Supplementary Online Content


**eTable 1.** Observed cesarean delivery rates for 172 WHO member states

**eTable 2.** Yearly number of births, total health expenditure per capita, cesarean delivery volume, and cesarean delivery rates for all 194 WHO member states

This supplementary material has been provided by the authors to give readers additional information about their work.
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*Regional (in the capital Brazzaville) cesarean delivery rate estimate

bRegional estimate
eTable 2: Imputed yearly cesarean delivery rates, cesarean delivery volume, total health expenditure per capita, and live births for 194 WHO member states in 2012

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<td>37010 (32132-42627)</td>
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<th>Country</th>
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<th>Upper 95% CI</th>
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Statistical Appendix

Total health expenditure per capita for countries without recent data

For countries (Somalia, North Korea, and Zimbabwe) that only had older total health expenditure data (from 2000 to 2004), multiple imputation was used to extrapolate older total health expenditure data to 2012. This was performed using a linear regression model with log of 2012 total health expenditure as the outcome and the given year for observed total health expenditure data as a covariate. The assumption underlying this analysis was a high correlation ($R^2 \geq 0.94$) between total health expenditure per capita in 2012 and any single year between 2000 and 2011 for all other WHO member states with 2012 total health expenditure data (N=191).

Sources of Available Cesarean Delivery Rate Data

Of all the 194 WHO member states, 172 countries had observed cesarean delivery rates from 2005 to 2012 from multiple sources (table 1). Health-related databases and the peer-reviewed literature on PubMed were searched for the most recent annual cesarean delivery rate using the following keywords (inter-changing “cesarean” with “caesarean” and “delivery” with “section”) and for all 194 WHO member states: “cesarean delivery”, “cesarean delivery rates”, and “cesarean delivery volume.” In total, 22 of the 194 countries had no available cesarean delivery rate data ranging from 2005–2012.

<table>
<thead>
<tr>
<th>Data Source</th>
<th>Number of Countries (Total N=172)</th>
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<tbody>
<tr>
<td>Organization of Economic Co-operation and Development (OECD) Health Statistics Database$^1$</td>
<td>25$^a$</td>
</tr>
<tr>
<td>European Health For All Database (HFA-DB)$^3$</td>
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<tr>
<td>Demographic and Health Surveys (DHS) Program Database$^4$</td>
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<td>WHO Global Health Observatory Data Repository$^5$</td>
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<td>WHO World Health Statistics 2010 report$^7$</td>
<td>4</td>
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<tr>
<td>UNICEF Global Databases 2014$^6$</td>
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</tr>
<tr>
<td>Peer-reviewed publications$^b$</td>
<td>4</td>
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<tr>
<td>Ministry of health/national agency data sources$^b$</td>
<td>8</td>
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</tbody>
</table>

$^a$ Among these, the OECD provided a cesarean delivery rate for 5 countries and the total number of annual cesarean deliveries for 20 countries.

$^b$ See eTable 1 for country-specific cesarean delivery rate data sources.
Calculation of number of cesarean deliveries from cesarean delivery rates at a country level

In order to estimate the number of cesarean deliveries performed in each country from the reported cesarean delivery rate per 100 live births, the number of live births (if not obtained from available sources) was calculated by multiplying the birth rate (per 1,000 in the population) by the total population and dividing by 1,000. From this estimate, the total number of cesarean deliveries performed in countries with observed cesarean delivery rates was estimated by multiplying the number of live births by the reported cesarean delivery rate per 100 live births, which equals (live births x cesarean delivery rate)/100.

