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RESEARCH ARTICLE

# Prevalence of Neonatal Mortality and its Associated Factors: A Meta-analysis of Demographic and Health Survey Data from 21 Developing Countries

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**Abstract**
Neonatal mortality is high in developing countries, and reducing neonatal mortality is an indispensable part of the third Sustainable Development Goal. This study estimated the prevalence of neonatal mortality and the impact of maternal education, economic status, and utilization of antenatal care (ANC) services on neonatal mortality in developing countries. We used a cross-sectional study design to integrate data from 21 developing countries to acquire a wider perspective on neonatal mortality. A meta-analysis was conducted using the latest Demographic and Health Survey data from 21 developing countries. In addition, sensitivity analysis was adopted to assess the stability of the meta-analysis. The random-effects model indicated that women with higher education were less likely to experience neonatal death than mothers with up to primary education (odds ratio [OR] 0.820, 95% confidence interval [CI] 0.740–0.910). Women with higher socioeconomic status were less likely to experience neonatal death than mothers with lower socioeconomic status (OR 0.823, 95% CI 0.747–0.908). Mothers with ANC were less likely to experience neonatal death than those with no ANC (OR 0.374, 95% CI 0.323–0.433). Subgroup analysis showed that maternal education and ANC were more effective in Asian countries. In this study, mothers' lower educational level, poor economic status, and lack of ANC were statistically significant factors associated with neonatal death in developing countries. The effect of these factors on neonatal death differed in different regions.

**Keywords** Neonatal mortality · Maternal education · Antenatal care · Sustainable development goals · Meta-analysis

**Abbreviations**

| | |
|---|---|
| ANC | Antenatal care |
| SDGs | Sustainable Development Goals |
| MDGs | Millennium Development Goals |
| DHS | Demographic and Health Survey |

## 1 Introduction

The neonatal phase, which is the first 4 weeks (28 days) from birth, is the most vulnerable phase of human life for acquiring diseases [1]. Neonatal death is an indicator of a country's demographic, biological, and socioeconomic conditions as well as the health system, public health, and population growth rate [2, 3]. Although the neonatal mortality rate has decreased worldwide, the decline is slower than the under-5 child mortality and is still unacceptably high at 37 per 1000 live births [4, 5]. Globally, about 7000 babies die daily; most of these deaths occur within the first week, and nearly 2.6 million babies die in the first month of life [6]. About 78% of these neonatal deaths occur in developing countries, particularly in South Asia and Sub-Saharan Africa [7, 8], which account for 39% of all global neonatal deaths and are among the top 10 countries with the highest neonatal mortality rate [9, 10]. To address maternal, neonatal, child, and adolescent health issues, sustainable development goals (SDGs) to build on millennium development goals (MDGs) were introduced in 2015 [11]. The first three targets of the health goals of SDGs are a continuation of the MDGs. The most important target is to decrease under-5 deaths to below 25 deaths per 1000 live births and to reduce neonatal mortality to below 12 deaths per 1000 live births [12, 13]. To fulfill the SDGs, it is essential to explore the factors determining neonatal death. Furthermore, to initiate the proper steps

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and appropriate strategies for reducing neonatal mortality rate, identifying the causes of neonatal death and triggering factors of neonatal mortality should be the first step [14]. Neonatal deaths are influenced by multiple factors and represent a complex interaction among these factors [15]. The majority of neonatal deaths occur among the poor and most deprived with low socioeconomic status, less education, and less or no access to health care [16].

In this study, we estimated the impact of maternal education, economic status, and utilization of antenatal care (ANC) services on neonatal death and their consistency in 21 developing countries in Asia and Sub-Saharan Africa. This study explored the impact of maternal education, wealth index, and ANC access on neonatal mortality in 21 developing countries using the latest Demographic and Health Survey (DHS) data. The effect of maternal education and ANC on neonatal death was different in Asia compared to developing countries in Africa. This study recommends raising awareness regarding neonatal mortality and implementing strategies to achieve the SDG by 2030.

## 2 Materials and Methods

### 2.1 Study Design

We used a cross-sectional study design to apply meta-analysis techniques to data from 21 developing countries. The data were obtained from the DHS.

