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First-day Neonatal Mortality in the Developing world: A Neglected Crisis?

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Abstract

We examined the Demographic and Health Surveys (DHS) data from 31 countries over the last 20 years to estimate the levels and trends of first-day mortality rates considering potential differences in socioeconomic and healthcare factors. The trends in first-day mortality rates and 95% confidence intervals were estimated adjusting for potential clustering effects, comparing three successive DHS held across countries covering sub-Saharan Africa, South and Southeast Asia and Latin America. The findings show that first-day mortality rates varied widely from 21 deaths per 1000 live births in Mali and Ethiopia to about 17 per 1000 in Kenya and Nepal to less than 10 per 1000 in Dominican Republic, Philippines, Jordan and Egypt. The absolute change in the rates between DHS2 and DHS3 were not significant in about 24 countries and the levels were stagnantly high or increased in about 8 countries. First-day mortality increased consistently in Zimbabwe, Zambia, Senegal, Cambodia and Philippines. A negative linear relationship was found between skilled birth attendance, per-capita income and first-day mortality rates whereas a negative curvilinear relationship was observed between years of maternal schooling and first-day mortality rates. In countries where there is high medical intervention in births had relatively low rates of first-day mortality.

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Rationale and background

Demographers and epidemiologists have paid little attention to evaluating the trends and patterns of early neonatal mortality in developing countries. Evidence from clinical studies highlight that the first-day of life is the most critical period in an infant's life where mortality risks are substantially higher: deaths in the first 24 hours of life account for about two-third of early neonatal deaths (Yinger and Ransom 2003). Yet, most child health interventions including the UN MDGs fail to recognise the importance of early life of infants. There is little systematic analysis of the levels and trends of the first-day mortality and how they vary across different populations in the developing world. A report produced by Save the Children (2013) estimated that in 2011 about 3 million newborns died which constituted about 43% of under-five mortality, with a share of about two-fifth of all newborn deaths in south Asia itself. Population level evidence in economically developed countries is also limited, except for a few studies based on clinical or aggregate registration statistics (Whyte 1992).

The estimation of first-day mortality is not straight forward especially in resource poor settings where there is lack of registration data. This is because most women in low income countries especially in sub-Saharan Africa and south Asia have poor access to healthcare and they tend to give birth at home in the absence of essential medical infrastructure and healthcare resources. In such circumstances, data are difficult to obtain through registration systems since births and deaths are not usually registered particularly when an infant dies at or soon after birth. Although hospitals tend to collect mortality statistics on regular basis they do not provide representative data at the regional or national level (Woods 2008; Yinger and Ransom 2003; Padmadas 2000). Moreover, there is often a tendency in both public and private hospitals to misclassify new-born deaths as stillbirths for institutional and political reasons.

The only reliable source of data available in developing countries is the nationally representative cross-sectional surveys such as the Demographic and Health Surveys (DHS) which are conducted frequently every five years since the 1990s. The DHS record data on the timing of deaths of children ever-born who are not alive at the time of survey using birth histories of eligible women of reproductive ages. These data provide reliable information on pregnancy histories and associated health related factors especially for recent births.

There are biological, healthcare, social and environmental determinants that explain the risks associated with first-day mortality. The common causes of first-day neonatal mortality are birth asphyxia, infections, jaundice, apnoeic attacks, respiratory distress, preterm/ low birth weight, birth trauma, congenital abnormalities including neural tube defects and convulsions (Valman and Thomas 2009). Infants born in a health setting under proper medical supervision have relatively higher chance of survival when compared to those born in home especially in unhygienic conditions and with no skilled attendance at birth. On the other hand, there is evidence that appropriate medical interventions at birth can positively influence the survival chances of an infant. There is evidence to suggest that mothers from socially and economically deprived background are vulnerable to experiencing high rates of infant and child mortality. Social and environmental factors influence new born survival indirectly through a set of intermediate biological and clinical/healthcare related factors.