Spearman correlation test to evaluate relationship between observed country-level cesarean delivery rate and population and health data

Of the 172 countries with reported cesarean delivery rates, a Spearman correlation test was performed on 168 that had all population and health data, which included total health expenditure per capita, life expectancy at birth, GDP per capita, percent urban population, total fertility rate, and birth rate. The following country-level population and health variables were found to be significantly correlated (p<0.0001) with observed country-level cesarean delivery rate: total health expenditure per capita (Spearman r = 0.6730), life expectancy at birth (0.7453), GDP per capita (0.6765), percent urban population (0.6069), total fertility rate (-0.7575), and birth rate (-0.7499). Among these, the following were found to be co-linear: total health expenditure per capita and GDP per capita (Spearman r = 0.9675, p<0.0001) and total fertility rate and birth rate (Spearman r = 0.9848, p<0.0001). Total health expenditure per capita was retained in the model to estimate cesarean delivery rate because it had been chosen a priori, and total fertility rate was chosen because it had a higher Spearman r when evaluating its’ correlation to observed cesarean delivery rate. Additionally, WHO region was significantly
Comparing countries with and without available cesarean delivery rate data
Countries with available cesarean delivery rate data were compared with countries without any available cesarean delivery rate data by fitting exact bivariate logistic regression models\(^9\) to test whether the probability that missing cesarean delivery rate data was related to observed population and health data (defined as missing at random in the statistics literature) or did not depend on any of these observed data (defined as missing completely at random in the statistics literature).\(^{10,11}\) Observed data refers to population and health data. If the probability that cesarean delivery rate data were missing depended on any of the observed population and health data, then this would support the inclusion of these population and health data in the model to estimate cesarean delivery rate for countries without any data. The only population and health variable that was significantly associated with whether cesarean delivery rate data was missing among the 194 WHO member states was WHO region (p-value=0.015) (table 1), and region was subsequently included in the final predictive model.

Developing Predictive Model for Imputing Cesarean Delivery Rate
Cesarean delivery rates were obtained for individual countries for the period ranging from 2005 to 2012 for 172 of the 194 WHO member states. Data for 2012 was available for 54 countries. For the 118 countries that did not have cesarean delivery rates available for 2012, 2012 rates were imputed from prior year information. This information was only available for a single year prior to 2012 for most of these countries. This precluded using repeated measures models to impute cesarean delivery rates for the year 2012. A predictive model was used for updating the cesarean delivery rate data to 2012 for countries (N=118) that had data ranging from 2005 to...
The relationship between cesarean delivery rate and maternal and neonatal mortality

2011. An important aspect of this modeling is that countries with cesarean delivery rate data ranging from 2005 to 2012 (N=172) were used in the predictive model for updating the cesarean delivery rate data to 2012 for countries that had cesarean delivery rate data ranging from 2005 to 2011 (N=118). Likewise, the same predictive model was used to impute 2012 cesarean delivery rate data for countries without any previously observed cesarean delivery rate data (N=22). The cesarean delivery rate was modeled as a function of all population/health data that were previously found to be correlated to cesarean delivery rate in univariate analyses. These population and health data included total health expenditure per capita, fertility rate, life expectancy, percent of urban population, and region information. The model included linear and quadratic effects of the year that cesarean delivery rate data was observed as well as pairwise interactions between the year variable and the other population/health data. This was performed in case the relationship (regression coefficients) between cesarean delivery rate and the other population/health variables changed over time. If the interaction terms between year and population/health data are significant then the effect of the population/health data depend on year (and thus change over time). None of the pairwise interactions were significant, nor was year itself statistically significant. Since none of these pairwise interactions were significant this supports the finding that the predictive model was similar over this time span (2005 to 2012).

Using the significantly correlated population and health variables, a total of 256 possible spline models were tested (combinations of 0 to 3 splines for each of the 4 continuous population and health variables: total health expenditure per capita, fertility rate, life expectancy, and percent of urban population). Region was included in the model as a categorical variable. The best fitting spline regression model between the log transformation of cesarean delivery rate and all correlated population and health variables had a cross-validation adjusted-$R^2$ of 0.7452. The cross-validation adjusted-$R^2$ was calculated as the square of the correlation between observed
TITLE: The relationship between cesarean delivery rate and maternal and neonatal mortality

and predicted values where the predicted cesarean delivery rate value for a country was
obtained from the regression model without that country. This spline regression model included
one inflection in the relationship between cesarean delivery rate and total health expenditure,
and no inflections in the relationship between cesarean delivery rate and the remaining
variables and took the following form:

