Global Patterns of Skilled Birth Attendance, Socioeconomic Factors, and Maternal Mortality

Modèles mondiaux de l'assistance qualifiée à l'accouchement, des facteurs socioéconomiques et de la mortalité maternelle

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Abstract | Résumé

Skilled birth attendance (SBA) is an important proxy for quality of maternal care, and is negatively correlated with maternal death. The present cross-national ecological study aimed to examine the association between SBA and maternal death considering socioeconomic predictors of MMR across a broad range of countries, and World Bank World Development Indicators were extracted for 180 countries between 2010 and 2023. Hierarchical linear regressions were performed to examine the association between SBA and MMR adjusting for GDP per capita, life expectancy, female literacy, sanitation, adolescent fertility and health expenditures.

SBA ranges from 58.5% (low-income) to 98.8% (high-income) while the MMRs are 538.3 (low-income) to 19.3 (high-income). The correlations of SBA with MMR show a high degree of negative association ($r = -0.775$, $p < 0.001$). Once fully adjusted for wealth, social and demographic factors, the association between SBA and log(MMR) turned out to be non-significant ($\beta = -0.004$, $p = 0.539$). GDP per capita, life expectancy ($\beta = -0.049$, $p = 0.010$) and adolescent fertility ($\beta = +0.006$, $p = 0.032$) have remained significant independent predictors of log(MMR). The full adjusted model explained 81.4% of the variance in log(MMR).

While SBA was not an independent predictor of maternal death at the ecological level controlling for level of development in the country, its beneficial effects were included within country level social determinants. This must be interpreted with caution due to ecological fallacy and a cross-section study design. At the individual level, there are direct clinical benefits for mothers receiving skilled birth attendance. Sustained reduction in maternal mortality requires the combination of development inputs related to education, sanitation, reproductive health and access to health care.

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L'assistance qualifiée à l'accouchement est un indicateur important de la qualité des soins maternels et est généralement associée à une diminution de la mortalité maternelle. La présente étude écologique menée à l'échelle internationale avait pour objectif d'examiner l'association entre l'assistance qualifiée à l'accouchement et la mortalité maternelle, tout en tenant compte de plusieurs facteurs socioéconomiques pouvant influencer le ratio de mortalité maternelle. Pour cela, des indicateurs de développement de la Banque mondiale ont été recueillis pour 180 pays entre 2010 et 2023. Des régressions linéaires hiérarchiques ont ensuite été réalisées afin d'analyser l'association entre l'assistance qualifiée à l'accouchement et le ratio de mortalité maternelle, en ajustant les résultats selon le PIB par habitant, l'espérance de vie, le taux d'alphabétisation des femmes, l'accès à l'assainissement, la fécondité chez les adolescentes et les dépenses en santé.

Les résultats montrent que la proportion d'accouchements assistés par du personnel qualifié varie de 58,5 % dans les pays à faible revenu à 98,8 % dans les pays à revenu élevé. De leur côté, les ratios de mortalité maternelle varient de 538,3 décès maternels pour 100 000 naissances vivantes dans les pays à faible revenu à 19,3 dans les pays à revenu élevé. L'assistance qualifiée à l'accouchement présente une forte corrélation négative avec la mortalité maternelle ($r = -0,775$, $p < 0,001$), ce qui signifie que les pays où l'accès à une assistance qualifiée est plus élevé tendent à avoir une mortalité maternelle plus faible. Cependant, après ajustement complet pour la richesse, les facteurs sociaux et les facteurs démographiques, cette association entre l'assistance qualifiée à l'accouchement et le logarithme du ratio de mortalité maternelle n'était plus statistiquement significative ($\beta = -0,004$, $p = 0,539$). Le PIB par habitant, l'espérance de vie ($\beta = -0,049$, $p = 0,010$) et la fécondité chez les adolescentes ($\beta = +0,006$, $p = 0,032$) sont demeurés des prédicteurs indépendants significatifs du logarithme du ratio de mortalité maternelle. Le modèle entièrement ajusté expliquait 81,4 % de la variance du logarithme du ratio de mortalité maternelle.

Ainsi, même si l'assistance qualifiée à l'accouchement n'était pas un prédicteur indépendant de la mortalité maternelle au niveau écologique après ajustement pour le niveau de développement des pays, ses effets bénéfiques semblent être intégrés dans des déterminants sociaux plus larges, comme l'éducation, les conditions sanitaires et l'accès général aux soins. Ces résultats doivent toutefois être interprétés avec prudence, notamment en raison du risque d'erreur écologique et du devis transversal de l'étude. À l'échelle individuelle, l'assistance qualifiée à l'accouchement demeure cliniquement bénéfique pour les mères. Une réduction durable de la mortalité maternelle nécessite donc une combinaison d'interventions liées au développement, incluant l'éducation, l'assainissement, la santé reproductive et l'accès aux services de santé.

