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Association of the Quality of Antenatal Care with Neonatal Mortality: Meta-Analysis of Individual Participant Data from 60 Low- and Middle-Income Countries

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Abstract

Objective We investigated the quality of ANC and its effect on neonatal mortality in 60 low- and middle-income countries (LMICs).

Methods We used pooled comparable cross-sectional surveys from 60 LMICs (N=651681). Cox proportional hazards multivariable regression models and meta-regression analysis were used to assess the effect of the quality of ANC on the risk of neonatal mortality. Kaplan-Meier survival curves were used to describe the time-to-event patterns of neonatal survival in each region.

Findings Pooled estimates from meta-analysis showed 34% lower risk of neonatal mortality for children of women who were attended to at ANC by skilled personnel. Sufficient ANC advice lowered the risk of neonatal mortality by 20%. Similarly, children of women who had adequate ANC had 39% lower risk of neonatal mortality. Pooled multivariable model showed association of neonatal mortality with ANC quality index (HR 0.85, 95% CI 0.77-0.93).

Conclusion Improvement in the quality of ANC can reduce the risk of neonatal mortality substantially. Pursuing the sustainable development goal 3, which aims at reducing neonatal mortality to 12 per 1000 live births by 2030 should tackle the quality of ANC women receive in LMICs.

Key words: quality of ANC, neonatal mortality, meta-analysis, child health, low- and middle-income countries

Introduction

Although there has been considerable improvement in child health over the past few decades, neonatal, infant and child mortality remain high in most low- and middle-income countries (LMICs) [1, 2]. Many countries in these regions were unable to meet the millennium development goal (MDG) 4 of reducing under-5 mortality by two-thirds between 1990 and 2015 [3]. Addressing neonatal mortality is therefore a global public health challenge of the 21st century, which requires global efforts with local actors. A renewed global effort at addressing the child health challenge is demonstrated in the sustainable development goals (SDGs) [4]. In particular, SDG 3, target 3.2 aims at reducing neonatal mortality to 12 per 1000 live births by the year 2030. This renewed effort requires comprehensive data from LMICs in order to provide evidence-based information for interventions to improve neonatal survival and child health in general.

The SDGs also prioritised access to quality health care including antenatal care (ANC) during pregnancy[6]. Access to quality healthcare during pregnancy and after child birth considerably improves health outcomes including neonatal deaths[5]. In LMICs where obstetric and gynecological facilities may be unavailable, ANC can be one of the most cost effective preventive services for maternal and child health. Adherence to commencing ANC in the first trimester of pregnancy and having at least four visits during the gestation period can reduce neonatal mortality [6]. However, studies investigating the quality of ANC and its association with specific maternal and child health outcomes including neonatal mortality is lacking. The quality of ANC measures the continuum of the health care services in various dimensions before the delivery care[7]. Lack of relevant quality data on the subject is therefore an important constraint to interventions aimed at improving child health in these countries. The goal of this study is two-fold. Firstly, we sought to assess the quality of ANC at national and regional levels in LMICs, and secondly, investigate the association of the quality of ANC with neonatal mortality in these countries and regions.

METHODS

Data

We used the most recent Demographic and Health Survey (DHS), which is nationally representative cross-sectional data collected using standardized questionnaire, methodology and protocols in order to facilitate international comparison. The DHS has generated high quality data on important demographic, economic, social and health for LMICs, which have been used in high quality research over the past decades. We pooled the most recent dataset which were publicly available from 60 LMICs conducted from 2001 to 2014/15 to generate a large dataset with sufficient statistical power to investigate the association of ANC quality with neonatal death. The number of countries included in this study represents 43.2% of the LMICs in the world. We restricted our analyses to the most recent singleton livebirth for each women of reproductive age (15-49 years) (N=651681).

