National, regional, and worldwide estimates of stillbirth rates in 2015, with trends from 2000: a systematic analysis

Hannah Blencowe, Simon Cousens, Fiorella Bianchi Jassir, Lale Say, Doris Chou, Colin Mathers, Dan Hogan, Suhail Shiekh, Zeshan U Qureshi, Danzhen You, Joy E Lawn, for The Lancet Stillbirth Epidemiology Investigator Group*

Summary

Background Previous estimates have highlighted a large global burden of stillbirths, with an absence of reliable data from regions where most stillbirths occur. The Every Newborn Action Plan (ENAP) targets national stillbirth rates (SBRs) of 12 or fewer stillbirths per 1000 births by 2030. We estimate SBRs and numbers for 195 countries, including trends from 2000 to 2015.

Methods We collated SBR data meeting prespecified inclusion criteria from national routine or registration systems, nationally representative surveys, and other data sources identified through a systematic review, web-based searches, and consultation with stillbirth experts. We modelled SBR (≥28 weeks' gestation) for 195 countries with restricted maximum likelihood estimation with country-level random effects. Uncertainty ranges were obtained through a bootstrap approach.

Findings Data from 157 countries (2207 datapoints) met the inclusion criteria, a 90% increase from 2009 estimates. The estimated average global SBR in 2015 was 18·4 per 1000 births, down from 24·7 in 2000 (25·5% reduction). In 2015, an estimated 2·6 million (uncertainty range 2·4–3·0 million) babies were stillborn, giving a 19% decline in numbers since 2000 with the slowest progress in sub-Saharan Africa. 98% of all stillbirths occur in low-income and middle-income countries; 77% in south Asia and sub-Saharan Africa.

Interpretation Progress in reducing the large worldwide stillbirth burden remains slow and insufficient to meet national targets such as for ENAP. Stillbirths are increasingly being counted at a local level, but countries and the global community must further improve the quality and comparability of data, and ensure that this is more clearly linked to accountability processes including the Sustainable Development Goals.

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Introduction

WHO first published national, regional, and worldwide estimates of stillbirths in 2011, highlighting the large global burden of stillbirths, with an estimated 2·6 million women and families affected in 2009.[1] This process also showed the dearth of reliable data in the regions where most stillbirths occur. In 2014, the Every Newborn Action Plan, a global multipartner movement to end preventable maternal and newborn deaths and stillbirths, set a target for national stillbirth rates (SBRs) of 12 or fewer stillbirths per 1000 births in all countries by 2030, accompanied by action in countries to address disparities.[2] This stillbirth target was included in response to the requests of many countries during the consultation process.[3] To achieve this target, countries will need to act to reduce preventable stillbirths and improve monitoring of SBRs.[4,5]

In this study, our objective was to estimate national, regional, and worldwide stillbirth rates and absolute numbers for 195 countries in both 2000 and 2015, to enable an assessment to be made of the extent to which SBRs have changed over time.

We sought to improve on the 2011 WHO exercise and our work previous to that[6] in terms of both the quantity of SBR data, by undertaking more extensive searches, and the quality of the data, by applying more stringent inclusion and exclusion criteria. Variation in definitions used for stillbirths affects comparability. For this exercise, we examined the effect of different definitions, and sought to adjust all input SBR data to correspond to a standard definition (≥28 weeks' gestation) before modelling.

We present our methods and results using the Guidelines for Accurate and Transparent Health Estimates Reporting (GATHER) checklist. This is a new reporting checklist for worldwide health estimates that promotes transparency, including the sharing of input data and modelling code.[7]

Methods

Data inputs

For the purposes of these estimates, we defined a stillbirth as a baby born with no signs of life at 28 weeks' gestation or more (third trimester; panel). When

Research in context

Evidence before this study
Previous global estimates for stillbirths have been undertaken, of which the most recent was for 2009 by WHO.[1] Stillbirths were not tracked under the Millennium Development Goals, and progress in reducing stillbirths is slower than that for maternal or neonatal deaths. In 2014, the Every Newborn Action Plan set a target of a national stillbirth rate of 12 or fewer stillbirths per 1000 births by 2030 and to address within-country disparities in all countries. However, stillbirths are still not included in global burden estimates or global goals.

Added value of this study
Through systematic searches (national statistical office, ministry of health and nationally representative household survey websites, and published literature) and consultation with a group of stillbirth investigators to identify further unpublished stillbirth data, we compiled the largest stillbirth rate dataset so far. The final dataset included 2207 datapoints from 157 countries, almost doubled from 1149 datapoints from 135 countries in the previous estimation exercise. This increase was predominantly due to increased data availability

from national routine data sources in middle-income countries. We also improved the consistency of the stillbirth definitions, and strengthened the criteria for quality of data. These national stillbirth rates estimates are for 195 countries for 2015 with time-trends from 2000.

Implications of all the available evidence
We estimate that 2·6 million (uncertainty range 2·4–3·0 million) babies were stillborn in 2015, affecting women and their families in all settings. 98% were in low-income and middle-income countries, of which over two-thirds were in sub-Saharan Africa and southern Asia. Data from 39 countries with complete time series shows slow progress in reducing this burden. Nearly half (45%) of the data available is for the 2% of stillbirths from developed regions, and more must be done to close this data gap and improve data quality and comparability in all settings. Stillbirths are increasingly being counted at a local level; however, absence of global goals and reporting mechanisms continues to restrict their visibility, especially in the countries with the greatest disease burden. Unless this changes, stillbirths are likely to remain invisible beyond 2015.

See **Online** for appendix

For the **DHIS2** see https://www.dhis2.org/

For more on the **DHS programme** see http://www.dhsprogram.com

presenting results by region, we used the Millennium Development Goal (MDG) regions (appendix pp 3–4).

The database for the previous WHO stillbirth estimates[1] included 1149 datapoints covering the period 1995–2009, and this was updated with data covering the whole period from 1990 to 2015. SBR data were identified from multiple sources (figure 1) including national routine data defined as data from national systems such as civil registration and vital statistics (CRVS) systems, national health management information systems (HMIS), and birth registries; nationally representative surveys including demographic and health surveys (DHS) and reproductive health surveys (RHS); and subnational data sources including population-based studies (eg, from demographic surveillance sites or research studies), and facility-based data.