Keywords: Maternal mortality; Skilled birth attendance; Healthcare accessibility; Socioeconomic development; Ecological study; World Bank WDI

Introduction

Globally, maternal mortality is the leading cause of death among women of reproductive age. There are estimated to be 287,000 maternal deaths per year from pregnancy and childbirth causes (1), nearly 95% of which occur in low- and middle-income countries, with Sub-Saharan Africa comprising approximately 70% of the global burden (2). The maternal mortality ratio (MMR, maternal death per 100,000 live births) varies by country, from less than 5 to greater than 1000 among the highest burden countries. With the exception of the smallest numbers, the most common causes of maternal death — postpartum hemorrhage, eclampsia, sepsis, and obstructed labor — can be managed effectively by skilled providers with timely obstetric care (3).

Skilled attendance at birth (i.e., a birth attended by doctors, midwives, or other trained healthcare personnel) is one of the formal SDGs indicators (3.1.2) which measures the country-level availability of delivery services (4) and which shows this association with individual-level clinical benefit for maternal outcome (5). Despite the fact that global skilled birth attendance (SBA) coverage has increased, a huge gap remains at the country level to achieve SDG Target 3.1 among the high burden countries.

At the population level, the ecological association between skilled birth attendant and maternal mortality might be affected by groups of factors together. The most skilled attendant countries are those with more social economic developing conditions (e.g., countries with higher gross domestic product (GDP) per capita, higher female literacy, better sanitation conditions, and low adolescent fertility rates) compared to those with less developed conditions (6). High literacy may relate to healthcare-seeking behaviors and good patient-provider relationships (7), while poor sanitation relates to the risk of infection and it is independent of attendance skill (8). Low adolescent fertility rate relates to reproductive health situation and higher obstetric risks (9). These development indices often cluster together rather than change independently; thus, determining the ecological effect of SBA alone becomes challenging.

This ecological study, conducted across 180 countries between the years 2010–2023, had two main purposes: I) to provide an overview of the world distribution of skilled birth attendant and maternal mortality, and to assess the correlation between SBA and MMR and socioeconomic indicators; II) to examine the SBA-MMR association and its changes over time, adjusted for the effects of socioeconomic confounders. Finally, the interaction of female literacy and sanitation with SBA was also investigated. The main goal of the study was to determine the standalone ecological contribution of SBA toward reducing maternal mortality.

Methods and Materials

Study design and data sources
This ecological, cross-national study used publicly available country-level indicators for the period of 2010 to 2023, sourced from the World Bank World Development Indicators (WDI). Country eligibility was based on data being available for SBA and MMR for at least one year. If multiple years of data were available for a country, then a mean value for the period of 2010–2023 was used. Institutional review board approval was not required due to the use of aggregated, publicly available data.

Variables
The dependent variable of interest was the MMR (WDI indicator: SH.STA.MMRT). Data was generated by the World Health Organization/United Nations International Children's Emergency Fund/United Nations Population Fund/World Bank Maternal Mortality Estimation Inter-Agency Group and was modeled using the Bayesian BMat model. Logarithm (log) of MMR was used in the regression analyses as MMR is right-skewed.

The independent variable of interest was the percentage of births attended by skilled health personnel (WDI indicator: SH.STA.BRTC.ZS), derived from DHS and UNICEF MICS surveys. Skilled health personnel included doctor, nurse, or midwife in attendance at birth.

A set of socioeconomic variables were pre-selected a priori including GDP per capita (current 2015 USD), adult female literacy (%), life expectancy at birth (years), access to basic sanitation (%), adolescent fertility rate (per 1,000 women aged 15-19), and health expenditure per capita (USD). GDP per capita and health expenditure per capita were log-transformed and all continuous variables were mean-centered to decrease multicollinearity. Countries were categorized by the World Bank income groupings.

Statistical analysis
Descriptive analyses provided summary statistics for each variable stratified by country income category. The bivariate association of each variable with the dependent variable was evaluated using Pearson correlations. These were represented using color-coded heat maps using R software (version 4.6.0).

Using Hierarchical Ordinary Least Squares regression, the change in the SBA-log(MMR) association was examined after sequential adjustment of the primary exposure. Model I included only the exposure and the primary outcome, the SBA-log(MMR) association. Model II added log(GDP per capita) to the model. Model III added life expectancy at birth and adult female literacy to the model. Model IV (full adjustment) included log(health expenditure per capita), sanitation, and adolescent fertility. Model fit was analyzed using R and adjusted R statistics. Multicollinearity was evaluated using variance inflation factors (VIF); VIF greater than 10 suggests high collinearity. Model coefficient plots were generated showing the beta coefficients with 95% confidence intervals (CI) at each step and plotted using standard functions within R.

