Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Impact of High-Risk Fertility Behaviour on Under-five Mortality in Asia and Africa: Evidence from Demographic and Health Surveys

Rafi Amir-ud-Din
COMSATS University Islamabad - Lahore Campus
Lubna Naz
Karanchi University
Anila Rubi
COMSATS University Islamabad - Lahore Campus
Muhammad Usman
COMSATS University Islamabad - Lahore Campus
Umesh Ghimire (creationumesh@gmail.com)
New ERA https://orcid.org/0000-0002-4246-8379

Research article

Keywords: under-five mortality, high-risk fertility behaviour, women's age at childbirth, birth spacing and birth order, Demographic and Health Survey

Posted Date: December 16th, 2020

DOI: https://doi.org/10.21203/rs.3.rs-29205/v3

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Impact of High-Risk Fertility Behaviour on Under-five Mortality in Asia and Africa: Evidence from Demographic and Health Surveys

Rafi Amir-ud-Din [a]; Lubna Naz [b]; Anila Rubi [c]; Muhammad Usman [d]; Umesh Ghimire [e]*

[a] Assistant Professor,
Department of Economics,
COMSATS University Islamabad, Lahore Campus, Pakistan

[b] Assistant Professor,
Department of Economics,
Karachi University, Karachi, Pakistan

[c] Research Scholar, Department of Economics,
COMSATS University Islamabad, Lahore

[d] Assistant Professor,
Department of Management Sciences, COMSATS University
Islamabad, Lahore Campus, Pakistan

[e] New ERA, Kalopul, Rudramati Marga, Kathmandu, 44600, Nepal
*Umesh Ghimire, New ERA, Kalopul, Rudramati Marga, Kathmandu, 44600, Nepal,
Email: creationumesh@gmail.com, ORCiD:https://orcid.org/0000-0002-4246-8379

Abstract

Background: Younger or older maternal age, short inter-pregnancy birth interval, and higher birth order of the child are considered to be high-risk fertility behaviour (HRFB). Under-five mortality being disproportionately concentrated in Asia and Africa, this study analyses the association between HRFB and under-five mortality in selected Asian and African countries.

Methods: This study used Integrated Public Microdata Series-Demographic and Health Surveys (IPUMS-DHS) data from 32 countries in Sub-Saharan Africa, Middle East, North Africa, and South Asia from 1986 to 2017 (N=1,467,728). Previous evidence hints at four markers of HRFB: women's age at the birth of index child <18 years or >34 years, short preceding birth interval (PBI) <24 months, and child's birth order >3. Using logistic regression, we analysed the change in the odds of under-five mortality as a result of i) exposure to HRFB individually, ii) exposure to any single HRFB risk factor, iii) exposure to multiple HRFB risk factors, and iv) exposure to specific combinations of HRFB risk factors.

Results: Mother's age at the birth of index child <18 years and preceding birth interval (PBI) <24 months were significant risk factors of under-five mortality, while a child's birth order >3 was a protective factor against under-five mortality. Presence of any single HRFB was associated with 1.067 times higher risk of under-five mortality (OR = 1.067; 95% CI: 1.042 - 1.090; $P < 0.001$). Presence of multiple HRFBs was associated with 1.392 times higher risk of under-five mortality (OR = 1.392; 95% CI: 1.355 - 1.431; $P < 0.001$). Some specific combinations of risky fertility behaviour such as younger maternal age (<18 years) and short preceding birth interval (PBI <24) significantly increased the odds of under-five mortality.

Conclusion: Younger maternal age and short preceding birth interval significantly increase the risk of under-five mortality. This highlights the need for effective legislation to curb child marriages and increased public investment in reproductive healthcare with a focus on higher contraceptive use for an optimal interpregnancy interval.

Keywords: under-five mortality; high-risk fertility behaviour; women's age at childbirth; birth spacing and birth order; Demographic and Health Survey

Background

Child mortality is a serious global health issue. Although under-five mortality decreased by 59% from 93 deaths per 1,000 live births in 1990 to 39 in 2018, 5.3 million children died before their fifth birthday in 2018 [1]. Sub-Saharan Africa has the highest mortality rate in the world and contributes to 52% of all under-five deaths, followed by Central and Southern Asia, accounting for 29% of under-five death [2]. Goal 3 of Sustainable Development Goals seeks to reduce neonatal mortality to 12 per 1000 live births and under-five mortality to 25 per 1000 live births [3].