To identify routine national data, we searched the websites of the national statistical office and ministry of health of all countries. For countries where routine CRVS systems are less well developed (those outside the MDG Developed region), we identified additional sources of data for SBRs. These included compiling all DHS and RHS reports from the DHS programme website, and undertaking a systematic search of the published literature (appendix pp 5–7). Searches included terms relating to the following key concepts: "stillbirth", "stillbirth timing", "rate/prevalence", and "low and middle income (LMIC) countries". MESH headings were used where available. Because SBR data can be collected in other programme and study settings, but not reported via the above mechanisms, a Stillbirth Epidemiology Investigator Group was convened to identify further unpublished stillbirth rate data, with calls for data distributed via relevant groups and list serves, and investigators from individual studies

approached (appendix p 8). An effort was made to include HMIS data from the District Health Information Systems 2 platform, with emails sent to national contact persons.

WHO's country consultation process was used to confirm, for every country, the validity of the data from that country included as inputs in the estimation process, and to ask for any additional data. Preliminary estimates were also circulated to WHO member states for review. New or updated country-year observations (282 from 25 countries) were added through the consultation process in July and August, 2015—mainly more recent data, or resubmitted data using the 28 week or more definition.

We assessed all reports that included more than 50 total births with a midpoint of data collection of 1990 or later and in which an SBR was given or could be calculated. Although we aimed to estimate SBRs using the 28 week or more definition, in the input database, we included SBR data using other definitions. Data reports from specialised services such as diabetes, hypertension, or growth restriction clinics or on specific subpopulations or ethnic groups were excluded as non-generalisable. We classified health facility data as likely to have minimum bias, where the facility covered more than 90% of births in the population. We excluded population-based prospective studies with rates of loss to follow-up of more than 20% of pregnant women. Similar to the approach taken for the previous stillbirth estimates, data from health facilities with potential for greater bias were included and identified using a dummy variable.[1]

Premodelling adjustments

Before applying exclusion (implausibility) criteria and modelling, data inputs with a non-standard stillbirth

definition were adjusted to correspond with the 28 week or more definition. For 15 countries in the MDG Developed region with high quality CRVS data, where stillbirth rates based on more than one definition were available for a given year, a pooled estimate of the adjustment factor was calculated using all years with more than one definition from that country, and the stillbirth rates were adjusted for all years reporting only an alternative definition using this adjustment factor. For 34 countries in the MDG Developed region without such data, the rates were adjusted on the basis of meta-analyses of data from countries in the same region. For example, based on a meta-analysis of 139 country-years of data, where the 28 week or more rate was 32% lower than the 22 week or more rate, a data source reporting a stillbirth rate of 6·2 using the 22 week or more definition was adjusted as follows: 6·2×0·68=4·2 stillbirths at 28 weeks or more per 1000 total births (panel; appendix pp 72–75). For countries in other regions (n=146), data were adjusted based on a meta-analysis of data from the WHO global survey on maternal and perinatal health and the WHO multicountry survey on maternal and newborn health, which included more than 0·5 million births (appendix pp 75–76).[11,12] Data were not available for gestational age in these facility-based surveys, so the 500 g and 1000 g cutoffs were used to approximate 22 weeks and 28 weeks, respectively. Although our new meta-analysis of routine data from high-income settings shows that use of a 1000 g cutoff instead of a 28-week based one underestimates the gestational age rate by around 15% (panel), this effect could be less in LMICs, where a greater proportion of stillbirths are intrapartum at term without fetal growth restriction, owing to lower access to high quality intrapartum care. However, it was not possible to quantify the degree of underestimation, and currently it is assumed that birthweight and gestational age thresholds are equivalent for stillbirths in these regions; this assumption is likely to underestimate the true burden of stillbirths at 28 weeks or more.

Additionally, for countries with data for several years but small birth cohorts and hence relatively large annual variations in SBRs (coefficients of variation >10%; Cook Islands, Andorra, Iceland, Luxembourg, and Malta), data were smoothed using a moving average (appendix p 72).

Exclusion criteria

Underascertainment of stillbirths is recognised as a common problem across data sources, especially when using definitions with cutoffs close to the threshold of newborn viability. For example, fetal deaths are commonly coded as miscarriages when the health provider assesses the baby to be below the threshold of viability. While in many high-income countries this is most likely to affect fetal deaths at 22 weeks' and 23 weeks' gestation, in lower resource settings, without neonatal intensive care, fetal deaths up to 30 weeks' gestation might not be included in stillbirth figures.

Panel: Definition of stillbirth

A fetal death or stillbirth is defined as a baby born with no signs of life after a given threshold. For international comparison, WHO defines a stillbirth according to the 10th edition of the International Classification of Diseases (ICD-10) definition of late fetal death. ICD-10, which was developed several decades ago when gestational age assessment was not standard, gives birthweight as the first preference in the definition, with gestational age second. ICD-10[8] defines late fetal death as a death at a birthweight of 1000 g or more, if the birthweight is not available, a gestational age of 28 weeks or more or a length of 35 cm or more. The corresponding values are 500 g, 22 weeks, or 25 cm or more for early fetal death, and 500 g, 22 weeks, or 25 cm or more for miscarriage.

However, the birthweight and gestational age thresholds do not give equivalent results. This problem is compounded by the frequent occurrence of fetal growth restriction, associated with an adverse intrauterine environment before fetal death, and hence a birthweight-based cutoff will give a lower stillbirth rate than one based on gestational age. This difference is most marked the earlier the gestational age: in our new meta-analyses, stillbirth rates across high-income countries were 15% (95% CI 13–17) lower using a 1000 g or more definition compared with 28 weeks or more, whereas stillbirth rates in the USA are 40% lower with the 500 g or more definition compared with 22 weeks or more.

A gestational age threshold would be most appropriate because it is a better predictor of maturity and hence viability than is birthweight, with many fetuses at risk of stillbirth or preterm birth having preceding fetal growth restriction.[9] Information about gestational age is also more widely available than for birthweight for many stillbirths, with early ultrasound dating of pregnancies now standard of care in high-income and middle-income countries, and its use is increasing in low-income countries. Hence, most high-income and middle-income national routine data now include robust gestational age data. Even in settings where gestational age is mainly based on last menstrual period, which is less reliable than early ultrasound dating, it is more commonly available than birthweight, especially for those born at home where it is frequently seen as not culturally acceptable to weigh a stillborn baby.[10]

Therefore, we use a 28 week or more definition. Where possible, data were abstracted or requested according to this definition. Data with alternative definitions were adjusted to the 28 week or more definition (appendix pp 72–75).