An analysis was conducted using interaction terms between the exposure (SBA) and two covariates to examine effect modification between the exposure and I) adult female literacy and II) access to

Table 1. Descriptive analysis of study variables by World Bank income group. Summary statistics for maternal mortality ratio (deaths per 100,000 live births) and skilled birth attendance coverage (percentage of births) stratified by income classification. MMR = maternal mortality ratio. Data: World Bank WDI, country-level means 2010–2023.

Income Group	n	MMR Mean	MMR SD	MMR Min	MMR Max	Skilled % Mean	Skilled % SD
Low income	24	538.3	298.4	70.0	1,440.0	58.5%	20.4%
Lower middle	48	250.9	215.2	21.9	1,106.0	76.5%	17.4%
Upper middle	53	67.7	58.6	2.0	254.0	96.2%	7.1%
High income	53	19.3	24.2	2.2	116.0	98.8%	1.5%
Total	**178**	**189.2**	**248.1**	**2.0**	**1,440.0**	**82.4%**	**23.8%**

basic sanitation. Visualization of geographical trends was conducted using income-stratified scatter plots showing linear regression trendlines. All analyses were performed in R using WDI data accessed through the WDI R package. All tests were two-tailed with =0.05.

Results

Descriptive characteristics

180 countries were included in the analyses of SBA and MMR for the period of 2010–2023. The two countries that had a "Not classified" status were removed from income strata analyses, resulting in 178 countries. Significant variation was found across countries for both MMR (ranging from 2.0-1440.0 deaths/100,000 live births) and SBA (<60% to near universal) and distinct gradients were evident for each indicator according to country income category (Table 1). High income countries had a mean SBA of 98.8% (standard deviation, SD: 1.5%) while low-income countries had a mean of 58.5% (SD: 20.4%). The high-income group had a mean MMR of 19.3 (SD: 24.2), whereas the low-income group had a mean of 538.3 (SD: 298.4).

Geographic distribution

Figure 1 graphs SBA coverage and MMR by income group. There appears to be gradients for SBA coverage (from low coverage in low-income countries to high coverage in high-income countries) and for MMR (from high MMR in low-income countries to low MMR in high-income countries). However, particularly in low-income countries, the large standard deviations demonstrate a significant heterogeneity among the income categories.

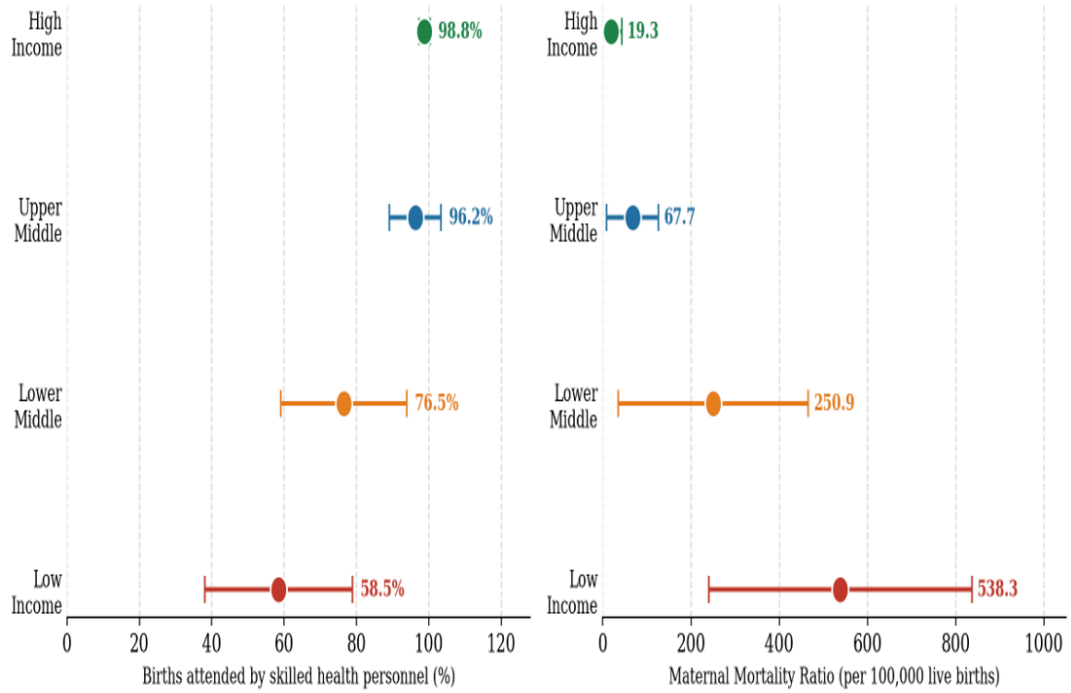

Figure 1. Skilled birth attendance and maternal mortality ratio by World Bank income group. Dot plots with error bars showing mean skilled birth attendance as percentage of births (left panel) and mean maternal mortality ratio per 100,000 live births (right panel) across income classifications. Error bars represent standard deviations. Country-level means are from 2010–2022; n = 178. Data: World Bank WDI.