\[ \gamma = \beta_0 + \beta_1 \text{ (log expenditure)} + \beta_2 \text{ (log expenditure)}x_i \\
+ \beta_3 \text{ (life expectancy)} + \beta_4 \text{ (percent urban population)} + \beta_5 \text{ (region1)} + \ldots \beta_9 \text{ (region5)} \]

where \( \gamma = \log \text{ cesarean delivery rate}; \beta_0 = \text{ the intercept of the line}; \ x_i = 0 \text{ if total health expenditure per capita } \leq 267 \text{ and equals 1 if total health expenditure per capita } > 267 \text{ and} \ 
\beta_1 = \text{ slope of the line when } x_i = 0; \ \text{and} \ \beta_1 + \beta_2 = \text{ slope of the line when if } x_i = 1. \ \text{The six regions include the African Region, South-East Asia Region, Eastern Mediterranean Region, Regions of the Americas, European Region and Western Pacific Region. The usual assumption of constant variance (\( \sigma^2 \)) of the outcome in the regression model was found to hold using the test proposed by White}^{12} \ (p=0.55 \text{ for the null of constant variance versus the alternative of heterogeneity of variance).}

Multiple imputation approach in this study

The multiple imputation of cesarean delivery rate estimates for countries with missing cesarean
rate data was based on Rubin’s theory.\(^{11}\) The predictive model for estimated missing cesarean
delivery rate estimates was developed from cesarean delivery rates that were available for 172
countries. From the previous section, log cesarean delivery rate is distributed as approximately
normal with mean \( \gamma \) and variance \( \sigma^2 \), where \( \gamma \) is the regression equation in the previous section
evaluated at a country’s covariate values (population/health data). Then, in an imputation, the
missing cesarean delivery rate is sampled from a normal distribution with mean \( \hat{\gamma} \) and variance \( \sigma^2 \), where \( \hat{\gamma} \) and \( \sigma^2 \) are estimated from the spline regression approach. Then these imputations were repeated 300 times for all countries with missing cesarean delivery rates, creating 300 imputed datasets. From these 300 imputed datasets we were able to estimate all quantities of interest in this study (Table 2, etable 2, and Figures 1 and 2). First we estimated each quantity of interest in each of the 300 imputed datasets separately. Then, using Rubin’s approach, these 300 estimates were averaged to generate the final multiple imputation estimate. The standard error was estimated as the square root of the combination of the within and between imputation variance over the 300 imputed datasets.

A sensitivity analysis was performed to determine the effect imputed data had on the results (intercepts, slopes, or change-points) by cross-validation. Data from each country with imputed data was sequentially removed from the imputation resulting in 172 (number of countries with observed cesarean delivery rates) sets of 300 multiply imputed datasets. Sequentially removing each country did not change the intercepts, slopes, or change-points of the spline function that was fitted to find the best predictive model for cesarean delivery rate in the imputations.

**Measurement Error in Cesarean Delivery Rate Data**

Because cesarean delivery rate data were obtained from surveys, they might have measurement error, i.e., more variability than if obtained from a complete count of the cesarean deliveries in a country (which would still have random error, but much less). This measurement error is not expected to be systematically high or low, and, therefore should not lead to biased estimates. The error could result in biased estimates if the error was in a covariate. In the imputation model, the cesarean delivery rate is the outcome, and should not bias the imputation model. To account in the model for the possible extra variability due to
measurement error in the cesarean delivery rate, the assumption was made that the number of cesarean deliveries in a country follows a negative binomial distribution; this gave much more variability than a Poisson distribution, which is often assumed for count data. The Poisson distribution is a special case of the negative binomial distribution in that the overdispersion parameter (which accounts for the extra variability) equals 1. The Akaike Information Criterion (AIC) was used to determine if negative binomial was a better fit than Poisson distribution.