We excluded datapoints likely to reflect poor case ascertainment based on a conservative implausibility criterion for the ratio SBR:neonatal mortality rate (NMR).[13] The median ratio of SBRs (≥28 weeks) to NMRs from the developed region was 0·9 (IQR 0·65–1·15). Ratios less than 0·33 (first centile) are likely to represent substantial under-recording of stillbirths in comparison with neonatal deaths. Generally, stillbirths are more poorly recorded than deaths of liveborn neonates, which are themselves under-recorded in many settings.[5,13] Because ratios within the normal range will be found where there is under-reporting of both stillbirths and neonatal deaths in a given data source—eg, in some household surveys—we calculated the ratio of the reported SBR (≥28 weeks) relative to the national estimate of NMR for the same year, and excluded datapoints with a ratio of less than 0·33 (n=116). No upper limit for the ratio was set. Although some misclassification of neonatal deaths as stillbirths can occur, especially in lower resource settings, this effect is

For the **UN Child Mortality Estimates** see http://www.childmortality.org/
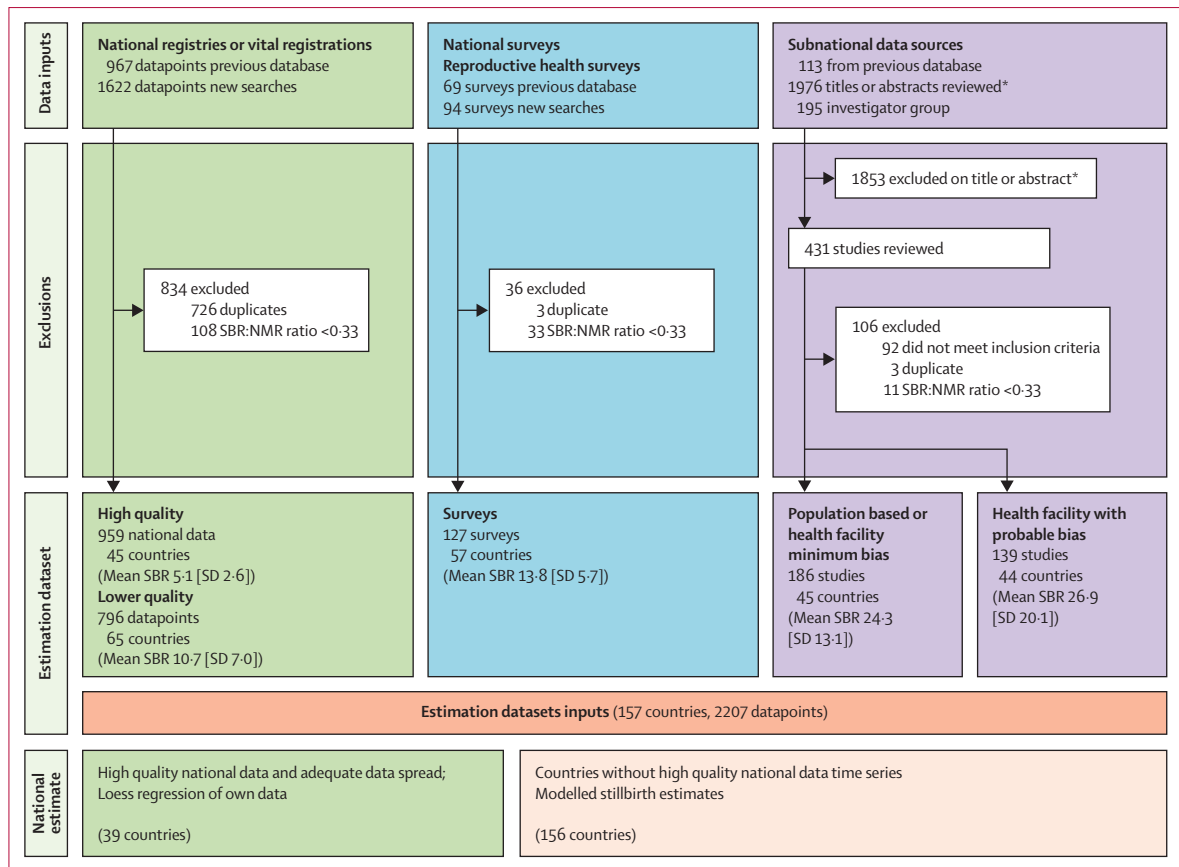
Figure 1: Flow diagram for input data
*See appendix p 7 for details. †Includes those with more than one definition for a given country year (n=432).

relatively small on the SBR:NMR ratio,[14] and evidence from high-income countries shows increasing SBR:NMR ratios as NMRs reduce below three per 1000 livebirths (appendix pp 8–9). Six datapoints had a ratio of more than 3·0, but these were small, high-income countries reporting very low NMRs in the given year, and the SBRs from these were in keeping with other years' estimates from these countries.

Classification of stillbirth data type
Included data were categorised into five classes, which were determined a priori, based on data type and quality. A dummy variable was created based on these five types (figure 1): national routine information systems, further categorised as high quality or lower quality; nationally representative retrospective household surveys; sub-national population-based data—ie, prospective population-based studies or health-facility-based data with minimum bias (covering >90% of births in the population); and other subnational data—ie, other health-facility-based data with possible sources of bias.

No previously established reliable quality criteria for assessing the capture of stillbirths were identified. Hence, in this exercise, data from national routine information

systems were categorised as being of high quality if they met the following criteria. First, if a functioning CRVS system was well established before 2000. Consistent with previous stillbirth estimates,[1] we used good vital registration for purposes of maternal mortality estimation, which included the requirement of a functioning CRVS system from 1996, including the ability to capture high quality information about maternal and perinatal outcomes.[15] Second, if the SBR (adjusted to 28 week definition) to national estimated NMR ratio was greater than 0·5 for all years in the time series. Third, if, for the given year, the country had a greater than 85% female child mortality capture[16] (a marker of CRVS system strength for capture of child outcomes; appendix pp 67–68).

For countries assessed as having high quality CRVS, we assumed that other routinely collected national data—eg, birth registry or HMIS data—would also be of high quality. All other country-years of national routine data not fulfilling all the above criteria were considered to be of lower quality (appendix p 69).