### 2.2 Data Source and Extraction

We conducted a meta-analysis utilizing recently accessible datasets (accessed in June 2020) from the Monitoring and Evaluating to Assess and Use Results DHS (MEASURE DHS) (www.measuredhs.com). We accessed recently available DHS data for 20 developing countries [17]: Afghanistan (2015), Angola (2015–16), Benin (2017–18), Chad (2014–15), Cambodia (2014), Ethiopia (2016), Ghana (2014), Guinea (2018), India (2015–16), Indonesia (2017), Kenya (2014), Lesotho (2014), Myanmar (2015–16), Nepal (2016), Nigeria (2018), Pakistan (2017–18), Sierra Leone (2013), Timor-Leste (2016), Zambia (2013–14), and Zimbabwe (2015). One of the primary goals of the DHS program is to provide high-quality, accessible data for analyses such as in the form of a questionnaire. The DHS database contains information from 91 countries (http://dhsprogram.com/data/available-datasets.com). We have selected Bangladesh and 20 other developing countries, followed homogenous sampling schema. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Fig. 1) clearly illustrates the process of identifying and including DHS datasets for the random-effects meta-analysis [18].

### 2.3 Variables

In this study, we considered neonatal mortality as the dependent variable. We measured this as a two-category dummy variable, and the two distinct levels were "Yes" if neonatal death occurred and "No" if death did not occur. We included maternal education, ANC services, and wealth index as independent variables. We combined secondary and above primary education for the variable maternal education, and up to primary education as another category. We changed the variable's wealth index label to "living below the poverty line." We combined poorer and poorest and labeled them "Yes" if the individuals were poor or lived below the poverty line; we combined middle, richer, and richest and labeled them "No" for individuals who lived above the poverty line. For binary logistic regression, we subcategorized mothers who received ANC into two categories: "Yes" for at least one ANC visit; and "No" for no ANC visit.

### 2.4 Statistical Analyses

We used SPSS Statistics 23.0 (SPSS Inc., Chicago, IL, USA) and R 3.6.2 for Windows (Bell Laboratories, Murray Hill, NJ, USA) to conduct the statistical analyses. We applied meta-analysis techniques to the DHS data from 21 developing countries. Heterogeneity was assessed by enumerating the $I^2$- and $P$-values among datasets [19]. We performed a random-effects model in the meta-analytical approach, as significant heterogeneity was found by which we estimated DerSimonian and Laird's pooled effect [20]. Forest plots were used to display 95% confidence intervals (CIs), summary measure, and the weight of each study for the most significant determinants. Subgroup analysis was used to compare the effect of selected factors on neonatal mortality among the different groups [21]. As a summary measure, we used the odds ratio (OR), and all findings were weighted to handle bias due to undersampling and oversampling. Sensitivity analyses indicated that the included country had a similar influence on the overall estimate (Supplementary information, Appendixes 1–3).

## 3 Results

### 3.1 Background Characteristics of the Selected Datasets

The percentage of neonatal mortality was highest (3.6%) in Nigeria. In Afghanistan, maternal education up to primary level was highest (92.6%), whereas living below the poverty