**Propagation of uncertainty and its use in the generation of 95% confidence intervals**

The negative binomial was found to be a better fit than the Poisson distribution for the number of cesarean delivery since it had a smaller Akaike Information Criterion (AIC) (AIC = 4043 for negative binomial; AIC = 44,476,500 for Poisson distribution). Thus the 95% confidence intervals in eTable 2 were derived from multiple imputation assuming the cesarean delivery volume follows a negative binomial distribution. In the negative binomial distribution one must estimate both the mean for each country and an overdispersion parameter, where the mean can vary across countries but the overdispersion parameter is the same across countries. For countries without missing 2012 cesarean delivery rate data, the cesarean delivery volume will be the same across all imputations and the negative binomial estimate for these countries will be the observed 2012 cesarean delivery volume. For countries with missing 2012 cesarean delivery rate data, the imputed 2012 cesarean delivery volume will be different across all 300 imputed datasets. For these countries, the multiple imputation negative binomial estimate was average of the imputed cesarean delivery volumes over the 300 imputed datasets. To calculate the standard errors and the 95% CI, we needed to calculate the overdispersion parameters for each imputed dataset.
The unadjusted relationship between cesarean delivery rate estimates for 2012 with maternal and neonatal mortality

In the unadjusted analysis, for cesarean delivery rate estimates of 7.2 per 100 live births or less the correlation between cesarean delivery rate and maternal mortality ratio was significant with an unadjusted slope coefficient of -88.3, 95% CI -104.3 to -72.4, p<0.0001. For cesarean delivery rate estimates of >7.2 to 19.1 per 100 live births, the unadjusted slope coefficient was -16.1, 95% CI -21.9 to -10.2, p<0.0001. To interpret these slopes, for example the value of -88.3 when evaluating the relationship between maternal mortality ratio and cesarean delivery rate represents a decrease of 88.3 maternal deaths per 100,000 live births for each additional cesarean delivery per 100 live births. Similar to the adjusted analysis, cesarean delivery rate estimates above 19.1 per 100 live births were not correlated with maternal mortality ratios (cesarean delivery rate estimate >19.1–27.3 per 100 live births, unadjusted slope coefficient 0.1, 95% CI -7.0 to 7.3, p=0.97; cesarean delivery rate estimate >27.3 per 100 live births, unadjusted slope coefficient 0.2, 95% CI -3.5 to 3.9, p=0.92).

Like with the adjusted analysis, there was a significant inverse correlation up to a cesarean rate estimate of 19.4 (95% CI 18.6–20.3) and neonatal mortality rate (unadjusted slope coefficient -1.6, 95% CI -1.8 to -1.4, p<0.0001). Above 19.4%, estimated cesarean delivery rate was not correlated with neonatal mortality rate (unadjusted slope coefficient 0.004, 95% CI -0.150 to 0.143, p=0.96).

First Sensitivity Analysis

Sensitivity analyses were performed with 76 countries having the highest quality cesarean delivery rates available from the OECD (N=25) and DHS (N=51. This regression showed (CV adjusted-R2 = 0.7008) that cesarean delivery rate estimate in 2012 and maternal mortality ratio
in 2013 had 2 change-points at 6.9% (95% CI 4.6–9.2%) cesarean deliveries per 100 live births and 20.1 cesarean deliveries per 100 live births (95% CI 15.6–24.5%). As cesarean delivery rates increased, maternal mortality fell up to 6.9 cesarean deliveries per 100 live births (slope coefficient -53.1, 95% CI -92.7 to -13.4, p<0.009). Maternal mortality fell less rapidly between cesarean delivery rates of >6.9 and 20.1 cesarean deliveries per 100 live births (slope coefficient -21.3, 95% CI -32.2 to -10.5, p<0.0001). No further gain in maternal mortality was observed for cesarean delivery rates estimate greater than 20.1 cesarean deliveries per 100 live births. A sensitivity analysis evaluating the relationship between the 2012 cesarean delivery rate estimate for these 76 countries and neonatal mortality rate in 2012 showed similar results. The regression model (CV adjusted-R2 = 0.6465) had 3 change-points (5.0 cesarean deliveries per 100 live births (95% CI 3.4–6.7), 12.6 cesarean deliveries per 100 live births (95% CI 8.1–17.2%), and 24.0 cesarean deliveries per 100 live births (95% CI 19.5–28.4%). Neonatal mortality fell with increasing cesarean delivery rates for cesarean delivery rates between 12.6–24.0 cesarean deliveries per 100 live births (slope coefficient -1.4, 95% CI -2.3 to -0.4, p=0.004). Neonatal mortality was not influenced by cesarean delivery rates less than 12.6 cesarean deliveries per 100 live births and greater than 24.0 cesarean deliveries per 100 live births.