Correlation structure

From the bivariate correlations, large relationships between variables were observed (Figure 2). A strong correlation was found between SBA and MMR (r = -0.775; p < 0.001; n = 180). The largest correlations with MMR were with life expectancy (r = -0.852). Both access to sanitation and female literacy had strong correlations with MMR (r = -0.807 and -0.793, respectively). Adolescent fertility had a strong positive correlation with MMR (r = +0.721). The correlation between SBA and log(GDP per capita) was also large (r = 0.73), showing high degrees of clustering of development indicators.

Figure 2. Pearson Correlation Matrix of Primary Study Variables (n = 178-180; all p < .001)

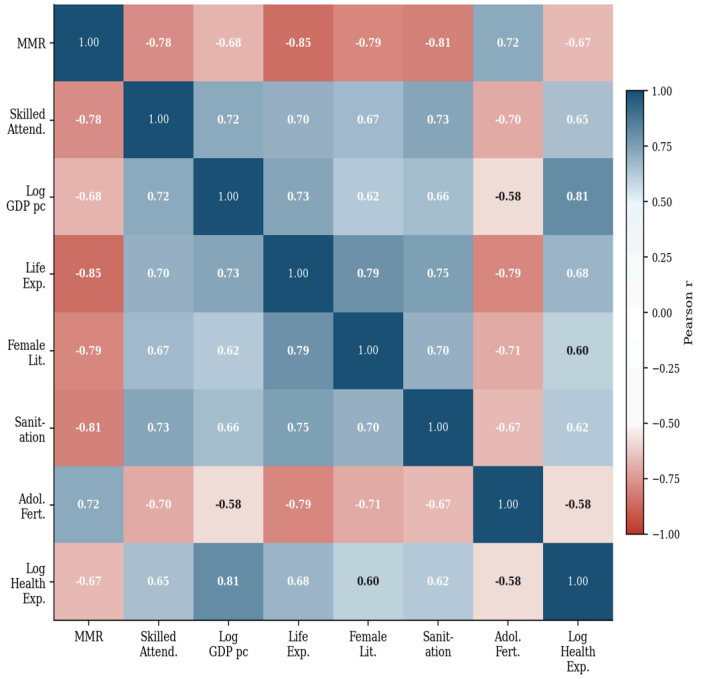

Figure 2. Pearson Correlation Matrix of primary study variables. Heat map displaying correlation coefficients between all study variables (n = 178–180). Color intensity indicates correlation strength: darker shades represent stronger correlations (positive in teal/green, negative in pink/red). All correlations significant at p < 0.001. Data: World Bank WDI 2010–2022, analyzed in R v4.6.0.

Figure 3 displays a scatter plot of SBA coverage against MMR by income group. There appears to be a strong negative relationship. There is a lot of overlap between income groups in the middle ranges of SBA coverage. On the other hand, high-income countries are situated mainly in the top-right (high SBA coverage, low MMR), while low-income countries are more dispersed.

Hierarchical regression models

Hierarchical regression analyses were used to test changes in the SBA-log(MMR) relationship after successive adjustment (Table 2). In Model I, a significant negative relationship (of -0.061, 95% CI: -0.069, -0.052, p < 0.001, R = 0.530) was present between SBA and log(MMR). Following inclusion of log(GDP per capita) (Model II), the SBA coefficient became negative but weaker (-0.027, 95% CI:

Figure 3. Skilled Birth Attendance vs. Maternal Mortality Ratio by Income Group (country-level means 2010–2022; n = 180; r = −0.775, p < .001)

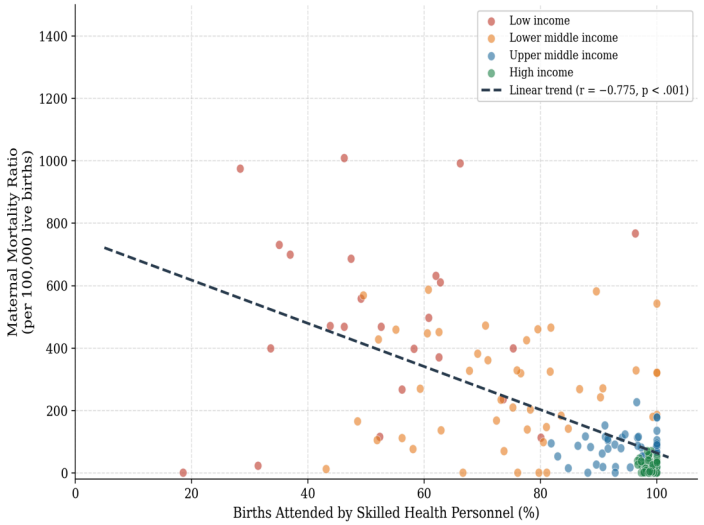

Figure 3. Scatter plot of skilled birth attendance and maternal mortality ratio by income group. Each point represents one country, color-coded by World Bank income classification (high-income = blue, upper-middle-income = green, lower-middle-income = yellow, low-income = red). Dashed line shows overall linear trend (r = -0.775, p < .001). Country-level means from 2010–2022 are used; n = 180. Data: World Bank WDI.