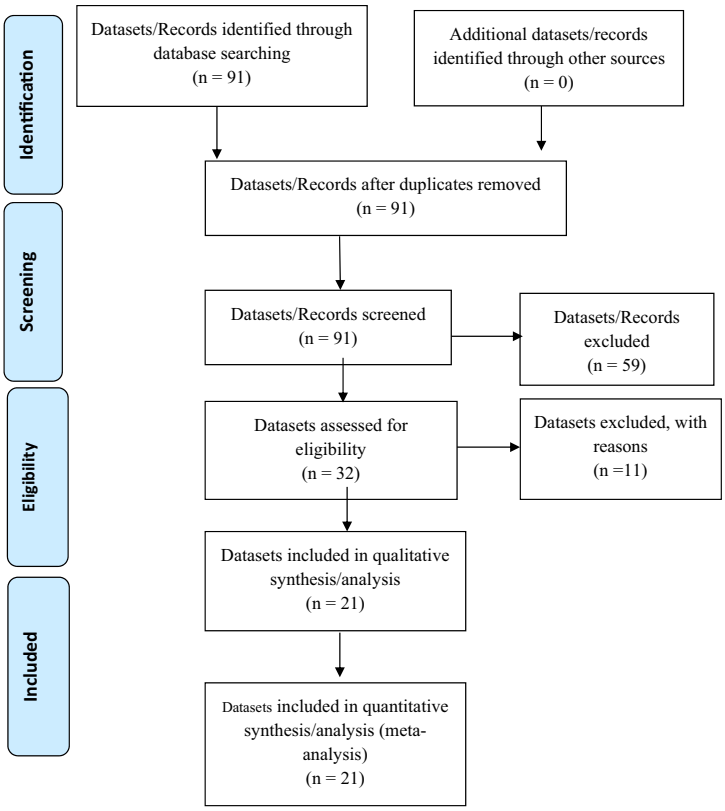


**Fig. 1** PRISMA flow diagram for eligibility criteria of datasets

line was highest in Timor-Leste (64.5%), and the percentage of no ANC was highest in Afghanistan (Table 1).

### 3.2 Binary Logistic Regression Model

### 3.3 Random-Effects Model in Meta-analysis of 20 Developing Countries

Our study used the random-effects model, which showed high between-study variation (heterogeneity). Table 2 shows the results of the random-effects model of 21 developing countries' data, and Table 3 shows the summary effect of different explanatory variables. For maternal education, the overall OR was 0.820 (95% CI 0.740–0.910; $P \leq 0.0306$), showing that mothers who had above primary education were 0.820 times or 18.0% less likely to experience neonatal death compared to mothers who had up to primary education. About 61.3% of the variation ($I^2 = 61.3\%$) was found for this variable. For living below the poverty line, $I^2$ was found to be 70.7%, where the overall OR was 0.823 (95% CI 0.747–0.908; $P \leq 0.0001$), which revealed that the odds of neonatal mortality was 0.823 times or 17.7% lower among individuals who do not live below the poverty line compared to those who live below the poverty line. About 86.3% of the variation ($I^2 = 86.3\%$) was found for ANC. The overall OR was 0.374 (95% CI 0.323–0.433; $P \leq 0.0001$), which means that neonatal death was 0.374 times or 62.6% less likely among women who received ANC compared to women who did not have access to ANC.

From Fig. 2a, the overall estimate of the random effects model for maternal education is 0.82. The 95% CI of the overall estimate (0.74–0.91) also does not overlap with one, so it can be concluded that women who were educated above the primary level were 18% less likely to experience neonatal death as compared to women who were educated up to primary level.

From Fig. 2b, the overall estimate of the random effects model for ANC utilization is 0.37; the 95% confidence interval of the overall estimate (0.32–0.43) also does not overlap with one, so it can be concluded that women who utilized ANC during their pregnancy were 63% less likely to experience neonatal death compared to those who did utilize ANC.

### 3.4 Subgroup Analyses of Different Factors

From Table 4 and Fig. 3a, it can be seen that maternal education with respect to region had a significant impact on neonatal mortality. For instance, having above primary education was a better predictor for reducing neonatal mortality in Asian countries (OR 0.76) than in African countries (OR 0.87).

Table 4 and Fig. 3b show that ANC utilization with respect to region had a significant impact on neonatal