The 60 countries were grouped into six regions in accordance with the World Health Organisation's (WHO) regional classification. By this classification, 33 (53%) of the countries in this study were in Africa, four in East Asia & Pacific (6%), six in Europe & Central Asia (2%), eight in Latin America & Caribbean (14%), four in Middle East & North Africa (12%) and five in South Asia (13%). The full list of countries and survey years are shown in Table 1. Neonatal death, defined as death of a live born baby within the first 28 days of life, was calculated based birth history which had information on the month and year of each birth and child's survival status at the time of interview and current age or age at death, as applicable, which were recorded during the interviews. Age at death was recorded in days if the child dies within one month of birth.

We measured the quality of ANC as the main independent variables based on three main measures namely, adequacy of ANC, sufficiency of advice and skilled ANC provider. These variables cover a wide range of quality interventions supported by the WHO guidelines recommendation for ANC[8]. *Adequacy of ANC* was constructed from the following; weight and height measurement, and whether

blood pressure and urine and blood samples were taken during ANC. *Sufficiency of advice* refers to whether a woman was told about the signs of pregnancy complications and where to go for care if complications occurs. ANC service provider was described as skilled if a doctor, a nurse/midwife, or an obstetrician/gynecologist attended to the ANC visits. For adequacy of ANC, "yes" (coded as 1) refers to having had at least two of the three recommended ANC observation, measurements or tests while "no" (coded as 0) refers to those who had less than two of the essential observation, measurements or tests . For sufficiency of advice "yes" refers to having been either told of signs of pregnancy complications or where to go should complications arise and "no" refers to those who were neither advised about signs of complications nor where to go should they arise. Furthermore, an *ANC quality index* was constructed by summing up three dummy variables namely, *adequacy of ANC (*adequate vs no adequate), *sufficiency of advice* (sufficient advice vs no sufficient advice) and *skilled ANC service provider* (namely skilled provider vs others) and categorized as low (0-1), medium (2), and high (3).

The data on background characteristics of the mother (age, place of residence, wealth quintile, children ever born and education) as well as the place of delivery (categorized here as health facility versus other) were also collected during the interview and included in the analysis as covariates in order to investigate the independent association of ANC quality with the risk of neonatal death. The wealth quintile is a composite measure of the household's cumulative living standard based on ownership of specified assets split into quintiles: poorest, poorer, middle, richer, richest [9].

Statistical analysis

We considered the sampling strategy of each survey using sample weights to estimate the distribution of independent and dependent variables. We considered recommendations of strengthening the reporting of observational studies in epidemiology (STROBE) in reporting of the results [10]. We first

presented a weighted distribution of main independent variables by country and pooled values for the regions and for the total sample (Table 1). Neonatal death per 1000 live births, and the proportion of skilled ANC provider in each countries are presented in the world map (Figure 1a and 1b). Birth records for which days of birth were missing, the 15th day of the month was imputed to estimate the survival time in days. For neonates who were still alive, survival time was estimated as the time elapsed between birth and the day of the survey while for those who died it was estimated as the time between birth and death within the first 28 completed days of life. All children alive at 28 days were censored. We used Cox proportional hazard regression [11], which is the most robust multivariate approach for estimating the hazard ratios (HRs) from survival data in medical research. The Cox proportional hazard is a survival analysis regression model, which describes the relation between the event incidence, as expressed by the hazard function and a set of covariates to adjust their effect. The final Cox model was calculated as;

$$h(t) = h_0(t) \times \exp[b_1 x_1 + b_2 x_2 + \cdots + b_p x_p]$$

Where, the hazard $h(t)$ at time *t* is dependent on a set of covariates (x_1, x_2 ,……, x_p), whose impact is measured by the size of the coefficients (b_1, b_2 , ……, b_p) [12].

The assumption is that each event (outcome) occurs independently, hence the probability of no event (survival) between each time points is multiplied together to obtain the cumulative survival probability. We used the survey commands in Stata to adjust for the effect of the multi-stage cluster sampling on the estimates. The Schoenfeld residuals diagnostic test confirmed the adequacy of the multivariable proportional hazard model (p=0.139) [12, 13].