Several socioeconomic factors, including mother's age and hereditary characteristics, nutritional status and substance use, were associated with increased child mortality [4]. Lack of skilled human resources, inadequate infrastructure, and low investment in healthcare systems have significantly increased the rate of child and maternal mortality in low and middle-income countries [5, 6]. Among various risk factors of under-five mortality, three factors namely, women's age at the time of birth, interpregnancy interval and child's birth order have particularly been highlighted as some of the most critical risk factors behind under-five mortality [7-9].

Recently, there has been a growing realisation that a woman may experience multiple risk factors of child mortality simultaneously, also called high-risk fertility behaviour. High-risk fertility behaviour (HRFB) can be expressed in terms of too-early or too-late women's age at delivery, shorter birth interval, and a higher number of live births [10, 11]. Evidence suggests that risky fertility behaviour is widespread and is a significant cause of neonatal and under-five mortality in low and middle-income countries [12, 13]. Bangladesh Demographic and Health Survey (DHS) report showed that 41.8 % of women showed HRFB, out of whom 33% showed any single HRFB and 8.8% showed multiple HRFB, respectively [11]. A study from Ethiopia indicated a higher risk of under-five mortality associated with women aged 15 to 18 years, having repeated pregnancies with short interpregnancy spacing [14].

The developing world faces severe socioeconomic and demographic challenges. Apart from the child mortality, the developing world also faces the issues inextricably linked with child mortality such as child marriage, high fertility and high population growth. Around 46% of the women in South Asia and 37% of the women in Sub-Saharan Africa were married before their 18th birthday [15]. The teenage pregnancy rate in Bangladesh is as high as 35% [16]. According to the 2018 estimates, the global fertility rate was 2.5, but the fertility rate in Sub-Saharan Africa was 4.7 [17]. The global annual population growth rate in 2019 was 1%, but the annual population growth rate in Sub-Saharan Africa was 2.7% [18].

Given the multiple risk factors of under-five mortality interacting with each other in a complicated way in the developing countries, this study sought to analyse the link between HRFB and under-five mortality using a large sample of 32 countries in Sub-Saharan Africa, Middle East, North Africa, and South Asia spanning over three and half decades. An analysis of specific combinations of various risk factors of HRFB is expected to highlight the structural drivers of child mortality and inform evidence-based policy for targeted action against child mortality.

Methods

Data sources

We used data from the Integrated Public Use Microdata Series project of Demographic and Health Surveys (IPUMS-DHS) for this study. The DHS collects information on critical demographic and health-related indicators such as mortality rates, fertility and family planning using a stratified sample of households based on cluster design with an average response rate of more than 90%. The advantage of using IPUMS-DHS data is that all the variables are consistently coded across all countries and survey periods. The IPUMS-DHS database includes data about the individual respondents, and the household information is linked from the household recodes. IPUMS-DHS database has data for 35 countries from Sub-Saharan Africa, Middle East, North Africa, and South Asia from1986 to 2017.

We restricted our sample to only those countries where the information about child mortality and HRFB was available in at least one survey wave. According to this criterion, 32 countries from Sub-Saharan Africa, the Middle East, North Africa, and South Asia from1986 to 2017 were selected. The sample size was 1,467,728 from 142 survey waves with as little as one survey from Angola and ten surveys from Senegal during this period.

Study outcomes

The outcome variable in this study is under-five mortality which refers to the death of all children under the age of five. Under-five mortality in this study is a binary variable. The age for the deceased children is based on the time between a child's birth and the date of the mother's interview. If the index child died before reaching the fifth birthday within five years before the mother's interview (coded as 1), and absent if the index child was alive at the time of mother's interview (coded as 0). Many studies have similarly constructed the outcome child mortality variable using Demographic and Health Surveys data [19-22]. The age distribution of the under-five children in our sample is given in Figure 1.