The ***goals*** of this study are to estimate the levels and trends of first-day mortality in low and middle income countries and further examine the associated socioeconomic and healthcare differentials. We ***hypothesise*** that (a) the decline in first-day mortality rates is uniform across time and consistent with observed reductions in early-neonatal mortality; (b) the share of first-day mortality rates over early neonatal mortality is not uniform across countries (Liu et al. 2012) and (c) first-day mortality rates are generally lower in countries with improved access to medical and healthcare.

Data and methods

We use cross-sectional population data from recent three successive standard DHS available in 31 countries covering sub-Saharan Africa, South and Southeast Asia and Latin America. Data on timing of deaths were extracted from recent birth histories reported by mothers of reproductive age for the 60 months preceding the survey. We define first-day neonatal mortality as death which was reported to have occurred either on day 0 or day 1 after a live birth. This is done to adjust for possible differences in the timing of death, for example death during day or night. We considered data of only the recent (last) birth in the case of multiple births. The trends in first-day mortality rates (per 1000 live births) and 95% Confidence Intervals (CIs) were estimated adjusting for potential clustering effects.

We used the Wilson Score method to estimate the 95% CIs of the proportion of first-day deaths

$p = \frac{O}{n}$; where O is the observed first-day deaths and n is the total number of live births in the sample. The 100(1- α)% CIs limit for p is expressed as:

$$p_{\text{lower}} = \frac{(2O + z^2 - z\sqrt{z^2 + 4Oq})}{2(n + z^2)} \text{ and } p_{\text{upper}} = \frac{(2O + z^2 + z\sqrt{z^2 + 4Oq})}{2(n + z^2)}$$

where q=(1-p) is the proportion surviving; z is the 100(1-α/2)th percentile value from the standard normal distribution (α=0.05 and z=1.96 for a 95% CI).

We estimated the absolute difference in first-day mortality rates adjusting for potential clustering effects. The most recent survey (DHS-3) was used to measure the association between first-day mortality and socioeconomic and health indicators. The corresponding economic indicator considered was Gross National Income per-capita, purchasing power parity derived from the World Bank. DHS-3 data were used to derive the social indicator (median years of mothers' schooling) and two healthcare indicators (percentage of births attended by skilled health personnel and percentage of deliveries by caesarean section).

Selected main results

First-day mortality rates varied widely from 21 deaths per 1000 live births [95%CI: 19, 23] in Mali and Ethiopia to about 17 per 1000 in Kenya and Nepal to less than 10 per 1000 in Dominican Republic, Philippines, Jordan and Egypt (Table 1). The absolute change in the rates between DHS2 and DHS3 were not significant in about 24 countries and the levels were stagnantly high or increased in about 8 countries (Figures 2a and 2b). First-day mortality increased consistently in Zimbabwe, Zambia, Senegal, Cambodia and Philippines.

There is also evidence of considerable variation in the share of first-day deaths over early neonatal mortality (Figure 3). A negative linear relationship was found between skilled birth attendance, per-capita income and first-day mortality rates whereas a negative curvilinear relationship was observed between years of maternal schooling and first-day mortality rates (Figures 4-5). In countries where there is high medical intervention in births had relatively low rates of first-day mortality.

Conclusions

The analysis of first-day mortality has received little attention in demographic and epidemiological analyses, especially in low and middle income countries where vital registration systems are weak or non-existent. The present analysis show wide ranging estimates of first-day mortality rates with 95% confidence intervals, consistent with economic growth, health, social and human development of countries representing Africa, South Asia, East Asia, south-East Asia and the Middle-East. On the other hand, in countries such as Ethiopia which recorded significant progress in reducing child mortality (UNICEF 2013), had first-day and early neonatal mortality declined first between DHS1 and DHS2, but then increased between DHS2 and DHS3. Among the countries analysed, Ethiopia ranks the second highest after Mali with a first-day mortality rate of 21 per 1000 live births [95% CI: 18, 23]. The first-day mortality rates showed consistent increase over time especially in Zimbabwe and Zambia which have made insufficient or no progress in reducing child mortality (WHO and UNICEF 2012). The findings clearly demonstrate the importance of examining the trends in first-day and early neonatal mortality rates in countries that are lagging in terms of achieving progress in specifically Goal 4 of the UN Millennium Development Goals. The findings suggest the need to strengthen community level interventions aimed at promoting antenatal and skilled-care at birth, and monitor high risk pregnancies from early stages of pregnancy throughout childbirth. Equally important is the need for greater investment on skilled human resources and essential health infrastructure to deal with high risk pregnancies especially emergency obstetric care services.