Second Sensitivity Analysis
A second sensitivity analysis excluding the 9 countries with the least reliable data was performed. This regression showed that cesarean delivery rate estimate in 2012 and maternal mortality ratio in 2013 had 3 change-points at 7.1 cesarean deliveries per 100 live births (95% CI 7.0–8.0), 18.9 cesarean deliveries per 100 live births (17.9–19.8), and 27.5 cesarean deliveries per 100 live births (26.4–28.2) per 100 live births. As cesarean delivery rates increased, maternal mortality fell up to 7.1 cesarean deliveries per 100 live births (adjusted slope
The relationship between cesarean delivery rate and maternal and neonatal mortality

coefficient -66.9, 95% CI -87.3 to -46.6, p<0.0001). Maternal mortality fell less rapidly between
cesarean delivery rates of >7.1 to 18.9 per 100 live births (adjusted slope coefficient -9.8, 95%
CI -16.2 to -3.4, p=0.003). No further gain in maternal mortality was observed for cesarean
delivery rate estimates greater than 18.9. This sensitivity analysis also had similar results with
regards to the relationship between 2012 cesarean delivery rate estimate and neonatal mortality
rate in 2012. The regression showed that cesarean delivery rate estimate in 2012 and neonatal mortality rate in 2012 had 1 change-point at 19.4 (95% CI 17.4–21.4) per 100 live births. As
cesarean delivery rates increased, neonatal mortality fell up to 19.4 cesarean deliveries per 100
live births (adjusted slope coefficient -1.6, 95% CI -1.8 to -1.4, p<0.0001).
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Data Source Appendix

Organisation for Economic Cooperation and Development (OECD)

In collecting and reporting data, the OECD takes the following seven dimensions into account when considering data quality: relevance; accuracy; credibility; timeliness; accessibility; interpretability; and coherence.¹ The OECD has procedures for reviewing the quality of existing statistical activities conducted across the OECD.¹ Furthermore, evaluation of the rates of surgical procedures that the OECD publishes has found that the variation of cesarean delivery between countries is less than that reported for other procedures.²

Demographic and Health Surveys (DHS)

According to the DHS website, “Demographic and Health Surveys (DHS) are nationally-representative household surveys that provide data for a wide range of monitoring and impact evaluation indicators in the areas of population, health, and nutrition. The Standard DHS Surveys have large sample sizes (usually between 5,000 and 30,000 households) and typically are conducted about every 5 years, to allow comparisons over time.”³ The entire survey process includes the time to complete a survey (18-20 months), survey preparation and questionnaire design, training and fieldwork, data processing, and final reporting, data preparation and dissemination.³ Due to DHS’s standardization in survey design, training, survey administration, data collection and data processing⁴, its data are considered the gold standard for population-based surveys.⁵ In their report demonstrating that officially reported rates of diphtheria-tetanus-pertussis vaccination were higher than those reported by DHS data, Murray CJL et al. considered DHS data to be the gold standard because they allow “comparative analyses, since the surveys use standardized instruments, training, data collection and data processing.”⁶
European Health for All Database

The European Health for All Database (HFA-DB) reports health statistics based on official registries and surveys collected from various sources, including individual government agencies, WHO, and international organizations for the 53 countries in the WHO European Region. These countries are given recommended definitions for most indicators that are collected and reported by the HFA-DB, and there is a process by which differing indicator definitions are reconciled. In order to ensure that data from individual countries are comparable, there is a uniform process for compiling, validating, and processing all collected data. However, “since health data recording and handling systems vary between countries, so do the availability and accuracy of data reported to WHO”.