Figure 1: About here

Exposures

The exposure variable for this study is HRFB of the mother, measured by four parameters: mother's age at the birth of index child <18 years (referred to as mother's age at birth hereafter); mother's age at the birth of index child (referred to as mother's age at birth hereafter) >34 years; preceding birth interval (PBI) <24 months, that is, the latest child born in <24 months after the preceding birth; and birth order of index child >3.

In addition to seeing the impact of four indicators of HRFB individually, we constructed a dichotomous variable i.e. *any single high-risk fertility behaviour (ASHFB)*, which took the value 1 if any single risk factor (mother's age at birth <18 or >34 years or PBI < 24 months or birth order >3) was found, and 0 otherwise. Our next variable of interest was a multicategory variable *multiple high-risk fertility behaviour (MHRB)* where the absence of any high-risk fertility behaviour (coded as 0) was compared with the presence of any single high-risk fertility behaviour (coded as 1), and multiple high-risk fertility behaviours (coded as 2).

Following the literature [10], we also tested some specific combinations of HRFB such as i) mother's age at birth <18 years and birth interval <24 months, ii) mother's age at birth <18 years and birth order >3, iii) mother's age at birth <18 years and birth interval <24 months and birth order >3, iv) mother's age at birth >34 years and birth interval <24 months, v) mother's age at birth >34 years and birth order >3, vi) mother's age at birth >34 years and birth interval <24 months and birth order > 3; and vii) birth interval <24 months and birth order >3.

Potential confounders

Though many studies have identified a wide array of risk factors of child mortality such as size of child at birth [23] and women empowerment [24], antenatal care visit [25], our criterion for including the confounding variables was that they should be associated with both the HRFB and child mortality. As only those confounding factors can be appropriate for this study which occurred *before* the HRFB and, by implication, before the birth of the index child, size of child at birth, antenatal care visits and women's empowerment are, therefore, not included in the list of confounding factors.

Recently, a vast literature has emerged, linking breastfeeding with child mortality [26]. However, in the context of DHS data, breastfeeding could suffer from endogeneity problem because a child could be reported as "never breastfed" because it died young (especially in the case of neonatal deaths). As regards women's empowerment, women's empowerment, strictly speaking, is not a binary outcome because it keeps on changing, and is a function of several factors which include the birth of her children [27]. Domestic violence against infertile women [28] is just one of many examples of how children affect the life circumstances of mothers. As the birth of a child may influence women's life circumstances, mother's empowerment may pose problems of endogeneity and has thus been excluded from the list of potential confounding factors.

Given the preceding debate on the issues of confounding of the relationship between HRFB and under-five mortality, we have adjusted our model with father's and mother's education, father's and mother's occupation, urban/rural residential status, household wealth status, and country and time fixed effects. Parental education variables reflected the complete educational level and were constructed with no education as the base category, and primary, secondary, and higher education as the alternative categories. Parental occupation variables were dichotomous, with "not currently working" as the base category, and "currently working" as the alternative category. Residential status is also a dichotomous variable with a rural residence as the base category and urban residence as the alternative category. Household wealth status is an ordered index variable with the poorest quintile as the base category and poorer, middle, richer, and richest quintiles as the alternative categories, respectively. We adjusted the models with time fixed effects by categorising the survey years from 1986 to 2017 into three periods: 1986-2000, 2001-2010, and 2011-2017.

Statistical analysis

We used the logistic regression model to estimate the association between HRFB and under-five mortality. We analysed how exposure to HRFB affects the odds of under-five mortality in four different ways: i) exposure to HRFB individually, ii) exposure to any single HRFB risk factor; iii) exposure to multiple HRFB risk factors; and iv) exposure to specific combinations of HRFB risk factors.

Additionally, we did the sub-group country-level analysis by estimating the impact of i) mother's age at the birth of index child <18 or >34 years, ii) mother's age at the birth of index child <18 *and* >34 years separately, iii) preceding birth interval (PBI) <24 months, and iv) birth order of index child >3 on under-five mortality (Figures 3-5). We regressed the variables described above on under-five mortality using logistic regression for each country separately and estimated the adjusted odds ratios of these variables. Each model was adjusted by father's and mother's education, father's and mother's occupation, urban/rural residential status, household wealth status, and country and time fixed effects. We used Stata's command `idpover` to make the forest plots for each country in the sample. The odds ratios of all countries were averaged to give the overall effect of different measures of HFRB on under-five mortality.