We fitted separate Cox proportional models to estimate hazard ratios for neonatal mortality with their 95% confidence intervals (CIs) for the pooled sample for each main independent variable (measured by adequacy of ANC, sufficiency of advice during ANC, whether ANC was administered by skilled

service provider, and ANC quality index), adjusting for the socio-demographic variables, place of delivery, year of survey and country in separate models. The estimates for socio-demographic variables were obtained from the ANC quality index model. Next, estimates for ANC quality variables were analysed and plotted (forest plot) for each country and region using fixed effect meta-analysis command in Stata. The fixed effects model considers that the variability between studies is due to random variations resulting from the size of the study. We also plotted smoothed hazard curves for the days of death to obtain the daily hazard rates for infants during the first 28 completed days of life stratified by the three main independent variables and the ANC quality index. Furthermore, we tested two-way and multiplicative interaction effects between the independent variables with respect to neonatal mortality. All statistical analysis were conducted using Stata/SE 14.0.

RESULTS

The distribution of neonatal mortality and the quality of ANC across countries and regions are presented in Table 1 and Figure 1a and b, respectively. Forty percent of the total sample have high ANC index and the quality of ANC varies across countries with lowest in Zambia (1.9%) and highest in Colombia (80.8%) (Table 1). After adjusting for potential confounding factors, Cox proportional hazard model showed that babies of women who had adequate ANC had 18% lower risk of dying at neonatal age compared to those who did not have adequate ANC (Table 2). Children of women who received sufficient advice had lower risk of neonatal death (HR 0.90, 95% CI 0.84-0.97). Similarly, babies of women who were attended to by skilled personnel had 29% reduced risk of death during the first 28 days of life. The ANC quality index shows that the higher the quality of ANC received by a woman the lesser the likelihood that her child would die within the first 28 days of life.

Country level risk of neonatal death among children born to the women who had skilled ANC provider is shown in Figure S1. The association of ANC with neonatal mortality varies across

countries. The strongest association of the quality of ANC with the risk of neonatal mortality were found in Moldova, Burundi and Sao Tome. On the contrary, having ANC attended to by skilled personnel seems to increase the risk of neonatal mortality in some countries, although these were not statistically significant.

The pooled HR showed 34% reduction in neonatal mortality among neonates of women who had ANC attended to by skilled personnel (Figure S1). Correspondingly, the pooled HR showed 20% (Figure S2) and 39% (Figure S3) reduction in the risk of neonatal mortality for children of women who had sufficient advice and adequate test, respectively. This association, however, varied across the countries, with significant heterogeneity for the effects (I-squared ranging from 41% to 76.6%) (Figure S1-3). Similarly, we found lower risk of neonatal mortality among neonates of women who had ANC administered by a skilled personnel, those who had sufficient ANC advice and those who had adequate ANC in all regions with significant heterogeneity for the effect size across the regions (I-squared ranging from 87.2% to 98.2%) (Figure 2a-c). The only exception was in Africa where no clear difference was found in the association of neonatal mortality and ANC attended to by skilled personnel (Figure 2a). Smoothed hazard functions for neonatal mortality during the first month of life are shown in Figure S4 (a-d) stratified by adequacy of ANC, sufficiency of advice, skilled ANC service provider and the ANC quality index. The hazard was greatest among those who had no adequate test, no sufficient advice, and those in the lower level on the ANC quality index. Overall, the risk was highest at the beginning of life for all neonates and the differences in the risk among the groups were also greatest during the early neonatal period. We found statistically significant two-way interaction between the ANC quality index and place of delivery. Consequently, we plotted predictive margins to investigate graphically the association between the ANC quality index and place of delivery with respect to neonatal mortality (Figure S5). In further analyses of these associations, we found multiplicative interactions between wealth index and maternal education, number of children ever born, maternal age and ANC quality index.

DISCUSSION

This study found evidence in support of positive association of the quality of antenatal care with neonatal survival in LMICs. Meta-analysis of individual level data suggests that children of women who were seen by skilled personnel during ANC visits had 34% lower risk of dying during the neonatal period. Correspondingly, the pooled HR showed 20% and 39% reduced risk of neonatal mortality for children of women who had sufficient advice and adequate test, respectively. However, these associations vary across countries. The differences in neonatal mortality by the quality of ANC were greater during the early neonatal period. With the exception of the African region, in all the regions children whose mothers had ANC attended to by skilled personnel had lower risk of dying during the first 28 days of life.