Model fitting
We modelled the natural logarithm of the SBR (≥28 weeks' gestation) as the outcome variable using

restricted maximum likelihood estimation and included a country-level random effect, using the same approach as the previous estimates.[1] We investigated multiple predictor variables with an established association with SBR, and with estimates available for all countries for the period 2000–15.

Potential predictors were selected based on the plausibility of an association with the SBR. These included distal determinants such as socioeconomic factors, and more proximal demographic and biomedical factors, markers of perinatal outcome and access to health care. All potential predictors with time series data or estimates available by country for 2000–15 were included in the model fitting process (appendix pp 76–77). Predictors were retained when the direction of the coefficient was biologically plausible. We sought to maximise the predictive power of the model, while avoiding overfitting. We removed one predictor at a time from the model, commencing with the predictor with the largest Bayesian information criterion (BIC) on univariate analysis, and refitted the model. If the model was improved by removing this predictor (lower BIC compared with the model containing the predictor), the predictor was dropped from the model. If the BIC was higher, the predictor was retained. We cycled through all the predictors once. For the 157 countries contributing data to the input dataset, the best linear prediction of the country-specific random effect was obtained.

The final model included: (natural log) of NMR, (natural log) low birthweight rate, (natural log) gross national income, mean years of female education, coverage of four antenatal care visits, the stillbirth data type (see above), and region (based on condensed Millennium Development Goal regions—Developed, South Asia and sub-Saharan Africa, and Other regions) (appendix p 77). Model performance was assessed with diagnostic plots (appendix pp 78–79).

Uncertainty estimation
Uncertainty estimates were generated with a bootstrap approach. For countries with high quality vital registration data for stillbirths, we assumed that the SE of the reported number of stillbirths was the square root of the reported number—ie, that the number of stillbirths was Poisson distributed (appendix p 99).

Generation of estimated national stillbirth rates and absolute numbers
For all countries the SBR was calculated as the number of stillbirths per 1000 total births, the total births including both livebirths and stillbirths ≥28 weeks.

Of the 45 countries classified as having high quality vital registration data for SBRs, 39 had complete time series data (earliest year of data available was before 2005, the latest year after 2010, and data were available for at least half of all years). For these countries, the country's own reported rates, adjusted where necessary
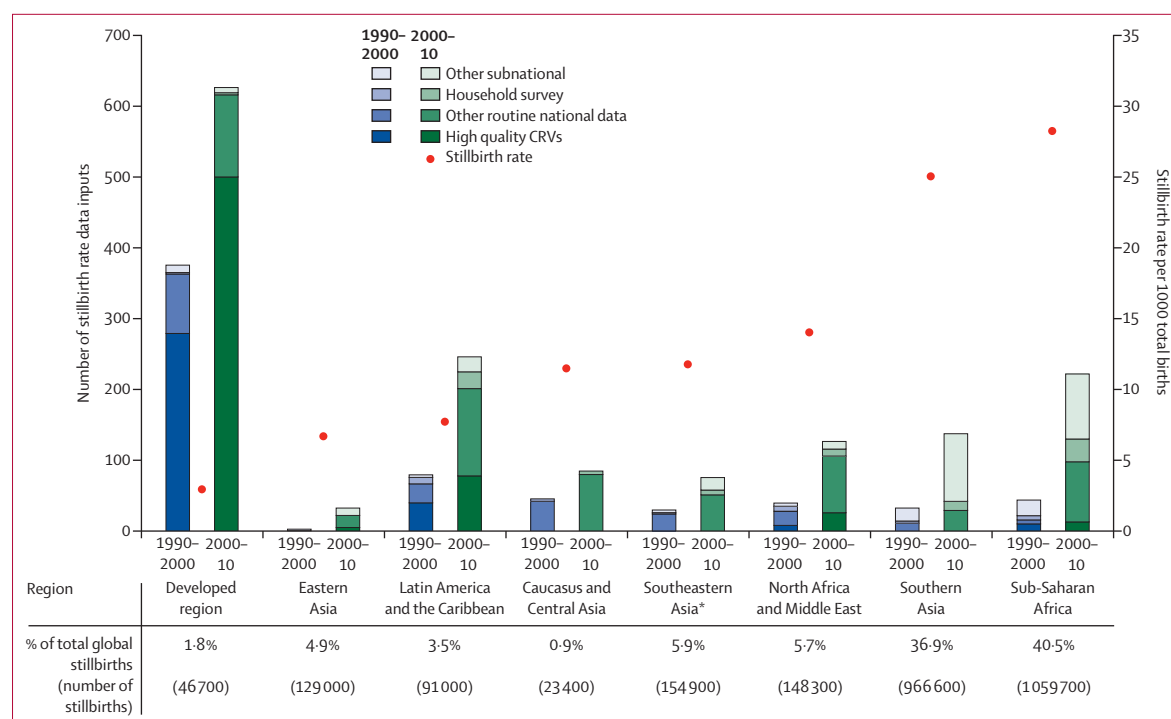

Figure 2: Availability and type of stillbirth data by region around 1990–2000 and 2000–10
See appendix p 67 for details. CRVS=civil registration and vital statistics.

(see above), were smoothed with loess regression to produce estimated trends for 2000–15 (figure 1; appendix pp 80–98). For all other countries, estimation and projection of SBRs was undertaken with the regression model as detailed above. For countries with data in the input dataset, the best linear unbiased prediction of the country-specific effect was included in the SBR prediction. For countries with no data, the random effect was assumed to be zero. The high quality national data (CRVS or birth registry) was used as the gold standard for prediction purposes for all countries. Livebirth estimates from the World Population Prospects, 2015 revision,[17] were used to estimate the absolute number of stillbirths using the following formula: number of stillbirths = livebirths × SBR / (1 − SBR).

Role of the funding source

The funders had no role in the study design, data collection, data analysis, data interpretation, or writing of the report. HB and JEL had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

The final SBR input dataset included 2207 datapoints from 157 countries (figure 1). Overall, we excluded 152 (6%) datapoints with an SBR:NMR less than 0·33. National surveys were more likely to have data excluded for this reason (33/160 [21%]) than were national CRVS or registry data (108/1863 [6%]) or subnational data sources (11/327 [3%]).