There are a few caveats worth mentioning. First, retrospective data might be subject to possible bias in recall and displacement. Second, the estimates tested for statistical significance at the country level might mask regional, state and small area level variations. The study is not validated using alternative data such as registration sources, which is almost impossible in the countries studied.

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References

Liu L et al. Global, regional, and national causes of child mortality: an updated systematic analysis for 2010 with time trends since 2000. *Lancet* 2012; 379: 2151–2161.

Padmadas SS. Intergenerational transmission of health: Reproductive health and child survival in Kerala, India. Thela Publishers: Amsterdam, 2000.

Save the children. Surviving the first day. State of the World's Mothers 2013, http://www.savethechildren.org/atf/cf/%7B9def2ebe-10ae-432c-9bd0-df91d2eba74a%7D/SOWM-FULL-REPORT_2013.PDF

UNICEF. Levels & trends in child mortality. Report 2012. Estimates Developed by the UN Inter-agency Group for Child Mortality Estimation, United Nations Children's Fund, 2013. http://apromiserenewed.org/files/UNICEF_2012_child_mortality_for_web_0904.pdf

Valman B and Thomas R. ABC of the first year. Sixth Edition, BMJ Books. Wiley-Blackwell. 2009.

Whyte RK. First day neonatal mortality since 1935: re-examination of the Cross hypothesis. *BMJ* 1992; 304: 343-346.

Woods R. Long-term trends in fetal mortality: implications for developing countries. *Bulletin of the World Health Organisation* 2008; 86(6): 460-466.

World Bank. GDP per capita, PPP estimates, 2006-2011 (current international $) http://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD

WHO and UNICEF. Building a future for women and children: The 2012 report. Countdown to 2015, Maternal, newborn and child survival. World Health Organisation and United Nations Children's Fund, 2012. http://www.countdown2015mnch.org/documents/2012Report/2012-complete-no-profiles.pdf

Yinger NV and Ransom EI. Why invest in newborn? Policy Perspectives on Newborn Health. Washington DC: Population Reference Bureau, 2003.

Figure 1 First-day neonatal mortality rates with 95% CI.