**Table 1** Frequency and percentage of selected factors from 21 developing countries

| Country | Neonatal mortality *n* (%) | | Mother's education *n* (%) | | Living below poverty line *n* (%) | | ANC visit *n* (%) | |
|---|---|---|---|---|---|---|---|---|
| | No | Yes | Up to primary | Above primary | No | Yes | No | Yes |
| Sierra Leone 2013 | 9836 (96.8) | 328 (3.2) | 8828 (86.9) | 1336 (13.1) | 4613 (45.4) | 5551 (54.6) | 4224 (41.6) | 5940 (58.4) |
| Zambia 2013–14 | 11,318 (97.7) | 263 (2.3) | 8026 (69.3) | 3555 (30.7) | 5607 (48.4) | 5974 (51.6) | 3896 (33.6) | 7685 (66.4) |
| Bangladesh 2014 | 4586 (97.3) | 127 (2.7) | 1954 (41.5) | 2759 (58.5) | 1906 (40.4) | 2807 (59.6) | 1203 (25.5) | 3510 (74.5) |
| Cambodia 2014 | 6981 (98.7) | 94 (1.3) | 4503 (63.6) | 2572 (36.4) | 3005 (42.5) | 4070 (57.5) | 1562 (22.1) | 5513 (82.6) |
| Ghana 2014 | 5240 (97.3) | 144 (2.7) | 3078 (57.2) | 2306 (42.8) | 2962 (55.0) | 2422 (45.0) | 1664 (30.9) | 3720 (69.1) |
| Kenya 2014 | 9007 (98.0) | 184 (2.0) | 6973 (75.9) | 2218 (24.1) | 5056 (55.0) | 4135 (45.0) | 3097 (33.7) | 6094 (66.3) |
| Lesotho 2014 | 2635 (96.6) | 94 (3.4) | 1408 (51.6) | 1321 (48.4) | 1303 (47.7) | 1426 (52.3) | 607 (22.2) | 2122 (77.8) |
| Chad 2014–15 | 16,290 (97.3) | 454 (2.7) | 15,393 (91.9) | 1351 (8.1) | 6560 (39.2) | 10,184 (60.8) | 10,995 (65.7) | 5749 (34.3) |
| Afghanistan 2015 | 30,087 (97.7) | 705 (2.3) | 28,524 (92.6) | 2268 (7.4) | 12,637 (41.0) | 18,155 (59.0) | 20,344 (66.1) | 10,448 (33.9) |
| Zimbabwe 2015 | 5002 (97.6) | 125 (2.4) | 1554 (30.3) | 3573 (69.7) | 1982 (38.7) | 3145 (61.3) | 1378 (26.9) | 3749 (73.1) |
| Angola 2015–16 | 9028 (98.0) | 183 (2.0) | 6666 (72.4) | 2545 (27.6) | 4617 (50.1) | 4594 (49.9) | 4877 (52.9) | 4334 (47.1) |
| India 2015–16 | 42,623 (97.2) | 1234 (2.8) | 19,010 (43.3) | 24,847 (56.7) | 20,798 (47.4) | 23,059 (52.6) | 17,232 (39.3) | 26,625 (60.7) |
| Myanmar 2015–16 | 4420 (97.4) | 120 (2.6) | 2791 (61.5) | 1749 (38.5) | 2384 (52.5) | 2156 (47.5) | 1408 (31.0) | 3132 (69.0) |
| Ethiopia 2016 | 9537 (97.0) | 290 (3.0) | 8811 (89.7) | 1016 (10.3) | 5363 (54.6) | 4464 (45.4) | 5569 (56.7) | 4258 (43.3) |
| Nepal 2016 | 4874 (98.0) | 102 (2.0) | 2642 (53.1) | 2334 (46.9) | 2380 (47.8) | 2596 (52.2) | 1263 (25.4) | 3713 (74.6) |
| Timor-Leste 2016 | 52,640 (98.4) | 94 (1.6) | 2229 (38.9) | 3505 (61.1) | 2037 (35.5) | 3697 (64.5) | 2178 (38.0) | 3556 (62.0) |
| Indonesia 2017 | 16,561 (98.7) | 216 (1.3) | 4294 (25.6) | 12,483 (74.4) | 7736 (46.1) | 9041 (53.9) | 2802 (16.7) | 13,975 (83.3) |
| Benin 2017–18 | 11,632 (97.5) | 296 (2.5) | 10,066 (84.4) | 1862 (15.6) | 5212 (43.7) | 6716 (56.3) | 5203 (43.6) | 6725 (56.4) |
| Pakistan 2017–18 | 12,093 (96.6) | 430 (3.4) | 8127 (64.9) | 4396 (35.1) | 5731 (45.8) | 6792 (54.2) | 5635 (45.0) | 6888 (55.0) |
| Guinea 2018 | 7072 (96.7) | 96.7 (3.3) | 6518 (89.1) | 798 (10.9) | 3499 (47.8) | 3817 (52.2) | 3199 (43.7) | 4117 (56.3) |
| Nigeria 2018 | 30,169 (96.4) | 1140 (3.6) | 19,339 (61.8) | 11,970 (38.2) | 14,701 (47.0) | 16,608 (53.0) | 16,628 (53.1) | 14,681 (46.9) |

*ANC* antenatal care

mortality. For instance, receiving ANC during pregnancy compared to not receiving ANC was a better indicator of reduced neonatal mortality in the Asian region (OR 0.35) than in the African region (OR 0.39).