WHO Global Health Repository

Data reporting births by cesarean section are obtained from household health surveys or from service or facility records. Household surveys collect data on birth history by administering “detailed questions on the last-born child or all children a woman has given birth to during a given period preceding the survey (usually 3 to 5 years), including characteristics of the birth(s).” Data obtained from service or facility records uses the number of women who gave birth by caesarean section at the respective service/facility as the numerator. WHO estimates the number of live births (denominator) by either using the number of live births to women who were surveyed, or if using data from service or facility records, then the number of live births (denominator) is estimated from census projections or vital registration data. If regional estimates are used to represent country-level cesarean delivery rates, these are weighted averages of the country data. In order to ensure that regional data are indeed representative of national data, regional data is only reported if it represents at least 50% of live births in the...
The relationship between cesarean delivery rate and maternal and neonatal mortality region. A weakness of data on births by cesarean section reported by WHO Global Health Repository is that it lacks any data on clinical indication, and thus the appropriateness of cesarean delivery cannot be ascertained. However, this applies to all of the databases that are used as sources in this study.

**UNICEF Data**

The United Nations Children's Fund (UNICEF) reports on data from the Demographic and Health Surveys (DHS), Multiple Indicator Cluster Surveys (MICS), National Family Health Survey (NFHS), Reproductive Health Surveys (RHS), the Sudan Household Survey (SHHS) and other national surveys. We used cesarean delivery rate data from UNICEF if countries did not have a cesarean delivery rate ranging from 2005 to 2012 from the primary sources (OECD, HFA-DB, or DHS). Most of the countries that we used data from UNICEF came from MICS and other national surveys.

The Multiple Indicator Cluster Surveys (MICS) was created in 1995 and consists of “Trained fieldwork teams conduct[ing] face-to-face interviews with household members on a variety of topics – focusing mainly on those issues that directly affect the lives of children and women.” Data collected and reported by MICS surveys is used by agencies and governments to report on progress being made towards goals, such as the Millennium Development Goals (MDG) indicators and are expected to be used in subsequent international goals, including Sustainable Development Goals. MICS ensures the quality of collected data with support from UNICEF with regional workshops that focus on survey design, data processing, and data interpretation, further analysis and dissemination. Additionally, “Effective on-site support is provided by country MICS coordinators and UNICEF focal points, backed up by technical assistance at the regional and global levels.”
Regarding MICS data collection, “Depending on the sample size and the time allocated to undertake a survey, required numbers of fieldwork teams receive training in the administration of customized questionnaires used in the survey, as well as on fieldwork procedures. The MICS programme recommends at least three weeks of training, supported by a regional expert as needed. Fieldwork is usually completed within two to four months. Each survey team has a supervisor who oversees day-to-day operations and troubleshoots problems. Interviewers conduct face-to-face interviews with eligible respondents, while the field editor checks the integrity of every questionnaire by reviewing them for possible errors or omissions. Fieldwork teams also include a measurer, who is equipped and trained to measure the weights and heights of children under 5, assisted by a second team member. Fieldwork teams use a number of tools and guidelines for quality assurance purposes – these include questionnaire editing guidelines and detailed instructions for all fieldwork team members.”

Regarding MICS data processing, “Data processing tools for entering and processing data are customized by survey teams, to reflect the customization that other survey tools have undergone – such as the questionnaires. Much of this work is carried out during the MICS data processing workshop. As the questionnaires for the first cluster of households are completed, they are sent to a centralised office where the data are entered – twice. The two datasets are then compared, to make sure no data entry errors have been introduced. Field check tables are tabulated and sent back to the field supervisor to provide feedback on the overall process and the progress of individual interviewers, providing a further check for internal consistency. Tools and support are also available for those teams willing to collect data through computer-assisted personal interviewing (CAPI), using tablets or laptops. While the use of such devices can save
Maternal mortality ratio and Neonatal mortality rate

Maternal mortality ratio (MMR)\textsuperscript{13} and neonatal mortality rate (NMR)\textsuperscript{14} are standard metrics that have been measured, validated and modeled by many worldwide data collection agencies (agencies like WHO, UNICEF, UNFPA, The World Bank and the United Nations Population Division).