80% more datapoints were included from all regions than in previous estimates (appendix pp 67–68). Compared with the previous exercise, the greatest relative increases in datapoints were in sub-Saharan Africa (177%), southern Asia (190%), and eastern Asia (414%). An increase in subnational datapoints is seen; however, from a low baseline, large relative increases in routine national data availability have been seen in both sub-Saharan Africa and southern Asia regions (293% and 233% increase, respectively), with 37% of countries in sub-Saharan Africa and 44% of those in southern Asia now contributing national routine data. Data increases in Latin America and north Africa or west Asia are largely due to increases in data from routine national data sources since 2000 (figure 2). Nevertheless, no data were located for 38 countries, and only subnational data were available for nine sub-Saharan African and south Asian countries.

Important differences in the types of data available from different regions remain. More than 70% of countries in the developed, north Africa, west Asia, and Caucasus and central Asia regions have national data meeting the inclusion criteria for both 2000 and 2010, compared with around a quarter of countries in sub-Saharan Africa and southern and southeastern Asia in 2000. There is some evidence of improvement in these lower-income regions by 2010. However, for many of the large countries in these regions, the national data are from retrospective household surveys, which have major limitations for SBR capture, and further research is required to address these (figure 2; table 1).[5]

Table 2 shows the estimated coefficients for the predictors retained in the final model. Each unit increase in natural log NMR is associated with a 0·33 unit increase in natural log SBR. Unit increases in natural log low birthweight are associated with a 0·014 unit increase in natural log SBR, whereas a unit increase in natural log gross national income, coverage of four antenatal care visits, and female education are associated with decreases in natural log SBR (by 0·13, 0·004, and 0·03 units, respectively). Compared with high quality vital registration, facility-based data that are subject to bias are estimated to overestimate the SBR, whereas all other data sources tend to underestimate the SBR. The model seems to fit the data well overall (R^2=0·81), and both the estimates of the country-specific random effects

	Number of data inputs	Stillbirth rate (≥28 weeks)	SBR:NMR ratio
Good quality CVRS/ birth registry data	959	4·3 (3·3–6·2)	1·03 (0·80–1·30)
Poor quality CVRS/HMIS data	796	8·8 (5·6–13·8)	0·74 (0·52–1·05)
Population based (retrospective survey)	127	13·5 (9·7–16·6)	0·60 (0·47–0·73)
Population based or health facility, minimum bias	186	23·6 (15·9–31·7)	0·77 (0·61–1·00)
Health facility, likely bias	139	21·1 (10·8–36·0)	0·99 (0·68–1·38)

Data are n or median (IQR). See appendix pp 7–12 for details. SBR=stillbirth rate. NMR=neonatal mortality rate. CRVS=civil registration and vital statistics. HMIS=health management information systems.

Table 1: Stillbirth rate data by type and median rate, showing quality based on ratio of stillbirth rate to neonatal mortality rate

	Model coefficient (95% CI)
Neonatal mortality rate*	0·33 (0·29 to 0·38)
Low birthweight*	0·01 (0·01 to 0·02)
Gross national income*	–0·13 (–0·07 to –0·19)
Mean years of female education	–0·03 (–0·02 to –0·05)
Antenatal care (4 visits)	–0·004 (–0·001 to –0·006)
Region	
Developed	..
Sub-Saharan Africa/south Asia	0·33 (0·21 to 0·46)
All other regions	0·32 (0·16 to 0·49)
Data type	
High quality CRVS	..
Poor quality CRVS/HMIS data	–0·22 (–0·14 to –0·29)
Population-based (retrospective survey)	–0·36 (–0·27 to –0·46)
Population-based or health-facility, minimum bias	–0·11 (–0·02 to –0·20)
Health facility, likely bias	0·14 (0·04 to 0·23)

See appendix pp 76–77 for details. CRVS=civil registration and vital statistics. HMIS=health management information systems. *Natural log.

Table 2: Model coefficients for included predictor variables of stillbirth rates

	2000		2015		Annual rate of reduction in stillbirth rate 2000–15
	Stillbirth rate per 1000 total births (uncertainty range)	Number of stillbirths (uncertainty range)	Stillbirth rate per 1000 total births (uncertainty range)	Number of stillbirths (uncertainty range)	
Developed region	4·5 (4·4–4·6)	59 000 (58 000–61 000)	3·4 (3·4–3·5)	47 000 (46 000–48 000)	1·8
Southern Asia	35·5 (31·3–41·2)	1 443 000 (1 266 000–1 684 000)	25·5 (22·5–29·1)	967 000 (847 000–1 104 000)	2·2
Caucasus and Central Asia	16·8 (13·9–23·6)	23 000 (19 000–33 000)	11·9 (9·8–15·6)	23 000 (19 000–31 000)	2·3
Eastern Asia	14·3 (10·6–19·6)	240 000 (177 000–331 000)	7·2 (5·6–9·7)	129 000 (100 000–175 000)	4·5
Latin America	11·3 (10·3–12·8)	135 000 (123 000–153 000)	8·2 (7·5–9·2)	91 000 (83 000–103 000)	2·1
North Africa and Middle East	19·9 (17·7–23·6)	156 000 (139 000–185 000)	14·5 (12·9–17·5)	148 000 (131 000–180 000)	2·1
Southeastern Asia	17·0 (14·6–21·5)	194 000 (166 000–246 000)	12·2 (10·7–14·6)	155 000 (135 000–186 000)	2·2
Sub-Saharan Africa	35·6 (31·4–42·2)	1 000 000 (879 000–1 194 000)	28·7 (25·1–34·2)	1 060 000 (923 000–1 271 000)	1·4
Worldwide	24·7 (22·4–28·4)	3 250 000 (2 931 000–3 740 000)	18·4 (16·6–21·0)	2 620 000 (2 359 000–2 984 000)	2·0

See appendix p 3 for details.

