Birth asphyxia (hospital records)	120	15	20.0
	Sri Lanka, Galle district (*93*)	Birth trauma, asphyxia, aspiration (death certificates, hospitals, clinics)	253	23.0	20.6
	Sri Lanka, Health Unit Kopay, Jaffna district (*94*)	Birth asphyxia (expert opinion, hospital/other records)	51	18.0	19.6
	Thailand, 3 provinces (Narathiwat, Yala, Pattani) (*95*)	Birth asphyxia (VA)	26	11.0 (ENMR)	15.3[a]
	Thailand, Bang Pa-In district, central Thailand (*96*)	Asphyxia, birth trauma (VA, hospital records, postmortems)	27	31.0	22.7
South Asia *Searo D*	Bangladesh, rural community ICCDR,B (Matlab) (*97*)	Birth injury (VA)	69	70.0	17.0
(VR, no countries)	Bangladesh rural community ICCDR,B (Matlab) (*55*)	Labour complications (VA)	210	38.0 (ENMR)	25.0[a]
	India, rural community Gadchiroli district, Maharashtra state (*98, 99*)	Severe asphyxia: 5 mins after birth breathing slow, weak, gasping (VA)	36	40.0	22.0

(Table A.2, cont.)

Region *GBD subregion* (number of countries with VR data included)	Place and level of data collection	Case definition (method of cause attribution)	No. of neonatal deaths with cause of death reported	NMR per 1000 live births	Percentage of NMR related to intrapartum events
South Asia *Searo D*	India, rural community Maharashtra state (*100*)	Labour complications (VA)	75	52.0	18.0
(continued)	India rural community Maharashtra state (*101*)	Birth injury/fetal asphyxia during labour (VA)	82	22.0 (ENMR)	16.0[a]
	India, rural community Upper Assam (*59*)	Perinatal asphyxia and birth injuries (VA)	113	46.0	11.0
	India, rural community Uttar Pradesh (*62*)	Labour complications (VA)	103	–	24.0[a]
	India, Patna, urban and rural (*61*)	Birth injury/asphyxia (VA)	1000	44.0	26.0
Western Pacific *Wpro B* (VR, no countries)	China, urban and rural Stratified random sample of 29 hospitals in Shanghai municipality (*70*)	Intrapartum hypoxia (hospital data)	526	7.0 (ENMR)	22.3[b]
	China, ethnic populations in Guizhou province (*102*)	Labour complications (expert opinion, death certificates, other records)	1845	–	25.0
	China, Shunyi township (*103*)	Labour complications (expert opinion, death certificates, other records)	27	14.0	37.0
	Malaysia, hospital in Kelantan state (*104*)	Birth asphyxia and meconium aspiration syndrome (hospital records)	61	8.7	15.0
Total	30 countries, 46 studies (additional 48 countries with VR data, 97 297 neonatal deaths)	–	Cumulative sample size 12 355	–	–

GBD, Global burden of disease; NMR, neonatal mortality rate; VA, verbal autopsy; ICD, International Classification of Diseases; FATA, Federally Administered Tribal Areas; ENMR, early neonatal mortality rate. DHS, Demographic Health Surveys; ICCDR,B, International Centre for Diarrhoeal Disease Research, Bangladesh; Afro, WHO African Region; Amro, WHO Region of the Americas; Emro, WHO Eastern Mediterranean Region; Euro, WHO European Region; Searo, WHO South-East Asia Region; Wpro, WHO Western Pacific Region.

Note: if the publication applied a case definition different to the standard used for these estimates, the numbers in the table may differ from the reported rates or proportions as we re-calculated where necessary to allow comparability across studies.

[a] Publication reports 3% proven perinatal hypoxia (case definition not given) but 17 (13%) of cases died after complicated labour lasting over 24 hours so the latter proportion was applied and may still be an underestimate as it does not include sudden events such as antepartum haemorrhage.