	Rate [95% CI]			Absolute difference [95% CI]	
Country (year of survey)	DHS 1	DHS 2	DHS 3†	DHS2-DHS1	DHS3-DHS2
Mali (1995/96, 2001, 2006)	22 [19, 26]	25 [22, 28]	21 [19, 23]	3.1 [-1.4, 7.8]	-4.0 [-7.6, -0.4]*
Ethiopia (2000, 2005, 2011)	24 [22, 27]	18 [16, 21]	21 [18, 23]	-6.1 [-9.1, -3.2]**	2.5 [-0.6, 5.8]
Nigeria (1999, 2003, 2008)	15 [11, 19]	20 [17, 24]	20 [18, 22]	5.1 [-0.1, 10.7]	-0.4 [-4.1, 3.8]
India (1992/93, 1998/99, 2005/06)	18 [17, 19]	16 [15, 17]	19 [18, 20]	-1.9 [-3.7, -0.1]*	2.6 [0.8, 4.4]**
Ghana (1998, 2003, 2008)	17 [13, 22]	23 [19, 28]	18 [14, 23]	6.2 [-0.3, 12.8]	-4.9 [-11.8, 1.8]
Malawi (2000, 2004, 2010)	17 [15, 20]	13 [11, 15]	18 [16, 20]	-4.1 [-7.4, -0.7]*	5.2 [2.3, 8.1]**
Zimbabwe (1999, 2005/06, 2010/11)	13 [13, 22]	13 [10, 16]	18 [15, 22]	0.0 [-4.6, 4.8]	5.3 [0.7, 10]*
Kenya (1998, 2003, 2008/09)	15 [11, 20]	18 [15, 22]	17 [14, 21]	2.8 [-2.3, 8.3]	-1.4 [-6.1, 3.4]
Nepal (2001, 2006, 2011)	16 [13, 19]	14 [11, 17]	17 [14, 21]	-2.9 [-7.2, 1.5]	3.7 [-0.8, 8.3]
Bangladesh (2004, 2007, 2011)	19 [16, 22]	19 [16, 23]	16 [13, 18]	-0.5 [-5.2, 4.2]	-3.4 [-7.8, 1.1]
Zambia (1996, 2001/02, 2007)	13 [11, 16]	13 [11, 16]	16 [13, 19]	0.0 [-3.8, 3.8]	3.1 [-1.0, 7.2]
Benin (1999, 2001, 2006)	19 [15, 24]	19 [16, 23]	15 [13, 17]	0.3 [-5.6, 6.7]	-4.1 [-8, 0.3]
Cameroon (1998, 2004, 2011)	16 [12, 22]	13 [11, 16]	15 [13, 17]	-2.9 [-8.0, 2.9]	1.3 [-2.0, 5.0]
Colombia (2000, 2005, 2010)	9 [7, 12]	6 [5, 7]	5 [4, 6]	-2.5 [-5.3, 0.8]	-1.4 [-3.1, 0.2]
Namibia (1992, 2000, 2006/07)	17 [13, 22]	12 [9, 16]	15 [12, 19]	-4.9 [-10.4, 1.0]	3.1 [-1.7, 8.0]
Senegal (1997, 2005, 2010/11)	12 [10, 15]	15 [13, 17]	15 [13, 17]	2.9 [-0.2, 6.2]	0.3 [-2.7, 3.4]
Uganda (2000/01, 2006, 2011)	17 [14, 20]	13 [11, 16]	15 [12, 17]	-4.0 [-7.8, -0.2]*	1.3 [-2.4, 5.1]
Cambodia (2000, 2005, 2010)	14 [12, 17]	14 [12, 17]	15 [13, 18]	0.2 [-3.4, 3.7]	1.1 [-2.6, 5.0]
Madagascar (1997, 2003/04, 2008/09)	18 [14, 23]	16 [13, 20]	13 [11, 15]	-1.7 [-7.0, 4.0]	-2.8 [-6.5, 1.3]
Tanzania (1996, 2004/05, 2010)	12 [10, 15]	17 [15, 20]	13 [11, 16]	5.5 [1.8, 9.2]**	-4.4 [-8, -0.7]*
Bolivia (1998, 2003, 2008)	14 [12, 17]	12 [10, 14]	12 [10, 14]	-1.6 [-5.0, 1.9]	-0.2 [-3.4, 2.9]
Rwanda (2000, 2005, 2010)	21 [18, 24]	18 [15, 21]	12 [10, 15]	-2.1 [-5.9, 1.6]	-6.1 [-10.2, -2.0]**
Burkina Faso (1998/99, 2003, 2010)	15 [12, 18]	11 [9, 13]	11 [9, 13]	-3.2 [-6.7, 0.6]	-0.6 [-3.3, 2.4]
Indonesia (1997, 2002/03, 2007)	11 [10, 13]	10 [9, 12]	11 [10, 13]	-1.4 [-3.6, 0.8]	1.0 [-1.2, 3.1]
Niger (1992, 1998, 2006)	12 [10, 15]	13 [10, 17]	11 [9, 13]	1.0 [-3.3, 5.0]	-1.6 [-5.2, 2.5]
Dominican Republic (1996, 2002, 2007)	12 [9, 16]	12 [10, 14]	8 [6, 10]	-0.1 [-3.7, 3.9]	-4.0 [-6.6, -1.4]**
Haiti (1994/05, 2000, 2005/06)	8 [6, 12]	11 [9, 14]	8 [6, 11]	2.3 [-1.4, 6.5]	-2.3 [-5.7, 1.1]
Philippines (1998, 2003, 2008)	8 [6, 10]	8 [6, 10]	8 [6, 11]	0.8 [-2.2, 3.6]	-0.3 [-3.3, 2.7]
Egypt (2000, 2005, 2008)	9 [7, 11]	8 [7, 10]	6 [5, 8]	-1.0 [-3.2, 1.4]	-1.6 [-3.8, 0.4]
Jordan (1997, 2002, 2007)	9 [7, 12]	5 [3, 7]	5 [4, 7]	-4.0 [-6.9, -1.0]**	0.0 [-2.1, 2.5]
Armenia (2000, 2005, 2010)	10 [6, 16]	4 [2, 9]	1 [0, 5]	-5.7 [-13.8, 2.2]	-2.6 [-11.3, 6.4]