## 4 Discussion

In our study, maternal education, wealth index, and ANC utilization had a substantial effect on neonatal death in developing countries. Our results demonstrated that the probability of neonatal death was reduced among mothers with education above primary level compared to mothers with education up to primary level. The positive impact of maternal education on neonatal survival is supported worldwide [22, 23]. Even when we control for the other factors of neonatal death, maternal education remains essential for child survival [23]. Maternal education improves awareness about a child's health and healthcare facilities and enhances the healthcare-seeking behaviors of mothers [24]. Neonatal mortality is greatly influenced by ANC utilization in developing countries. Overall estimates from our meta-analysis showed that neonatal death was less likely in women who used ANC compared to those who did not, in accordance with previous studies [25, 26]. ANC utilization is one of the key strategies recommended to reduce neonatal death

**Table 2** Random-effects model estimation of the odds ratio for 21 developing countries

| Country | Mother's education Odds ratio | Wealth index Odds ratio | ANC visit Odds ratio |
|---|---|---|---|
| Afghanistan | 0.980 | 0.927 | 0.574 |
| Angola | 0.614 | 0.646 | 0.570 |
| Bangladesh | 0.668 | 0.777 | 0.325 |
| Benin | 0.792 | 0.937 | 0.392 |
| Cambodia | 0.902 | 0.542 | 0.290 |
| Chad | 0.981 | 0.944 | 0.532 |
| Ethiopia | 0.850 | 0.728 | 0.325 |
| Ghana | 1.039 | 0.950 | 0.235 |
| Guinea | 0.603 | 0.745 | 0.484 |
| India | 0.588 | 0.598 | 0.378 |
| Indonesia | 0.873 | 0.903 | 0.244 |
| Kenya | 0.958 | 1.005 | 0.319 |
| Lesotho | 1.022 | 0.995 | 0.370 |
| Myanmar | 0.922 | 0.967 | 0.241 |
| Nepal | 0.696 | 0.493 | 0.178 |
| Nigeria | 0.808 | 0.843 | 0.528 |
| Pakistan | 0.699 | 0.754 | 0.513 |
| Sierra Leone | 1.167 | 0.226 | 0.668 |
| Timor-Leste | 0.819 | 0.972 | 0.557 |
| Zambia | 1.023 | 0.916 | 0.278 |
| Zimbabwe | 0.645 | 0.699 | 0.219 |
| $I^2$ | 61.3 | 70.7 | 86.3 |
| $\hat{\tau}^2$ | 0.031 | 0.033 | 0.094 |

*ANC* antenatal care, $\hat{\tau}^2$ estimate of between-study variance.

**Table 3** Random-effects model estimation (summary effect) of various covariates in 21 developing countries

| Variables | Random-effects model | | | |
|---|---|---|---|---|
| | Odds ratio | *P*-value | Confidence interval | |
| | | | Lower bound | Upper bound |
| Mother's education level | 0.820 | 0.0306 | 0.740 | 0.910 |
| Wealth index | 0.823 | 0.0001 | 0.747 | 0.908 |
| ANC visit | 0.374 | 0.0001 | 0.323 | 0.433 |

*ANC* antenatal care

globally [27, 28]. Proper healthcare facilities improve pregnancy outcomes, and ANC utilization provides an opportunity for prompt detection of complications and early inception of breastfeeding. With follow-up ANC visits, pregnancy complications can be identified and addressed, which can lead to quality essential newborn care that increases survival [29]. Presently, for an uncomplicated pregnancy, at least eight ANC visits are necessary for better survival of neonates, as suggested by the World Health Organization [30]. However in our study, we found that in some countries, more than 50% of women did not have a single ANC visit throughout their pregnancy, which indicates that this essential service is severely underutilized in developing countries. From our meta-analysis, the odds of neonatal mortality were lower among individuals who live above the poverty line compared to those who live below the poverty line, in accordance with previous research [31, 32]. As poverty results in shortage of food, hygiene products, and secure drinking water, which immediately affects health outcomes, children from low-income families fare worse than those from high-income families. Additionally, children from low-income families have less access to health care services, which leads to more risk of neonatal death [33, 34]. Studies from Nepal and Nigeria showed a high risk of neonatal death among women with low socioeconomic status [35]. Our study found that more than 50% of women are living under the poverty line in almost all countries, which must be the focus to reduce neonatal death in developing countries.