To the best of our knowledge, we did not find any multi-country study conducted in LMICs which examined the quality of ANC nor how it is associated with child health in general and neonatal mortality in particular. This study is therefore the first to provide detailed analysis on the subject. In this regards, there is lack of previous studies for comparison of the findings. Our finding of the ability of the quality of ANC to reduce neonatal mortality is consistent with a recent cohort study, which reported that adherence to ANC guidelines decreased neonatal and delivery complications [14]. The country differences found in this study are consistent with smaller earlier studies [15, 16]. Our finding of lack of evidence on the association of the quality of ANC with neonatal mortality in the African region varies from a previous study from 17 least developed countries in the same region which found reduced risk of neonatal mortality among children of women whose ANC were attended to by skilled personnel [17]. Our data is more recent and included 33 countries from the Africa region that are a mixture of LMICs. These differences could explain the disparities in the findings. Future study should investigate why the quality of ANC was not associated with reduced neonatal mortality in Africa.

Most of the ANC quality indicators used in our study such as blood and urine tests and counselling are essential, simple, and low cost clinical procedures, which can be readily available and easily used in most LMICs. These measures are, nevertheless, very critical screening techniques that can contribute to identifying high-risk pregnancies in order to offer preventive remedy and consequently avoid complications and ensure survival of both mother and child. The quality of ANC has also been reported to affect women's potential use of ANC services [18]. Our findings provide evidence for the need to promote adherence to simple ANC routine practices in order to improve survival of neonates in LMICs. Aside from the availability of skilled personnel and resources, cultural beliefs, practices, and policies of health authorities and healthcare delivery systems in LMICs can affect the quality of ANC and health care delivery in general and influence women's access to healthcare.

In a prospective randomized trial in six LMICs, Baqui et al.[19] found that half of neonatal mortality occurred during the first couple of days of life similar to what we found in this study. Furthermore, our finding of greater differences in neonatal survival during the early days of life underscores the crucial role of quality ANC in preventing avoidable early neonatal deaths. Many of the countries in this region did not meet the MDG of reducing under-5 mortality by two-thirds between 1990 and 2015, although some have made significant progress. The SDG 3 that aims at reducing neonatal mortality to 12 per 1000 live births has set a renewed agenda to address the global challenge of improving child health in pursuant of the unfinished agenda of the MDGs [3]. Moreover, improving access to quality healthcare, including utilization of quality ANC, is an important priority in the SDG era. The provision of efficient low cost ANC services such as essential tests and counselling/advice during ANC can contribute to the prevention of complications during delivery and save lives of babies and their mothers while accelerating progress towards the attainment of the SDG 3. A recent study has shown that neonates of women who deliver in a health facility have higher survival compared to those who do not deliver in health facility [20]. Similarly, we found that the association between neonatal mortality and the ANC quality index was observed only when the delivery took place in a

health facility. This highlights the importance of health facility delivery in achieving the goal of ANC. Overall, however, we found strong association of the effect of the quality ANC even after adjusting for the place of delivery and other potential confounders. Our findings therefore underscore strong independent effect of the quality of ANC on neonatal mortality in LMICs.

Besides, the association between ANC quality indicators, we found associations of neonatal mortality with wealth index, maternal education, maternal age and the number of children ever born. These associations were similar to those reported in previous studies[6], except that we found multiplicative interactions between wealth index and maternal education, number of children ever born, maternal age and ANC quality index. This suggests that the effect of wealth on neonatal mortality varies by these factors.