*$p<0.05$; **$p<0.01$; †countries ranked according to DHS3 estimates. Estimates adjusted for sample weights.

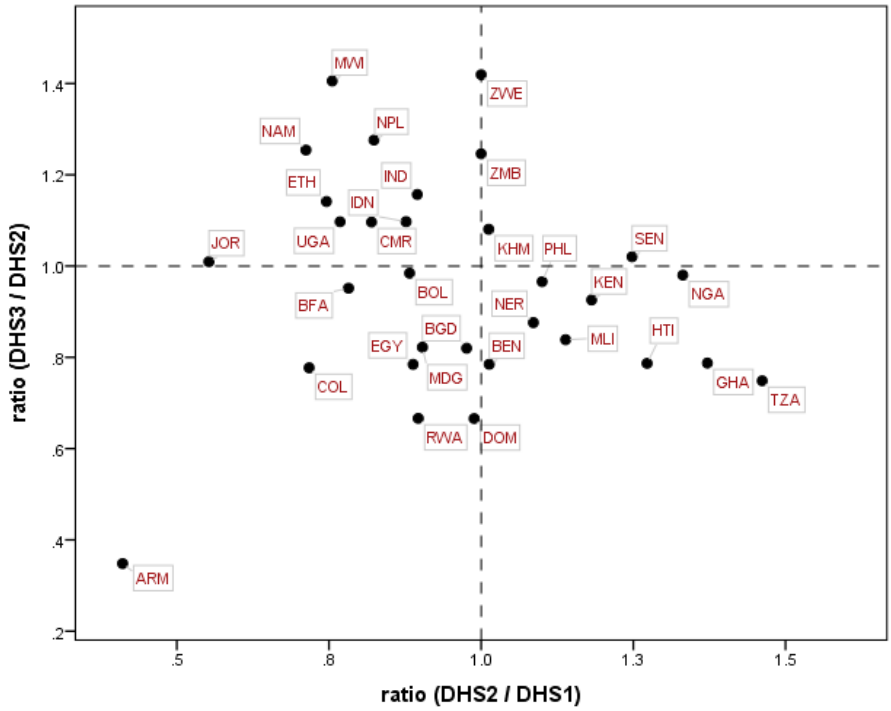
Acronyms for countries *(based on the World Bank ISO country codes)*

Armenia (ARM); Bangladesh (BGD); Benin (BEN); Bolivia (BOL); Burkina Faso (BFA); Cameroon (CMR); Columbia (COL); Dominican Republic (DOM); Egypt (EGY); Ethiopia (ETH); Ghana (GHA); Haiti (HTI); India (IND); Indonesia (IDN); Jordan (JOR); Kenya (KEN); KHM (Cambodia); Madagascar (MDG); Malawi (MWI); Mali (MLI); Namibia (NAM); Nepal (NPL); Niger (NER); Nigeria (NGA); Philippines (PHL); Rwanda (RWA); Senegal (SEN); Tanzania (TZA); Uganda (UGA); Zambia (ZMB); Zimbabwe (ZWE)