-0.036, -0.017, p < .001, R = 0.717). Adding life expectancy and female literacy to the regression (Model III) further attenuated the SBA relationship (-0.013, p = 0.052, R = 0.792). Finally, the addition of sanitation, adolescent fertility rate, and health expenditure to the full regression model (Model IV) made the SBA term insignificant (-0.004, 95% CI: -0.018, +0.010, p = 0.539, R = 0.814).

In the full regression model (Model IV), life expectancy (-0.049, p = 0.010) and adolescent fertility rate (+0.006, p = 0.032) had significant relationships with log(MMR). High levels of collinearity for log(GDP) (VIF = 14.26) and log(health expenditure) (VIF = 14.27) probably explain their non-significant relationships with log(MMR) despite their significant bivariate relationships, as indicated by the VIF values.

The stepwise decrease in the SBA coefficient and the increase in explained variance are shown in Figure 4 (left and right panels, respectively). The SBA coefficient decreased from -0.061 in Model I to -0.004 in Model IV and, in the fully adjusted model, crossing zero and gaining a negligible confidence interval. The R^2 value grew from 0.530 to 0.814, showing that socioeconomic characteristics account for most of the variation in cross-national MMR.

Effect modification

Significant effect modification was also noted. Interaction of SBA female literacy was significant (-0.0006, 95% CI: -0.0009 to -0.0002, p = 0.002) and SBA sanitation interaction was also significant (-0.0006, 95% CI: -0.0009 to -0.0003, p < 0.001). Negative coefficients indicated a stronger ecological association of increased SBA with decreasing log(MMR) in settings with higher female literacy and increased access to sanitation facilities.

Table 2. Hierarchical linear regression models predicting log(MMR). Unstandardized beta coefficients with 95% confidence intervals from four sequential models. MMR = maternal mortality ratio; GDP = gross domestic product; pc = per capita; VIF = variance inflation factor; SBA/skilled = skilled birth attendance. *** p < 0.001; ** p < 0.01; * p < 0.05; † p < 0.10; ns not significant. VIF in Model IV: skilled = 5.02, log(GDP) = 14.26, life expectancy = 5.44, literacy = 4.09, sanitation = 7.10, adolescent fertility = 3.08, log(health expenditure) = 14.27. High collinearity flagged for GDP and health expenditure. Sample size varies due to missing data, particularly female literacy. Data: World Bank WDI 2010–2022.

Predictor	Model I β [95% CI]	Model II β [95% CI]	Model III β [95% CI]	Model IV β [95% CI]
Skilled attend.	-0.061 [-0.069, -0.052]***	-0.027 [-0.036, -0.017]***	-0.013 [-0.026, +0.000]†	-0.004 [-0.018, +0.010]ns
Log(GDP pc)	—	-0.720 [-0.854, -0.587]***	-0.309 [-0.520, -0.098]**	-0.023 [-0.403, +0.358]ns
Life expectancy	—	—	-0.080 [-0.113, -0.047]***	-0.049 [-0.086, -0.012]*
Female literacy	—	—	-0.007 [-0.019, +0.004]ns	-0.004 [-0.015, +0.007]ns
Sanitation	—	—	—	-0.011 [-0.023, +0.001]†
Adol. fertility	—	—	—	+0.006 [+0.001, +0.011]*
Log health exp.	—	—	—	-0.245 [-0.590, +0.100]ns
R^2	**0.530**	**0.717**	**0.792**	**0.814**
Adjusted R^2	**0.528**	**0.714**	**0.784**	**0.802**
n	**180**	**178**	**113**	**112**