The pooled data used ensured large sample size, which guaranteed sufficient power of the study. In addition, the meta-analysis conducted is strengthened by the use of data which were collected using similar protocols in all the countries. Additionally, our data represent nearly half of all LMICs in the world and therefore provide a broader perspective on the subject in these regions. Despite these strengths, there are a number of constraints, which should be considered in the interpretation of the findings. All indicators used in this study were self-reported and may be biased by social desirability within the individual countries. Also, the cross-sectional nature of our data limits causal inference of the findings. Data on neonatal mortality were estimated from the births and deaths records, which were reported by the women retrospectively. The socio-demographic indicators such as age, wealth index and maternal education were measured at the time of survey while the ANC variables and neonatal mortality were reported on the most recent births within five years of the survey. Therefore, it is possible that some of the socio-demographic factors have changed within the five years. The data may be subject to misclassification of stillbirth as neonatal death as well as by recall bias. However, previous studies, which validated such measures in retrospective and longitudinal surveys found them

to be accurate [21]. Initial assessment of the health data in the DHS-I suggests that they are accurate estimates [22]. Moreover, a recent study of the validity of the DHS neonatal mortality measures concluded that notwithstanding the limitations of the surveys, they provide the most reliable estimates of neonatal mortality in LMICs [23]. Although this study provides the most detailed analysis of the association of the quality of ANC on neonatal mortality, it is limited by the availability of data on the cause of death to investigate further to what extent the quality of ANC might have contributed to the cause of death. This notwithstanding, the independent association between the quality of ANC after adjusting for a large number of potential confound strengthens our findings.

Overall, this study provides evidence regarding the potential of quality of ANC in future interventions to reduce neonatal mortality in low resources countries and to the attainment of the SDG 3, which targets reducing neonatal mortality to 12 per 1000 live births. Substantial improvement in the quality of ANC services are necessary to improve neonatal health in particular and maternal and child health in general. In LMICs where resources are very limited, it is important to adapt and monitor ANC quality assessment criteria appropriate to the local setting in order to improve the quality of ANC. Middle-level health personnel such as nurses and mid-wives should be trained to perform basic maternal and foetal assessments and tests during ANC.

Competing interests

We declare no competing interests.

Contributors

SN and DT developed the idea and the design of the study. SN and DT analysed the data, contributed to the data interpretation and wrote the first draft of the manuscript. Both authors reviewed the draft manuscript and approved the final version.

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Ethical approval

Ethical approval for the study was granted from the relevant institutions in the various countries (detail provided in a supplement file S5) and respondents gave written consents in all the countries. Participants gave consent for the data to be used for publication. Permission to use the data was granted by DHS Program.

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Figure Legends

Figure 1: a) Number of neonatal mortality per 1000 live births b) proportion of women who attended to by skilled antenatal care provider during pregnancy.

Figure 2: Meta-analysis of the association of ANC quality indicators with neonatal mortality, adjusted hazard ratios (HRs) and their 95% confidence intervals (CIs) for the risk of neonatal mortality among children of mothers who had **a)** antenatal care attended to by skilled personnel during pregnancy across regions **b)** sufficiency of advice during pregnancy across regions and **c)** adequacy of ANC during pregnancy across regions.

Supplementary files:

Figure S1: Meta-analysis of the association of ANC quality indicators with neonatal mortality, adjusted hazard ratios (HRs) and their 95% confidence intervals (CIs) for the risk of neonatal mortality among children of mothers who had antenatal care attended to by skilled personnel during pregnancy across countries. Four countries were excluded in this analysis due to fewer or no cases of neonatal mortality per the categories of the independent variable (Skilled attendants).

Figure S2 Adjusted hazard ratios (HRs) and their 95% confidence intervals (CIs) for the risk of neonatal mortality among children of mothers who had sufficiency of advice during pregnancy across countries. Three countries excluded in this analysis due to fewer or no cases of neonatal mortality per the categories of the independent variable (high sufficiency of advice).

Figure S3 Adjusted hazard ratios (HRs) and their 95% confidence intervals (CIs) for the risk of neonatal mortality among children of mothers who had adequacy of ANC during pregnancy

across countries. Ten countries excluded in this analysis due to fewer or no cases of neonatal mortality per the categories of the independent variable (high adequacy of test).