Source: http://wits.worldbank.org/WITS/wits/WITSHELP/Content/Codes/Country_Codes.htm

Figure 2 Ratios showing changes in first day and early neonatal mortality rates between successive DHS

(a) First day neonatal mortality



(b) Early neonatal mortality

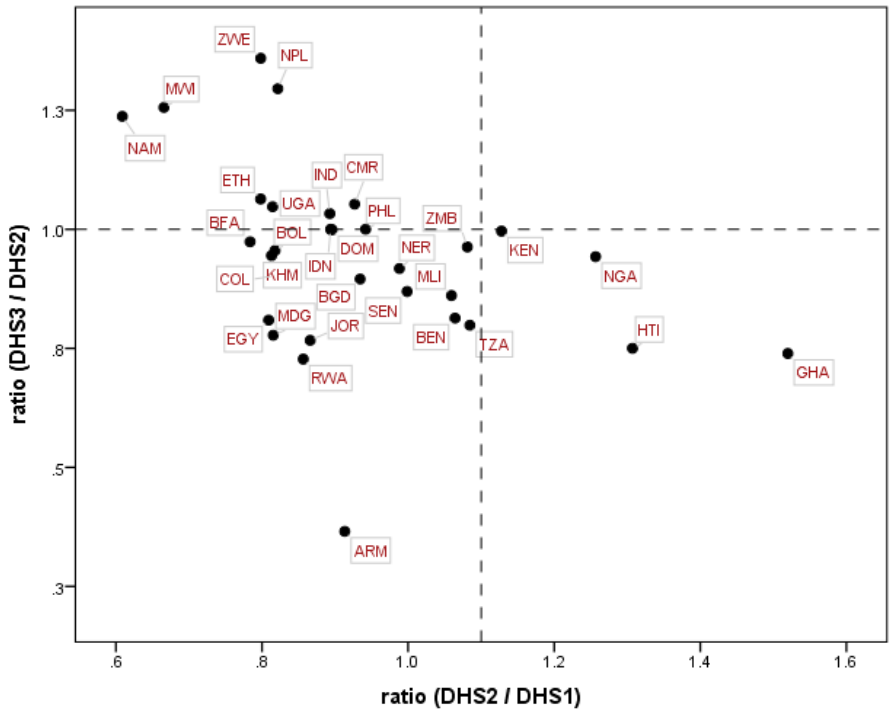