Table 3: **Estimated stillbirth rates and number of stillbirths for 2000 and 2015, by Millennium Development Goal region**
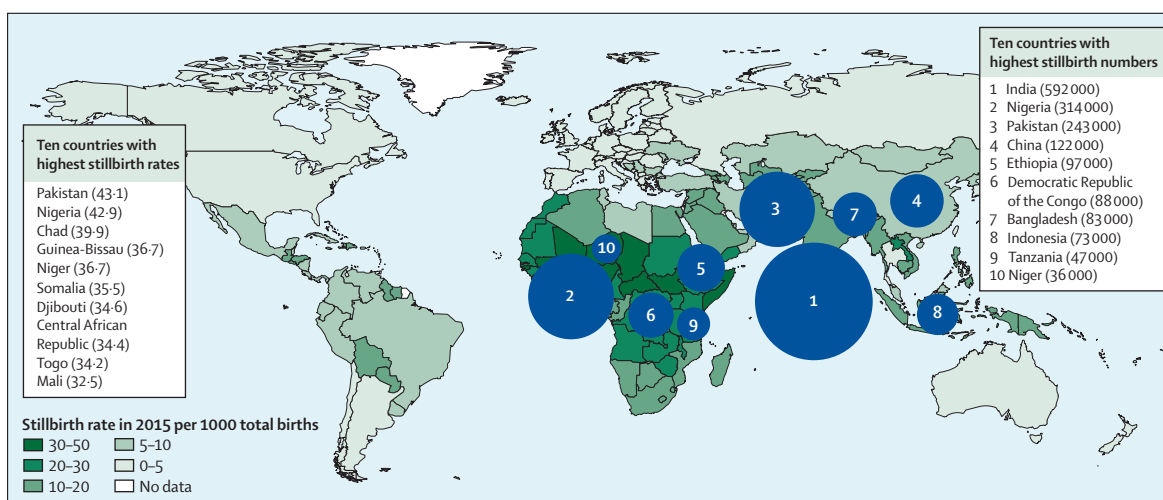

Figure 3: **Variation between countries in stillbirth rates in 2015 showing the ten countries with the highest rates, and those with the largest numbers**
See appendix pp 100–04 for details.

(SD 0·29) and the residuals for the individual datapoints included (SD 0·23) seem to be approximately normally distributed (appendix pp 78–79).

We estimate that the global SBR in 2015 was 18·4 per 1000 births (uncertainty range 16·6–21·0), down from 24·7 in 2000 (22·4–28·4; table 3). This represents an estimated 25·5% decline in the global SBR over this period. Although the uncertainty around this estimated reduction is sizeable (uncertainty range 6·6–41·5%), some decline in stillbirth rate over this time period is likely. The absolute number of stillbirths is estimated to have declined from 3·25 million in 2000 (uncertainty range 2·93–3·74 million) to 2·62 million in 2015 (2·36–2·98 million), a 19·4% decline (–1·8 to 36·9%). The highest burden, both in terms of stillbirth rates and numbers of stillbirths, continues to be

found in sub-Saharan Africa and southern Asian regions: 98% of all stillbirths occur in low-income and middle-income countries; 77% in south Asia and sub-Saharan Africa (table 3; figure 3). The estimated rate of reduction in stillbirth rates remains slowest in sub-Saharan Africa (1·4%), despite high baseline stillbirth rates. At a national level for 2015, six countries in western Europe were predicted to have SBRs of less than two per 1000 total births, whereas Pakistan and 13 countries in sub-Saharan Africa had estimated stillbirth rates of more than 30 per 1000 total births, with relatively slow progress since 2000 (appendix pp 100–05).

Our global and regional stillbirth rate estimates are within the uncertainty bounds of those from the last estimation round. Our current estimate of the global

stillbirth rate in 2009 is 20·3 (uncertainty range 18·4–23·0), compared with 18·9 (15·2–27·3) in the previous estimates. Of note, these two sets of estimates are not directly comparable. In this study, we attempted to estimate stillbirth rates using the 28 week or more definition, which would be expected to result in higher rates than in estimates based mainly on birthweight from the previous exercise. Changes for individual countries are mainly those for which new data have become available (appendix pp 8–67).

Discussion

Our estimates suggest that 2·6 million (2·4–3·0 million) babies were stillborn at 28 weeks or more in 2015. This represents a large burden for women, families, communities, and health-care providers.[18] Progress in reducing stillbirth rates is slower than that required to meet targets set to end preventable stillbirths,[3] and considerably slower than for maternal mortality reduction and for child mortality reduction, especially after the first month of life.[19] Despite this large burden, stillbirths remain barely visible on the global policy agenda.[20]

These new estimates are based on 80% more national datapoints than our previous estimates, with more such datapoints in all regions—notably from south and east Asia and sub-Saharan Africa (appendix pp 67–68). National-level data, from routine national data sources or nationally representative surveys, were available for more than three-quarters of countries in most regions, apart from sub-Saharan Africa (61% countries with national data) and southeastern Asia (32% of countries). However, there still remains huge variation in data availability and quality, especially over time, to enable improved tracking of stillbirth rate trends. Despite some progress, almost half (45%) of all datapoints are from the developed region, which accounts for fewer than 2% of the world's stillbirths, with only 17% from sub-Saharan Africa and south Asia, which account for 77% of stillbirths and where the stillbirth rate is ten-fold higher (figure 2).

Although we tested a wider range of potential predictors of stillbirth in this exercise, the final model was broadly similar to that used in the last exercise. Of the predictors retained in the model, low birthweight can be secondary to both fetal growth restriction and to preterm birth. Both fetal growth restriction and preterm birth are strongly associated with placental dysfunction and subsequent poor fetal health, which carry increased risk of both antepartum stillbirth, and, for a compromised fetus who handles the labour process poorly, intrapartum stillbirth. Of the other predictors, antenatal care coverage, neonatal mortality, and gross national income are associated with access to health-care services during pregnancy and at the time of birth. Stillbirth rates are highly sensitive to access to timely high quality antenatal and intrapartum monitoring and care;[19] however, the available indicators for these capture only coverage, and not effective coverage or the quality of these interventions. Women's empowerment plays an important part in reducing stillbirths, because women are able to maximise their prepregnancy health, access family planning enabling them to plan the timing of their pregnancies when desired, and demand and engage in high-quality antenatal and intrapartum care.[21] Our model includes mean years of maternal education, which might capture some of the variation in women's empowerment across settings.

Our estimates represent third trimester stillbirths and hence undercount the true burden if earlier fetal deaths were included. In high-income settings around half of fetal deaths at 20 weeks or more occur before 28 weeks' gestational age.[22,23] Further research is required to quantify the effect of including all fetal deaths of 20 weeks or more across low-income and middle-income settings. Stillbirth capture is lower around the threshold of viability. It is plausible therefore that in settings without neonatal intensive care, with near-universal neonatal mortality among babies born at less than 28 weeks, that these babies would be under-captured in statistics.