Figure S4: Hazard of neonatal death during the first month of life stratified by **a)** adequacy of ANC, **b)** sufficiency of advice, **c)** ANC provider, and **d)** ANC quality index.

Supplementary file S5: List of country specific ethical committee or institutional review board

Table 1: Distribution of maternal content of Antenatal Care (ANC) (adequacy of test, sufficiency of advice and care provider) and the ANC quality index by country and region.

	N = 651681	Antenatal Care content			
		Adequacy of test	**Sufficiency of advice**	**ANC provider**	**ANC quality index**
		Yes	**Yes**	**Skilled**	**High**
Africa					
Benin (2011-12)	13191	7767 (97.8)	5070 (63.7)	6847 (76.3)	4360 (54.9)
Burkina Faso (2010)	15375	5968 (59.8)	5242 (52.7)	8034 (76.8)	2584 (25.9)
Burundi (2010)	7981	316 (6.3)	1822 (36.4)	4997 (98.7)	154 (3.1)
Cameroon (2011)	11748	6203 (95.2)	3214 (49.4)	5598 (73.5)	2649 (40.7)
Chad (2014-15)	18635	5719 (79.6)	3336 (47.0)	5645 (50.9)	2225 (31.0)
Comoros (2012)	3235	1531 (79.7)	643 (33.6)	335 (16.3)	106 (5.5)
Congo (2011-12)	8170	5390 (98.4)	3413 (62.3)	5244 (89.2)	3262 (59.5)
Congo D Rep. (2013-14)	18390	7380 (74.2)	6249 (63.0)	5322 (48.2)	2761 (27.8)
Cote D'Ivoire (2011–12)	7492	3199 (66.1)	1769 (36.7)	4510 (86.4)	1329 (27.5)
Ethiopia (2011)	11872	1130 (33.3)	679 (20.0)	2554 (32.4)	370 (10.9)
Gabon (2012)	5122	3480 (98.7)	1683 (48.1)	3375 (92.1)	1593 (45.2)
Ghana (2014)	5695	3879 (96.1)	3387 (84.0)	3651 (88.1)	3000 (74.3)
Guinea (2012)	7067	2222 (51.2)	1455 (33.5)	3188 (64.1)	809 (18.6)
Kenya (2014)	19564	5646 (85.2)	3867 (58.4)	13704 (95.1)	3482 (25.1)
Lesotho (2014)	3112	1964 (80.0)	1556 (63.4)	2427 (94.3)	1316 (53.6)
Liberia (2013)	6502	3881 (83.4)	3261 (70.2)	4298 (90.2)	2609 (56.1)
Madagascar (2008-09)	12686	6157 (78.2)	3829 (48.7)	7287 (84.3)	3280 (41.7)
Malawi (2010)	19697	11334 (84.3)	10692 (79.6)	12688 (92.9)	8866 (65.9)
Mali (2012-13)	10402	2192 (43.1)	2102 (41.4)	4793 (70.8)	1222 (24.1)
Mozambique (2011)	11704	2765 (38.7)	2831 (39.6)	4333 (55.0)	769 (10.8)
Namibia (2013)	4804	3481 (93.7)	2729 (73.5)	3686 (96.2)	2578 (69.3)
Niger (2012)	13347	1930 (28.2)	3828 (56.0)	6610 (82.8)	1403 (20.5)
Nigeria (2013)	31828	10330 (77.1)	9032 (67.8)	12166 (60.0)	7148 (53.2)
Rwanda (2014-15)	8004	3210 (53.4)	4746 (79.2)	5918 (97.8)	2700 (44.9)
Sao Tome (2008-09)	1834	1356 (99.9)	899 (66.3)	1341 (98.1)	889 (65.4)
Senegal (2014)	11479	6075 (71.7)	7590 (89.9)	5546 (75.3)	2084 (28.3)
Sierra Leone (2013)	12198	5198 (70.6)	3333 (45.2)	5194 (60.4)	3687 (43.5)
Swaziland (2006-07)	2829	2043 (98.4)	1115 (53.7)	1739 (81.6)	944 (45.5)
Tanzania (2010)	8176	2459 (45.5)	2860 (53.1)	4380 (79.6)	1451 (26.9)
Togo (2013-14)	6706	3711 (82.4)	2974 (66.2)	1278 (26.3)	786 (17.4)
Uganda (2011)	8076	2726 (57.3)	2410 (50.7)	4406 (88.7)	1549 (32.6)
Zambia (2013-14)	13383	8096 (88.0)	8092 (88.0)	229 (2.5)	177 (1.9)
Zimbabwe (2010-11)	5596	2099 (52.7)	2496 (62.7)	799 (18.1)	364 (9.1)
Africa pooled	345898	140836 (71.0)	1181193 (59.7)	162122 (69.4)	72504 (35.2)
East Asia & Pacific					
Cambodia (2014)	7253	5364 (94.0)	4684 (82.1)	5594 (93.7)	4420 (77.5)
Indonesia (2012)	16948	13373 (93.4)	7591 (53.0)	9796 (66.6)	5354 (37.4)
Philippines (2013)	6982	4825 (96.8)	4003 (80.3)	1508 (29.1)	1278 (25.6)
Timor-Leste (2009-10)	9828	4903 (93.2)	2933 (55.7)	4694 (78.0)	2482 (47.1)
East Asia & Pacific pooled	41011	28465 (94.0)	19211 (63.5)	21593 (67.7)	13533 (44.7)
Europe & Central Asia					
Albania (2008-09)	1576	1137 (86.8)	616 (47.0)	1275 (97.3)	595 (46.7)
Armenia (2010)	1448	1140 (99.1)	651 (56.6)	1103 (95.8)	625 (54.8)
Azerbaijan (2006)	2289	1034 (61.4)	558 (33.1)	1289 (76.5)	503 (38.3)
Kyrgyz Republic (2012)	4082	2911 (99.5)	1801 (61.9)	2569 (85.5)	1569 (53.6)