[b] Proportion adjusted to all neonatal deaths from early neonatal proportion assuming that no deaths related to acute intrapartum events occurred in the late neonatal period and that 74% of neonatal deaths occurred in the first week (global average).

[c] Publication reports 12%. Personal communication with author (Fikree F, May 2003) provided unpublished information to redistribute categories of causes of death based on symptoms (e.g. convulsions, cyanosis).

Table A.3. **Regional epidemiological analysis categories for Global Burden of Disease (GBD) 2000 project: GBD regions and 17 subregions**

GBD region	Reporting subregion	WHO Member States
AFRO	AFRO D	Algeria, Angola, Benin, Burkina Faso, Cameroon, Cape Verde, Chad, Comoros, Equatorial Guinea, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Liberia, Madagascar, Mali, Mauritania, Mauritius, Niger, Nigeria, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Togo
	EMRO D	Djibouti, Somalia, Sudan
AFRO	AFRO E	Botswana, Burundi, Central African Republic, Congo, Côte d'Ivoire, Democratic Republic of the Congo, Eritrea, Ethiopia, Kenya, Lesotho, Malawi, Mozambique, Namibia, Rwanda, South Africa, Swaziland, Uganda, United Republic of Tanzania, Zambia, Zimbabwe
AMRO	AMRO A	Canada, United States of America
AMRO	AMRO B	Antigua and Barbuda, Argentina, Bahamas, Barbados, Belize, Brazil, Chile, Colombia, Costa Rica, Dominica, Dominican Republic, El Salvador, Grenada, Guyana, Honduras, Jamaica, Mexico, Panama, Paraguay, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Suriname, Trinidad and Tobago, Uruguay, Venezuela
	AMRO A	Cuba
AMRO	AMRO D	Bolivia, Ecuador, Guatemala, Haiti, Nicaragua, Peru
EMRO	EMRO B	Bahrain, Cyprus, Iran (Islamic Republic of), Jordan, Kuwait, Lebanon, Libyan Arab Jamahiriya, Oman, Qatar, Saudi Arabia, Syrian Arab Republic, Tunisia, United Arab Emirates
EMRO	EMRO D	Egypt, Iraq, Morocco, Yemen
EURO	EURO A	Andorra, Austria, Belgium, Croatia, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Israel, Italy, Luxembourg, Malta, Monaco, Netherlands, Norway, Portugal, San Marino, Slovenia, Spain, Sweden, Switzerland, United Kingdom
EURO	EURO B	Albania, Bosnia and Herzegovina, Bulgaria, Georgia, Poland, Romania, Slovakia, the former Yugoslav Republic of Macedonia, Turkey, Yugoslavia
EURO	EURO B	Armenia, Azerbaijan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan
EURO	EURO C	Belarus, Estonia, Hungary, Kazakhstan, Latvia, Lithuania, Republic of Moldova, Russian Federation, Ukraine
SEARO	SEARO B	Indonesia, Sri Lanka, Thailand
	WPRO B	Malaysia, Philippines
	WPRO A	Brunei Darussalam, Singapore
SEARO	SEARO D	Bangladesh, Bhutan, India, Maldives, Nepal
	EMRO D	Afghanistan, Pakistan
WPRO	WPRO A	Australia, Japan, New Zealand
WPRO	WPRO B	China, Mongolia, Republic of Korea
	SEARO D	Democratic People's Republic of Korea
WPRO	WPRO B	Cambodia, Lao People's Democratic Republic, Viet Nam
	SEARO D	Myanmar
WPRO	WPRO B	Cook Islands, Fiji, Kiribati, Marshall Islands, Micronesia (Federated States of), Nauru, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tonga, Tuvalu, Vanuatu

AFRO, WHO African Region; AMRO, WHO Region of the Americas; EMRO, WHO Eastern Mediterranean Region; EURO, WHO European Region; SEARO, WHO South-East Asia Region; WPRO, WHO Western Pacific Region.

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