Additionally, ANC and maternal education were more effective in Asian countries than in African countries. This may be due to the fact that the socioeconomic structure and household environmental indicators of Asian countries are relatively better than those of African countries [17, 35, 36].

Our study had some limitations. The DHS data utilized in this study covered a wide range and different time points. To estimate the OR from random-effects meta-analysis, we had to create 2 × 2 cross-tabulation for which each variable was divided into two categories. This is a limitation of doing

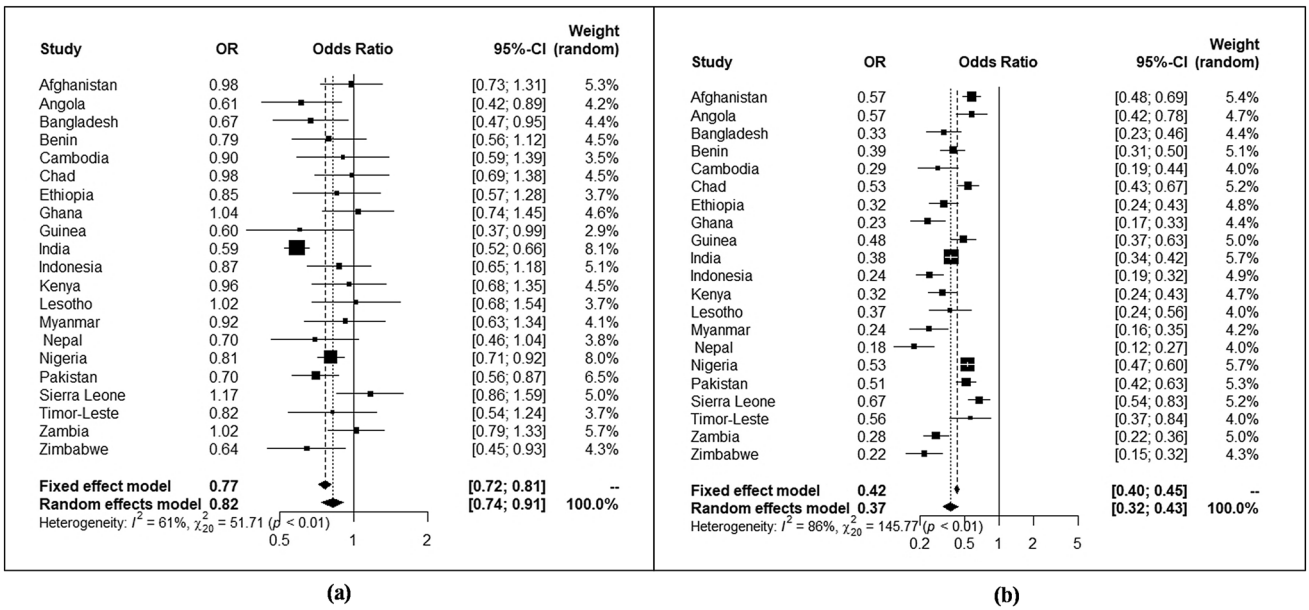


**Fig. 2** Forest plot for **a** mother's education and **b** ANC visit

**Table 4** Subgroup analyses of the variable mother's education and receiving ANC

| Variable | Asian countries | | | | | African countries | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | OR | 95% CI | $\hat{Q}$ | *P*-value | $I^2$ | OR | 95% CI | $\hat{Q}$ | *P*-value | $I^2$ |
| Mother's education | 0.76 | (0.66; 0.89) | 20.07 | 0.01 | 60% | 0.87 | (0.78; 0.97) | 16.96 | 0.011 | 35% |
| Receiving ANC | 0.35 | (0.27; 0.44) | 64 | 0.01 | 87% | 0.39 | (0.32; 0.48) | 77.16 | 0.01 | 86% |

CI confidence interval, $I^2$ between study variation, *OR* odds ratio, $\hat{Q}$ heterogenic statistic