Moldova (2005)	1591	1351 (99.3)	1029 (75.9)	1295 (93.5)	975 (71.7)
Ukraine (2007)	1177	1056 (100.0)	398 (37.7)	1053 (99.1)	396 (37.4)
Europe & Central Asia pooled	12164	8629 (95.2)	5051 (55.8)	8583 (89.4)	4662 (51.4)
Latin America & Caribbean					
Bolivia (2008)	8726	5622 (96.1)	3897 (66.7)	5814 (89.9)	3597 (61.5)
Colombia (2010)	15856	12801 (99.5)	10465 (81.3)	12785 (96.4)	10370 (80.6)
Dominican Rep (2013)	3618	2905 (99.8)	2100 (72.0)	2844 (97.2)	2038 (69.9)
Guyana (2009)	1886	1352 (98.1)	925 (67.2)	1288 (90.7)	868 (62.3)
Haiti (2012)	6893	4526 (95.7)	3075 (65.0)	4463 (85.5)	2842 (60.1)
Honduras (2011-12)	10174	7901 (98.8)	6046 (75.7)	7419 (89.8)	5580 (69.8)
Peru (2012)	8804	7238 (99.3)	6753 (92.7)	1254 (16.9)	1120 (15.4)
Nicaragua (2001)	32644	4100 (98.2)	3215 (77.0)	4106 (84.9)	3146 (75.3)
Latin America & Caribbean pooled	88603	46447 (98.4)	36476 (77.3)	39621 (79.6)	29560 (62.6)
Middle East & North Africa					
Egypt (2014)	15668	9184 (89.2)	4777 (46.5)	14124 (90.2)	4500 (31.9)
Jordan (2012)	9833	6374 (97.8)	2209 (33.9)	6518 (99.1)	2180 (33.5)
Morocco (2003-04)	31696	2605 (81.6)	1248 (39.1)	3177 (67.8)	1082 (33.9)
Turkey (2003)	21173	2564 (81.0)	NA	3138 (76.1)	0
Middle East & North Africa pooled	78370	20727 (89.5)	8234 (41.2)	26975 (86.8)	7762 (28.8)
South Asia					
Bangladesh (2014)	8092	3006 (82.7)	1695 (46.7)	2563 (57.9)	1061 (29.4)
India (2005-06)	56438	18635 (60.9)	14269 (46.6)	28152 (71.0)	11139 (36.4)
Maldives (2009)	3736	3164 (84.3)	1647 (51.9)	3019 (94.9)	1557 (49.0)
Nepal (2011)	5391	1489 (42.3)	2777 (78.9)	2227 (53.7)	1023 (29.1)
Pakistan (2012-13)	11977	3377 (60.0)	2837 (50.5)	5338 (71.8)	2004 (35.6)
South Asia pooled	85634	29670 (63.7)	23226 (49.9)	41299 (70.2)	16785 (36.1)
All countries					
Pooled	**651681**	**274773 (66.1)**	**210391 (50.6)**	**300175 (72.4)**	**144807 (39.6)**