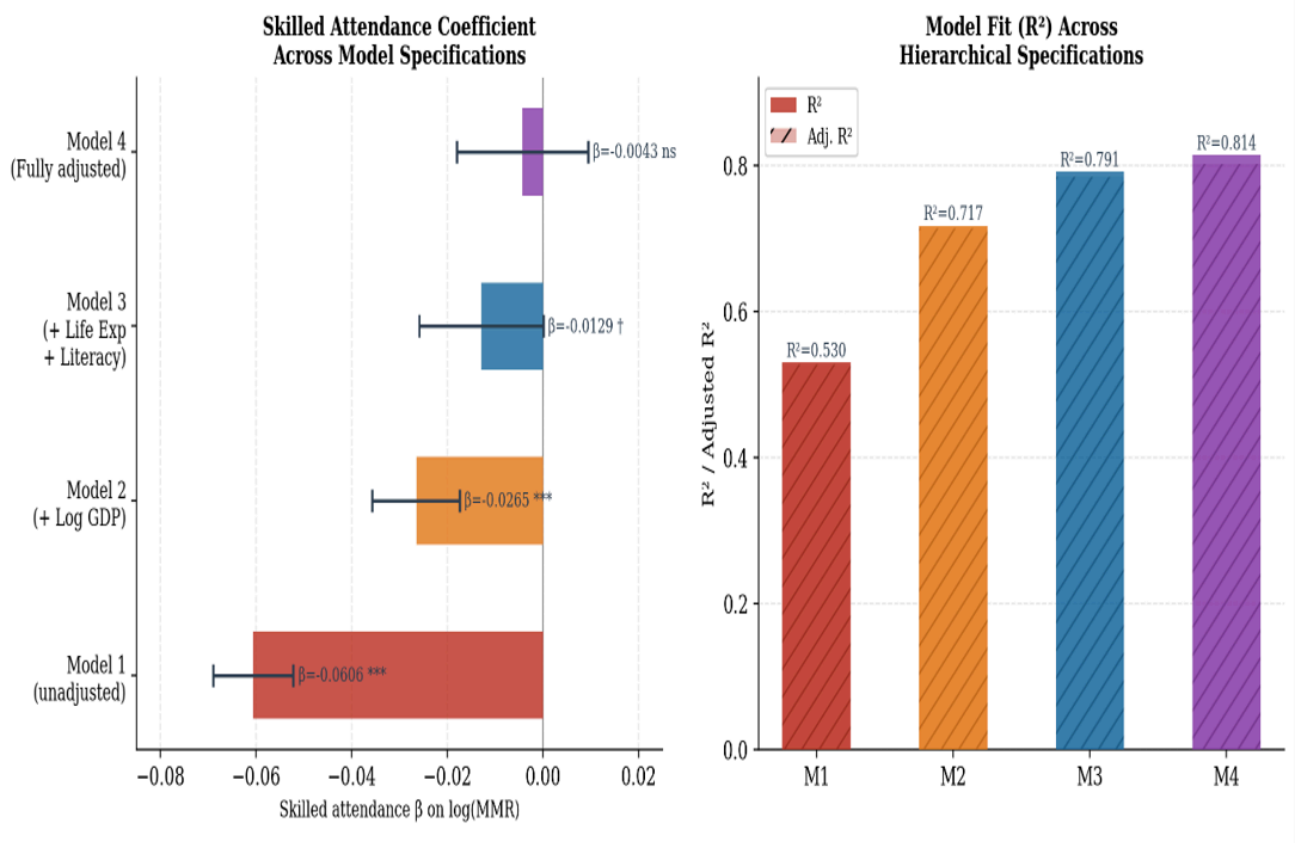

Figure 4. Evolution of skilled birth attendance coefficient and model fit across hierarchical models. Left panel: SBA beta coefficient on log(MMR) with 95% confidence intervals across four model specifications. Right panel: R^2 and adjusted R^2 by model. Sample sizes: n = 180, 178, 113, 112 for Models I-IV. Data: World Bank WDI, analyzed in R v4.6.0.

Discussion

This study conducted an ecological investigation into the associations between SBA and economic development and maternal mortality in 180 countries from 2010 to 2023. At a crudely ecological level, SBA showed a robust negative association with MMR. However, with hierarchical regression modeling, most of this relationship was mediated by broader socioeconomic determinants. After adjusting for all the identified covariates (i.e., GDP, life expectancy, female literacy, sanitation, adolescent fertility, and health expenditure), additional variation in SBA coverage explained no additional variance in maternal mortality.

It is vital to state that the relationships examined in this study are ecological and may not apply at the individual level; this concept is known as ecological fallacy (10). A country with high SBA coverage and low MMR does not necessarily translate to individuals in these settings having a lower mortality risk compared to individuals receiving SBA from a low SBA coverage country. The processes occurring at the individual level may not necessarily be at the population level. Clinical evidence at the individual level overwhelmingly supports that skilled attendance provides essential interventions during childbirth which lower the risk of maternal mortality (Graham et al., 2001; Say et al., 2014). The population-level finding that any additional variability in SBA coverage, beyond the socio-economic correlates, had no additional impact on maternal mortality does not invalidate this clinical evidence.