Figure 3 Share of first-day deaths over early neonatal mortality, recent DHS

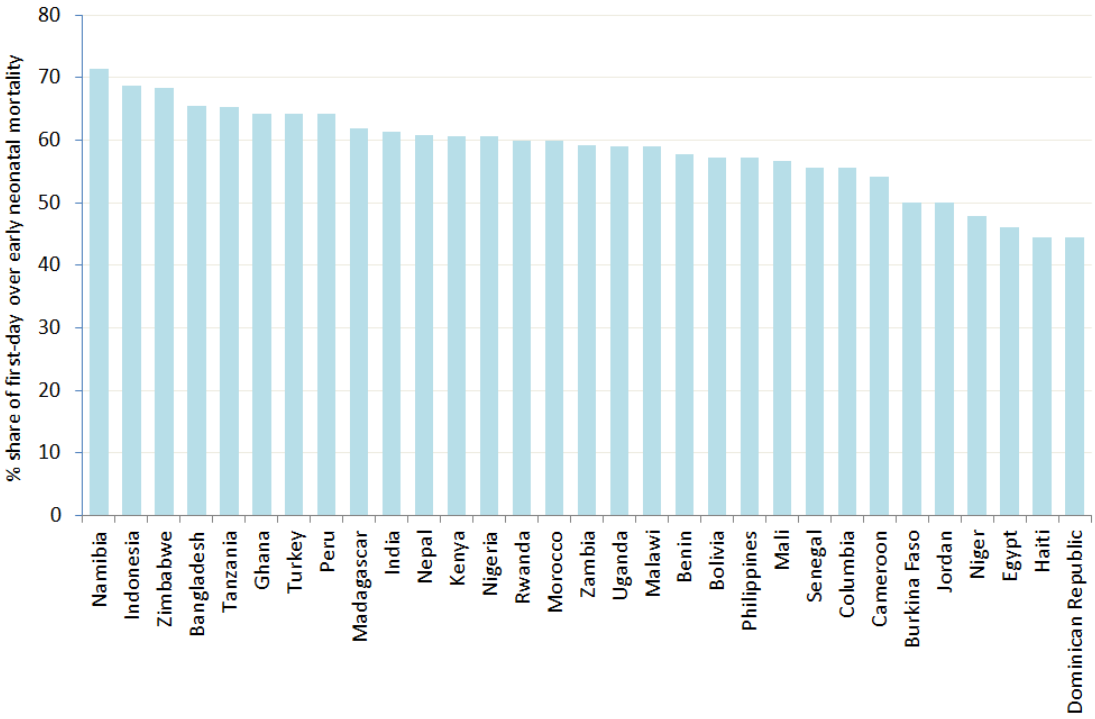


Figure 4 Relationship between first-day neonatal mortality and births attended by skilled attendants

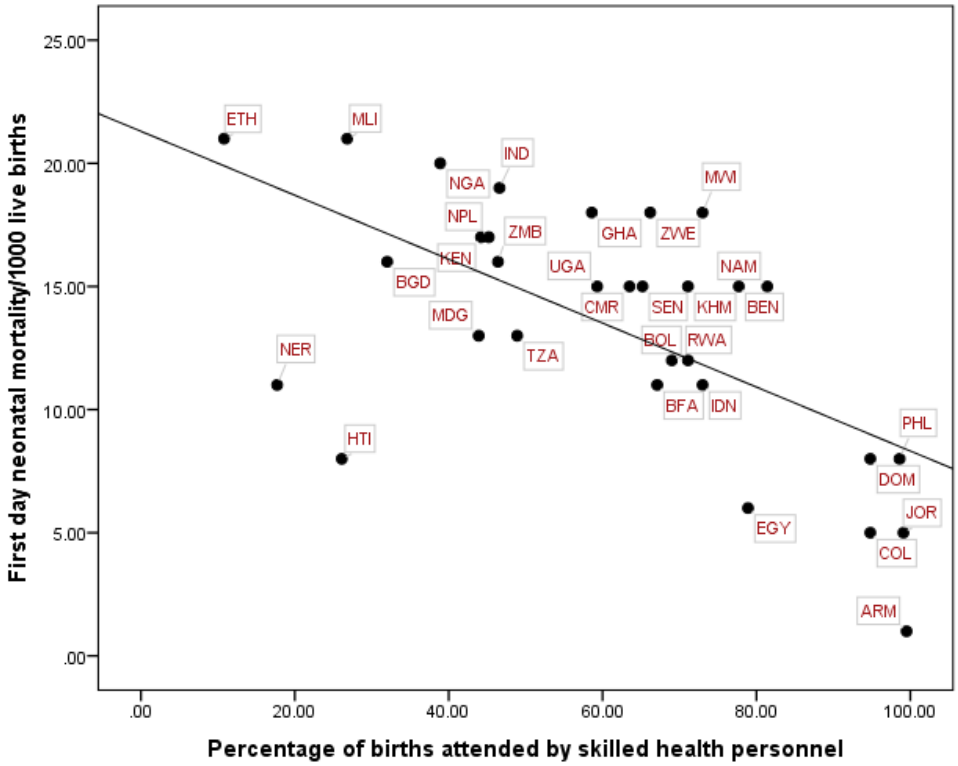


Figure 5 Relationship between first-day neonatal mortality and mothers' year of schooling