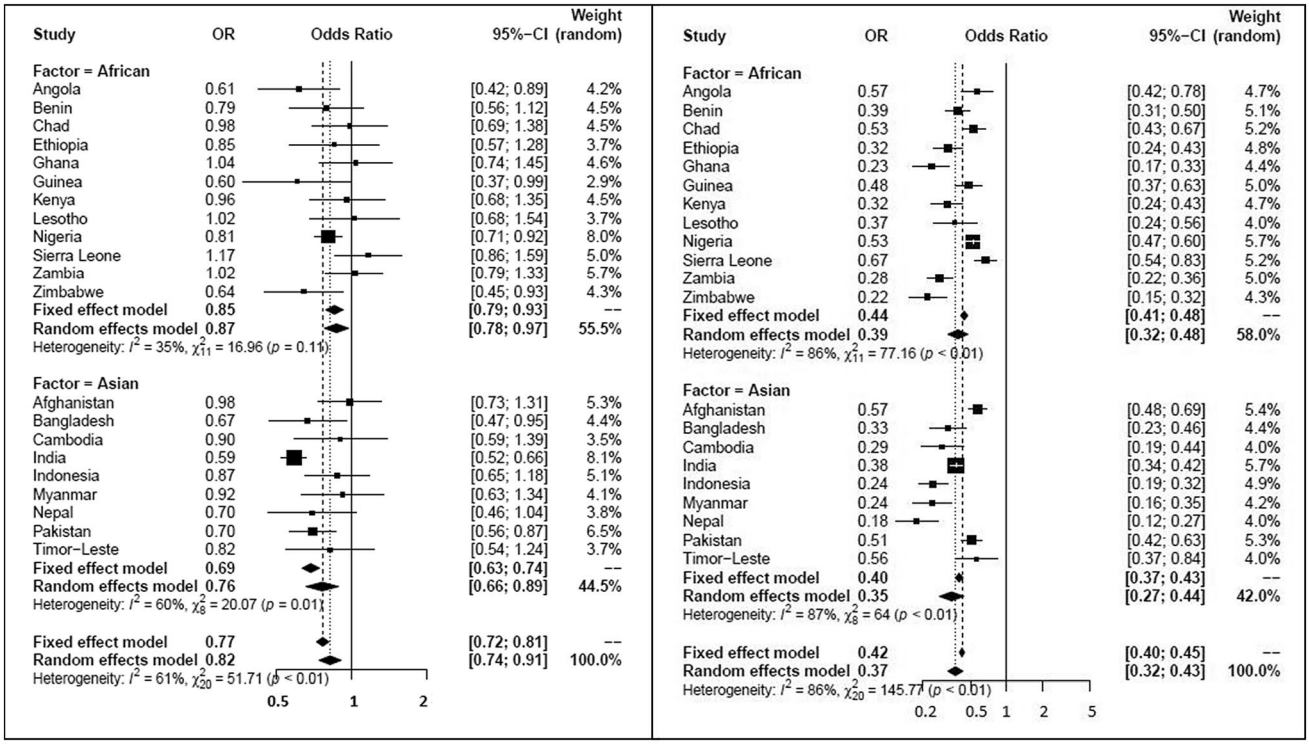


**Fig. 3** Forest plot of subgroup analysis for **a** mother's education and **b** ANC visit

a meta-analysis from cross-sectional datasets. Moreover, we were not able to incorporate all of the possible risk factors due to missing values of a particular variable in some of the countries. The range of years in the dataset of various countries, some of which date back several decades, might not reflect the actual data scenario.

## 5 Conclusion

To fulfill the SDG for the reduction of neonatal mortality rate by 2030, we need to implement different control programs focusing on risk factors of neonatal mortality. This study demonstrated the effect of maternal education, ANC, and wealth index on neonatal mortality using data from 21 developing countries. Proper steps and interventions should be initiated, focusing on the indicators identified in this study. Efforts toward increasing maternal education and utilization of ANC services must be ensured across developing countries, especially in African countries.

**Supplementary Information** The online version contains supplementary material available at https://doi.org/10.1007/s44229-022-00013-y.

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**Author contributions** MAI conceptualized the study, performed the data analyses, interpreted the data, and wrote the first draft of the

manuscript. NJS was responsible for manuscript writing and revisions. ZAB was responsible for significant editing and critical revisions of the manuscript.

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**Availability of data and material** The secondary datasets DHS for 21 developing countries that were analyzed in the current study are freely available on the following website: http://dhsprogram.com/data/available-datasets.cfm

## Declarations

**Conflict of interest** The authors have no competing interests to declare.

**Ethics declaration statement** Not applicable.

**Consent to participate statement** Not applicable.

**Consent to publication** Not applicable.



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