We sought to identify national routine data of the highest quality and use this as the gold standard for prediction purposes. No guidelines exist on the optimum classification of quality of stillbirth rate data from national routine sources. We sought to apply criteria consistent with previous estimation exercises; however, we were constrained by the availability of routine data sources to assess quality—notably reporting by gestational age—and further research is required to optimise these parameters. As in previous exercises, the results of our model suggest that population-based data sources outside of the developed regions consistently under-report SBRs compared with high quality routine national data systems, and have much wider uncertainty (table 1). For countries without high quality CRVS time series data, the estimated trends are mainly driven by covariate data, which might not fully capture any changes in stillbirth rates over the same time period.

A major limitation is the low quality of some of the data available. We excluded 152 so-called implausible datapoints based on a simple assessment of the SBR:NMR ratio. Of included datapoints, the median ratio of SBR:NMR in DHS/RHS was 0·6 (IQR 0·47–0·73) compared with 1·03 (0·80–1·30) for higher quality CRVS (table 1)]. More research regarding the SBR:NMR ratio, and other markers of quality—eg, markers of birth outcome capture measured around the threshold of viability where under-reporting is more common,[24] the use of intrapartum or antepartum stillbirth ratios and birthweight, or gestational age distributions in stillbirths—will be important to ensure that increases in data quantity can also be better assessed for quality.

Progress has recently been made in estimation of neonatal mortality rate, which shifted from intermittent estimates up to a decade apart to annual UN national estimates, with improvements in modelling and high visibility in UNICEF reports alongside child mortality, in

	High-income countries	Middle- income countries	Low-income countries (mainly sub-Saharan Africa and South Asia)
Data platforms	Vital registration—full coverage National perinatal and maternal mortality audit and strong Health Information Systems	Vital registration and HMIS—high coverage, quality may be variable Audit may not be full coverage	Limited vital registration 5 yearly national household surveys HMIS—variable coverage and quality 84% of global neonatal deaths and 81% of stillbirths
Counting all livebirths	Consistent counting of all livebirths regardless of gestation, noting if singleton or multiple birth		
Comparable definitions to count stillbirths	All countries to report stillbirths ≥28 weeks' gestation definition for international comparison and intrapartum stillbirth rate for same stillbirth definition (we propose a shift to gestational age as basis for stillbirth definition)		
	Record all stillbirths from 22 weeks and 28 weeks and birthweight (whilst collecting by other national definition for stillbirth if required—eg, 20 weeks in USA, Australia, New Zealand)		Prioritise collection of representative data for ≥28 week stillbirths and intrapartum stillbirths Promote standardised clinical records in facilities and strengthen facility recording and reporting mechanisms
Categorising small babies (weight and gestational age)	All babies (live and stillbirths) to be weighed at birth and recorded on birth and death certificates, whilst also improving and recording gestational age		
	Gestational age to be assessed using routine high-quality early pregnancy ultrasound and recorded on birth and death certificates Track the % of births that are reported <28 weeks (noting that if under 3% of preterm births are <28 weeks the system may be underrecording preterm births)		Gestational age to be assessed in all babies using simplified clinical examination or last menstrual period where early pregnancy ultrasound is not available Improved technology and low-cost assessment tools required to increase reliability
Collecting more detailed data on equity and improve linkage of data to action	Vital registration using death certificates which include birthweight and gestational age and maternal conditions Health facility surveillance with detailed dataset Cross-link vital registration and health facility databases to maximise capture Analyse to track and target disparities		Ensure that large-scale retrospective household surveys include more reliable measure of stillbirth (eg, pregnancy history as opposed to livebirth history) Consider including stillbirth data in middle-income countries surveys Consider developing or enhancing sentinel surveillance sites for pregnancy, child, and other health outcomes (prospective), with a focus on enhancing national representativeness and coverage of the poorest Improve vital registration systems and include stillbirths Use death certificates which include birthweight and gestational age and associated maternal conditions Track urban/rural and other key disparities
	Invest in making the data accessible (eg, online) and in communication approaches (eg, score cards and infographics)		
Comparable cause of death categories and linked to risks including maternal	Consensus on a minimum dataset to be collected on all stillbirths, neonatal deaths with a limited number of programmatically relevant, causal categories which are linked to ICD codes and that can be assigned using verbal autopsy, but can be further expanded in settings where detailed clinical data and diagnostics are available Include a direct fetal or neonatal causal group and cross-tabulate with associated maternal conditions[28]		

Adapted from the *Lancet* Every Newborn series analysis (appendix p 76),[3] following WHO technical consultation on newborn health indicators and the findings of the *Lancet* Ending preventable stillbirths Series.[19–21,29]

Table 4: Potential considerations in improving the measurement of stillbirths

part driven by the MDG 4 target (appendix p 208).[25,26] This should also be possible for stillbirths, but will require increased leadership and accountability for the data.

Improving measurement of stillbirths must occur alongside improvements in recording of all birth outcomes for mothers and their babies. The limitations of global estimates have been highlighted,[27] and efforts to support systems working towards high-quality reported data are sorely needed. Table 4 highlights some of the factors to be considered when seeking to improve the quality and availability of SBR data. Further recommendations regarding other aspects of stillbirth data, such as classification systems, are outlined in the *Lancet* Ending preventable stillbirths Series.[19] SBR data are collected and collated through death certificate data or routine hospital data—eg, birth registries, perinatal death surveillance, or hospital management information systems, linked to CRVS systems—in most high-income and many middle-income countries; however, inconsistent stillbirth definition makes comparisons of SBR data between countries and over time challenging. This could be rapidly remedied by consistent use of a gestational age threshold (≥22 and ≥28 weeks).

However, most stillbirths occur in settings without strong CRVS and routine data systems. As these systems develop, priorities should include ensuring that all facility births, including stillbirths, are recorded and collated in routine health information systems, linked to CRVS and made available in the public domain. The current expansion of DHIS2 provides a platform for this, and could rapidly increase the quantity of SBR data available. Integration of perinatal deaths into maternal death surveillance and response where available is another potential source of improving data availability and of facilitating data-based action at a local level. All facility births should also be registered, including details on vital status, gestational age, and birthweight. To achieve this, further work is required to improve both

For the **WHO indicators** see http://www.who.int/maternal_child_adolescent/documents/newborn-health-indicators/en/

birthweight measurement and the accuracy of gestational age assessment. Assessment of gestational age is a crucial metric to enable improved capture of birth outcomes. Currently, assessments are restricted by the methods used, especially in settings where routine first trimester ultrasound dating is not widespread.[30–32] Possible approaches to improve gestational age could include improving recall of last menstrual period, biomarkers, ultrasound assessment of gestational age after the first trimester, and improved algorithms to enable a best gestational age estimate.[30,33] At a minimum, death records should include the time of death (antepartum, intrapartum, or age at neonatal death). Currently, time of death is poorly assessed and recorded, but should be possible for all facility births.[3,13,34,35]