The stepwise increase in the coefficient reduction shown through the hierarchical regression is notable. In the unadjusted model, the negative association was large (-0.061, R = 0.530). After the addition of GDP per capita, the reduction was more than half (-0.027, R = 0.717), suggesting that income at the national level is a significant confounder. Following addition of life expectancy and female literacy, the association continued to decrease until it was no longer distinguishable from zero in the fully adjusted model. The interpretation of this finding is that in contexts with similar levels of socio-economic development, residual differences in SBA coverage are not related to subsequent differences in maternal mortality. This finding is not suggestive of the ineffectiveness of SBA scaling up, but rather that SBA coverage is intertwined with many of the determinants that are collectively associated with maternal mortality.

This is consistent with many previous ecological studies which emphasize the role of socioeconomic conditions in health status (6). Countries are generally not developing along individual parameters; improvements in health services access and health outcomes are highly correlated with improvements in the educational system, health, and economic infrastructure. The significant inter-correlation of SBA with its associated development determinants (e.g., R = 0.73 between SBA and GPD per capita) reflects this clustering. At the individual level, the benefits of skilled attendance are documented and the context within which it is delivered also contributes to maternal mortality (Karlsen et al., 2011; Prüss-Ustün et al., 2016). At the population level, it appears these components are tightly intertwined and it is difficult to separate their impact on maternal mortality patterns.

Life expectancy, in this study, remained the most robust predictor across all adjusted models, as found in other studies which identified life expectancy as an overall indicator that accounts for changes in nutrition, disease, health system performance, and age structure (2). Adolescent fertility rate remained positively associated with maternal mortality in the fully adjusted model, suggesting that the broader context surrounding reproduction is significant, as well as that pregnant adolescents have an increased risk of adverse obstetric events (9). In terms of interaction effects, higher female literacy and improved access to sanitation were associated with a larger ecological negative relationship between SBA and maternal mortality, suggesting that these enabling characteristics are important for healthcare access interventions.

Significant high correlation between GDP and health expenditures made interpretation difficult as this likely implies that individual parameter estimates may be unstable due to the strong correlation between these variables (VIF > 14 for health expenditure on GDP). While both variables are individually known to have a bivariate relationship with maternal mortality, it is not possible to distinguish between them individually when the model is adjusted for both, but further investigation would be necessary to fully account for this possibility.

Limitations

This analysis has significant limitations due to both its design and the nature of the data structure. Firstly, and perhaps most critically, this is an ecological analysis; all variables are measured at the country level. In ecological designs, inferences cannot be made about individual-level associations—this phenomenon is known as the ecological fallacy (10). If high coverage of SBA was not associated with low MMR after adjusting for the covariates of development, it does not mean that SBA does not work at the individual level. Clinical studies demonstrate clear reductions in mortality with SBA (5), and this ecological study is asking a different question (i.e., “do residual cross-country variations in SBA coverage explain variations in MMR over and above variations accounted for by overall development?”).

Secondly, the cross-sectional nature of the analysis does not allow for inferring cause and effect. It is possible that increasing SBA coverage leads to reductions in MMR; it is also possible that in countries where MMR is falling (whether due to better access to SBA, to other variables, or both) countries invest more in the infrastructure of SBA; or it is possible that underlying societal factors are driving both developments independently. Temporal precedence is inherently impossible to assess with cross-sectional data. Averaging data across the 2010-2023 timeframe mitigated any spuriousness or unusual fluctuations caused by single year data but did not allow any examination of changes within countries over time.

Thirdly, country-specific estimates of MMR vary in completeness and accuracy. It is possible that low-income countries' MMR is underreported due to weak civil registration systems and misclassification, though the MMEIG attempts to address this using Bayesian models. Despite these adjustments, there is likely still some level of residual error which may differ between countries and could bias estimates of the relation between SBA coverage and MMR.

Fourthly, this study's measure of SBA coverage is broad, capturing presence of a skilled attendant but not necessarily the quality of care, existence of essential equipment, or adequate referral facilities. Different forms of skilled attendance may have differing impact on mortality outcomes, which are masked by aggregate country-level measures. Like other covariates used, this measure is of national level and does not capture the situation at a facility level.

Fifthly, due to widespread lack of female literacy data, particularly in sub-Saharan Africa, there was a large drop-off in sample size for model III (n = 113) and model IV (n = 112). States without this data might systematically differ from those with it, meaning that the results presented for the fully adjusted models may not be generalizable.

Finally, although the study controlled for several factors, unmeasured confounders may remain. Unspecified cultural factors, varying quality of emergency obstetric care, availability of blood transfusion, and myriad other country-level phenomena might explain some portion of the observed variation. The tight correlations among the predictor variables also resulted in multicollinearity, meaning it is difficult to make definite statements regarding the relative influence of individual predictor variables.

Future directions

Based on the ecological findings, there are several promising avenues for future research. First, studies of individual-level data linking SBA to facility factors and maternal outcome would go beyond population-level correlations to assess the mechanisms implicated by the population-level data. A prospective cohort study following women from pre-conception to after childbirth would allow for stronger causal inference regarding the relationship between SBA and maternal survival.