The WHO defined maternal deaths as “the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of pregnancy, from any cause related to or aggravated by the pregnancy or its management but not from accidental or incidental causes”.\textsuperscript{13} Maternal mortality is reported as a ratio (number of maternal deaths in a time period divided by number of live births during the same time period). This captures a woman's risk of dying during a single pregnancy, and it is the preferred measure of maternal mortality because it describes the frequency of maternal death relative to its risk pool, as measured by the number of live births.\textsuperscript{15} Neonatal mortality rate is the number of neonates dying before reaching 28 days of age, per 1,000 live births in a given year.\textsuperscript{16} “Estimates of neonatal mortality rates are produced using a statistical model that uses under-five mortality rates as an input. These methods provide a transparent and objective way of fitting a smoothed trend to a set of observations and of extrapolating the trend to the present.”\textsuperscript{14}
Other secondary sources for cesarean delivery rates by country

* These countries (N=9) were excluded in the sensitivity analysis to assess the effect of countries with cesarean delivery rate data that came from the least reliable sources.

**Bhutan***
Cesarean delivery rate data came from Annual bulletin from the Ministry of health\textsuperscript{17}. There is no information on data quality.

**Brazil***
Cesarean delivery rate data came from Brazilian Ministry of Health report.\textsuperscript{18} There is no information on data quality.

**Cuba***
Cesarean delivery rate data came from a regional estimate from Villar et al Lancet publication\textsuperscript{19}. Villar et al wrote that, “After country selection, we identified a representative sample of geographic areas within each country and, within these geographic areas, a representative sample of care units. We selected countries with a probability proportional to the population of the country, provinces with a probability proportional to the population of the province, and health institutions with a probability proportional to the number of deliveries per year.”
Furthermore, “each country [was initially stratified] by its capital city (always included) and two other randomly-selected administrative geographic areas (provinces or states). Within these three areas, we undertook a census of hospitals that reported more than 1000 deliveries in the previous year. We then stratified data by province or state, choosing a representative sample of up to seven institutions each. If there were seven or fewer eligible institutions, we included them all. We included all women admitted to the selected institutions for delivery during a fixed data collection period of either 2 or 3 months, depending on the total number of expected deliveries per institution for the complete year (3 months if ≤6000 per year; 2 months if >6000 per year).”

Ecuador*
Cesarean delivery rate data came from Ecuadoran Ministry of Health. There is no information on data quality.

Germany
Cesarean delivery rate data came from the Statistisches Bundesamt Deutschland. Data is collected by the German Federal Health Monitoring System. Data sources are hospital statistics. Hospitals are surveyed annually for multiple data including the number of cesarean deliveries.

Lebanon*
Cesarean delivery rate data came from the DeJong et al study that employed a “self-completion questionnaire [that] was sent to private hospitals by the Syndicate of Private Hospitals in collaboration with the study team and to all public hospitals in Lebanon with a functioning maternity ward by the study team in cooperation with the Ministry of Public Health.” The authors reported an “overall response rate to the survey (46% of eligible hospitals) and the
deliveries reported by these hospitals account for about 42% of all live births that are reported to have taken place nationally in Lebanon in 2008.”

Mexico
Cesarean delivery rate data came from a study published in PLOS one by Heredia-Pi et al in 2014. This was a “cross-sectional study... based on data collected through the 2012 National Health and Nutrition Survey (ENSANUT), a probabilistic survey that is representative at the national and state level, as well as by urban/rural stratum.” More information can be found in the study publication.

Myanmar*
Cesarean delivery rate data came from the Annual Hospitals Statistics Report from the Ministry of Health. There is no information on data quality.

Oman*
Cesarean delivery rate data came from a Ministry of Health report. There is no information on data quality.

Qatar*
Cesarean delivery rate data came from the Public Health Department of Qatar. There is no information on data quality.

South Korea*
Cesarean delivery rate data came from a study by Chung SH et al, who obtained 2012 data from nationally published reports. There is no information on data quality.
United States

The cesarean delivery rate data for the United States came from National Vital Statistics Reports:Births:Final Data for 2011 from The U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics, and National Vital Statistics System. “Data shown in this report for 2011 are based on 100% of live birth certificates filled in all states and the District of Columbia (DC). The data are provided to the Centers for Disease Control and Prevention’s National Center for Health Statistics (NCHS) through the Vital Statistics Cooperative Program (VSCP). Information on methodology and measurement is available.”

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