For the 45 million births occurring outside facilities, most without a skilled attendant, household surveys are the largest source of population-based SBR data. However, the capture of stillbirths in these surveys remains mainly low quality. Recent evidence has highlighted the stigma and taboos around stillbirths that persist in many cultures, which might affect a woman's or family member's response to a survey question.[18,36,37] Despite being listed as a top priority to improve the SBR data inputs in 2011,[5] no research has yet been undertaken to compare pregnancy and livebirth history modules in terms of accuracy, time load, and relative costs, or to investigate the process of stillbirth data collection in surveys, including standard operating procedures for interviewers for this potentially sensitive information, especially where interviewers are male. Such research is urgently needed.[38]

Our estimates, even given the uncertainty in high-burden countries, indicate a large number of stillbirths, and little progress in reducing them. As the Sustainable Development Goal (SDG) era begins, stillbirths have gained some visibility. Despite no SDG target,[21] the Every Newborn Action Plan included a national target[2] and the WHO Global Reference List of 100 Core Health Indicators lists SBR.[39] Increasingly, stillbirths are routinely reported in national data and, especially in low-income and middle-income countries, there is an increase in population-based SBR data.

We welcome these changes. However, to ensure continued and increased momentum, as well as more and better data, leadership is required.[1,35] The high burden alone has been insufficient to drive appropriate action. More voice must be given to affected families, especially women. The leadership gap must also be addressed to ensure the gains in women's and children's health are accompanied by comparable reductions in stillbirths, especially in high-burden countries where most stillbirths could be prevented with known, low-cost, and effective interventions.

The Lancet Stillbirth Epidemiology Investigator Group
Jun Zhu, Juan Liang, Yi Mu, Xiaohong Li (National Office for Maternal and Child Health Surveillance of China, West China Second University Hospital); Anthony Costello, Tim Colbourn, Edward Fottrell, Audrey Prost, David Osrin, Carina King, Melissa Neuman (University College London [Institute for Global Health], Women Group's trials: Bangladesh-PCP, Ekjut-India, India—Society for Nutrition, Education and Health Action, Nepal-Dhanusha, Nepal-Makwanpur, Malawi-MaiMwana, Malawi-MaiKhanda); Neena Shah More (Society for Nutrition, Education and Health Action, Mumbai, India); Kishwar Azad (Diabetic Association of Bangladesh Perinatal Care Project, Bangladesh); Dharma Manandhar (Mother and Infant Research Association [MIRA], Nepal); Nirmala Nair, Prasanta Tripathy (Ekjut, Jharkhand, India); Rajesh Kumar, Ariarathinam Newtonraj, Manmeet Kaur, Madhu Gupta (Department of Community Medicine, School of Public Health, Post Graduate Institute of Medical Education and Research, Chandigarh, India); L K Dhaliwal, Neelam Aggarwal, Venkateshashan (Post Graduate Institute of Medical Education and Research, Chandigarh, India); Deepak Chawla, Anju Hurja (GMC32); Poonam Shivkumar, Manish Jain (MGIMS, Wardha); Geeta Gathwala, Smiti Nanda (PGI Rohtak); Shashi Gupta (GMC–Jammu); Sangeeta Singal, Raj Kumar (Civic Hospital, Panchkula); Sujata Sharma (GMCA, Punjab), Manjit Mohi (GMC Patiala); Santish Minhas (IGMC, Shimla); Rajendra Prasad, Suresh Verma (GMC, Kangra, Tanda); Neena Raina (WHO Regional office for South-East Asia); Aimable Musafili (Uppsala University); Beena Varghese (Public Health Foundation of India); Robert Pattison (South African Medical Research Council, Maternal and Infant Health Care Strategies Unit); Jane Hirst (University of Oxford); Peter Waiswa (INDEPTH network—Maternal Newborn Working Group; Makerere University, School of Public Health); Daniel Kadobera (Iganga HDSS); Sanni Kujala (Iganga HDSS; Karolinska Institutet); Anna Bergstrom (NeoKIP, Uppsala University); Tambosi Phiri, Jennifer A Hall (University College London [Institute for Global Health], MaiMwana, Malawi]; Louise T Day, Stacy L Saha, Shafiul Alam (LAMB Integrated Rural Health and Development, Bangladesh); Anisur Rahman, Shams El-Arifeen (iccdr-b); Sayed Rubayet (Save the Children); Ahmed Ali Hassan (Sudan Stillbirth Society and former MSF staff); Lucy Smith, Bradley N Manktelow, Elizabeth S Draper (University of Leicester, MBRRACE-UK); Nanbert Zhong (Peking University Center of Medical Genetics, New York State Institute for Basic Research in Developmental Disabilities); Jans Langhoff-Roos (University of Copenhagen); Vicki Flenady (Mater University); Kärt Allvee (Estonian Birth and Abortion Registries); Mika Gissler (THL National Institute for Health and Welfare, Finland); Nicholas Lack (Germany); Sonam Wangdi (Ministry of Health Bhutan); Jan Cap, Zuzana Podmanicka (Statistics Slovakia); Katarzyna Szamotulska (Poland); Chantal Hukkelhoven, Joyce Dijs-Elsinga (Perined, Netherlands); Theopisti Kyprianou (Statistical Office, Ministry of Health, Cyprus); Kari Klungsøyr (The Medical Birth Registry of Norway, Norwegian Institute of Public Health); Flor de Maria Herandez (Instituto Nacional de Estadistica, Guatemala); Ala Curteanu (Mother and Child Institute, Chisinau, Republic of Moldova); Henrique Barros, Sofia Correia (Epidemiology Research Unit [EPIUnit]—Institute of Public Health, University of Porto, Portugal); Shorena Tsiklauri (GEOSTAT); Ellen Lundqvist (National Board of Health and Welfare, Sweden); Tinga Fulbert Ilboudo (DHIS2—Burkina Faso); Abdouli Bah, Lamin Jawara (HMIS, The Gambia); Jennifer Zeitlin (EUROPERISTAT); Jelena Isakova (Health Information Centre, Institute of Hygiene, Lithuania); Olav Poppe (World Health Organization/DHIS 2).

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