More refined measures of quality of skilled birth attendance are also needed. Future research would benefit from separating the effects of doctors, nurses, and midwives, and should also incorporate data on emergency care capacity and facility resources, as well as data on quality of intrapartum care provided. Tracking SBA coverage and MMR trends within countries over time would help to establish temporal relations at the population level. Natural experiments that document the effects of interventions that dramatically increase SBA coverage on subsequent mortality rates would provide more robust quasi-experimental estimates of SBA's impact but require reliable civil registration data which remains elusive for the majority of countries that carry the highest burden.

Thirdly, research must continue to build comprehensive civil registration and maternal death surveillance systems for both middle- and high-income countries, in particular, high-burden countries where the stakes are highest. Improvement of civil registration infrastructure is not just "data gathering;" it is a critical public health intervention that enables all other health improvements.

Conclusion

This ecological study sought to explore associations between SBA coverage, socioeconomic development and MMR among 180 countries between 2010 and 2023. Significant ecological associations between SBA coverage and low MMR were found at a crude ecological level, but these associations became largely non-significant when controlling for other factors related to the general level of development of the country. After adjusting for GDP per capita, life expectancy, female literacy, sanitation, adolescent fertility, and health expenditure, residual variations in SBA coverage were not statistically associated with variations in MMR.

The limitations of the analysis restrict interpretation to some extent. Crucially, ecological relations cannot be generalized to individual-level associations (i.e., ecological fallacy). In addition, the cross-sectional design of the study prevents from inferring causality, and variations in measurement quality of MMR across countries may introduce bias. However, this does not imply that SBA may not be important for maternal survival, as clinical individual-level studies show considerable impact (5).

The results indicate that, at the population level, SBA clustered with other development factors that together predict maternal mortality. SBA coverage did not act as a unique predictor of MMR after taking other indicators of development into account. Future interventions intended to decrease MMR should therefore reflect multi-faceted approaches that consider development from a range of perspectives.

Future research needs to move beyond broad ecological analyses to investigate individual-level pathways and different dimensions of SBA and establish temporal precedence. Nevertheless, this study provides supporting evidence that while access to healthcare remains an important factor, it cannot be disentangled from other facets of development at the population level, highlighting the necessity of multi-dimensional policy approaches to reach SDG targets for maternal mortality reduction.

References

1. World Health Organization, Maternal mortality (2023); https://www.who.int/news-room/fact-sheets/detail/maternal-mortality.

2. L. Alkema, D. Chou, D. Hogan, S. Zhang, A. B. Moller, A. Gemmill, D. M. Fat, T. Boerma, M. Temmerman, C. Mathers, L. Say, Global, regional, and national levels and trends in maternal mortality between 1990 and 2015. Lancet 387, 462–474 (2016).
3. L. Say, D. Chou, A. Gemmill, Ö. Tunçalp, A. B. Moller, J. Daniels, A. M. Gülmezoglu, M. Temmerman, L. Alkema, Global causes of maternal death. Lancet Glob. Health 2, e323–e333 (2014).
4. United Nations, Transforming our world: The 2030 agenda for sustainable development (United Nations General Assembly, 2015).
5. W. J. Graham, J. S. Bell, C. H. W. Bullough, Can skilled attendance at delivery reduce maternal mortality in developing countries? Stud. Health Serv. Organ. Policy 17, 97–130 (2001).
6. C. G. Victora, A. Wagstaff, J. A. Schellenberg, D. Gwatkin, M. Claeson, J. P. Habicht, Applying an equity lens to child health and mortality. Lancet 362, 233–241 (2003).
7. S. Karlsen, L. Say, J. P. Souza, C. J. Hogue, D. L. Calles, A. M. Gülmezoglu, M. Rani, The relationship between maternal education and mortality among women giving birth in health care institutions. BMC Public Health 11, 606 (2011).
8. A. Prüss-Ustün, J. Wolf, C. Corvalán, R. Bos, M. Neira, Preventing disease through healthy environments (World Health Organization, 2016).
9. T. Ganchimeg, E. Ota, N. Morisaki, M. Laopaiboon, P. Lumbiganon, J. Zhang, B. Yamdamsuren, M. Temmerman, L. Say, Ö. Tunçalp, J. P. Vogel, J. P. Souza, R. Mori, Pregnancy and childbirth outcomes among adolescent mothers. BJOG 121, 40–48 (2014).
10. W. S. Robinson, Ecological correlations and the behavior of individuals. Am. Sociol. Rev. 15, 351–357 (1950).
11. R Core Team, R: A language and environment for statistical computing (Version 4.6.0) (R Foundation for Statistical Computing, 2026); https://www.R-project.org/.
12. World Bank, World Development Indicators (The World Bank Group, 2023); https://databank.worldbank.org/source/world-development-indicators.