Table 2: Association of neonatal death with content of antenatal care. Hazard ratios (HR) and their 95% confidence intervals (CI) adjusted for potential confounders (place of delivery, maternal age, area of residence, wealth quintile, children ever born, maternal education, country and year of survey variables) at the most recent birth.

	n[†]	Weighted percentage	Neonatal death, %	Adjusted HR[‡] (95% CI)	*P*-value[§]
Adequacy of test					<0.001
No	79987	22.5	3.1	1.0	
Yes	274773	77.5	2.2	0.82 (0.75-0.89)	
Sufficiency of advice					0.011
No	140782	40.1	2.6	1.0	
Yes	210391	59.9	2.2	0.90 (0.84-0.97)	
ANC provider					0.007
No care	49183	11.9	3.5	1.0	
Non-skilled	65262	15.7	2.4	0.62 (0.54-0.70)	
Skilled	300175	72.4	2.4	0.71 (0.64-0.79)	
ANC quality index					<0.001
Low	80961	22.1	2.9	1.0	
Medium	140078	38.3	2.4	0.88 (0.80-0.96)	
High	144807	39.6	2.1	0.85 (0.77-0.93)	
Place of delivery					0.838
Others	227637	39.5	4.4	1.0	
Health facility	349455	60.5	3.4	1.00 (0.92-1.10)	
Maternal age group					<0.001
15-19	35156	5.4	5.0	1.0	
20-24	142312	21.8	4.1	0.66 (0.57-0.76)	
25-29	172849	26.5	3.4	0.55 (0.47-0.64)	
30-34	129828	19.9	3.6	0.51 (0.43-0.61)	
35-39	91677	14.1	4.7	0.58 (0.48-0.69)	
40+	79858	12.3	8.2	0.62 (0.50-0.76)	
Area of residence					0.335
Urban	234027	35.9	4.0	1.0	
Rural	417654	64.1	4.4	1.04 (0.95-1.14)	
Wealth quintile					<0.001
Poorest	141770	22.9	4.5	1.0	
Poorer	133479	21.6	4.4	1.06 (0.95-1.18)	
Middle	126055	20.4	4.2	1.15 (1.03-1.28)	
Richer	117417	19.0	4.0	1.20 (1.07-1.36)	
Richest	100316	16.2	3.5	1.35 (1.17-1.55)	
Children ever born					<0.001
1 child	103156	15.8	2.8	1.0	
2-3	258510	39.7	3.7	0.86 (0.77-0.96)	
4-5	148018	22.7	4.4	1.06 (0.91-1.22)	
≥6	141973	21.8	6.7	1.48 (1.24-1.76)	
Maternal education					<0.001
No education	235728	36.2	5.4	1.0	
Primary	205021	31.5	4.4	0.87 (0.79-0.95)	
Secondary or more	210932	32.4	3.1	0.69 (0.62-0.77)	

† The total for each of the variable may not be same because of the missing information in ANC variables.
‡ Each independent variables were adjusted separately for each socio-demographic factors in table and for the place of delivery, country and year of survey variables.
§ Global *P*-values for each variables from multivariable cox model.