The general econometric model may be written as

$$U5Mort_{i,j,t} = \beta_0 + \beta_1 HRFB^{\tau}_{i,j,t} + \beta_2 \boldsymbol{X_{i,j,t}} + \chi_j + \delta_t + \epsilon_{i,j,t} \quad \tau = 1, \dots, 4 \quad Eq. (1)$$

Where $\mathrm{U5Mort}_{i,t}$ refers to under-five mortality and is a binary response variable with 1 referring to the child who is dead and 0 otherwise. $\mathrm{HRFB}^{\tau}_{i,j,t}$ is a high-risk fertility behaviour. The subscript *i* refers to the individual woman, j refers to the country, and *t* refers to the survey year. The superscript $\tau = 1$ refers to the model where all four HRFBs are estimated separately (Table 1). $\tau = 2$ refers to any single high-risk category (Table 2). $\tau = 3$ refers to HRFB as a multinomial variable with no risk as the base category and single and multiple high-risk fertility behaviours as the alternative categories, respectively (Table 3). $\tau = 4$ refers to specific combinations of high-risk fertility behaviour categories, as suggested in the previous literature [10] (Table 4). $\boldsymbol{X}_{i,j,t}$ is a vector of individual, household, and community level control factors. χ_j captures country-fixed effects and δ_t captures the time-fixed effects. The time fixed effects correspond with survey waves in three periods: 1986-2000; 2001-2010, and 2011 to 2017. $\epsilon_{i,j,t}$ is the error term.

Since DHS has a complex survey design, sampling weights are required to correct for the bias in probability selection [29]. Regression analysis was, therefore, done after adjusting for sampling design (stratification and clustering) using “svy” command in Stata/MP 15.1.

Eligibility criteria

The women aged 15-49 years who gave birth in the five years preceding the interview were included in this analysis. Only the single births were included in the analysis because twins have different risk of mortality for both children and mother [30, 31]. The sample includes all singletons born to a single woman because restricting the sample to only last born child would give mortality rates that are significantly different from WHO under-five mortality rates [32].

Results

Descriptive statistics

Figure 2 gives the prevalence rates averaged over the number of surveys available in each country. Child mortality rates revealed significant geographical and temporal differences. The average child mortality in 32 countries from 1986 to 2017 was 77 per 1000 live births. The child mortality rates in our sample were approximately 93, 77 and 52 per 1000 live births during 1986-2000, 2001-2010, and 2011-2017 respectively. The lowest child mortality rate was in Jordan (22 per 1000 live births), and the highest mortality rate was in Niger (125 per 1000 live births). Approximately 7 % of women delivered before they reached their 18th birthday, with the highest percentage concentrated in Bangladesh (17.46%) and the smallest percentage in Burundi (1.7%). Approximately 14 % of women delivered when they were above 34, with the highest percentage in Rwanda (19.36%) and the smallest percentage in India (4.38%). Around 21% of the women < 18 years or > 34 years gave birth, with the highest rate in Guinea (26.43%) and the smallest rate in India (12%). Around 20% of children had a preceding birth interval <24 months, with the highest ratio in Jordan (36.64%) and the lowest ratio in Lesotho (11.2%). Over 40% of the children in our sample had the birth order >3. The lowest percentage of such children was in India (25%), and the highest in South Africa (56%).

Figure 2: About here

Individual high-risk fertility behaviour

Compared to the reference category of the mothers whose age at the birth of index child was ≥18 years, the mothers who were <18 at the birth of the index child had 1.611 times higher odds of child mortality (AOR = 1.611, 95% CI: 1.558 - 1.666, P < 0.001) (Model 1, Table 1).

There was, however, no evidence that the women > 34 at the time of the birth of the index child were statistically different from the reference category of mothers aged ≤ 34 at the birth of the index child (Model 2, Table 1). Compared to the reference category of the children whose preceding birth interval was ≥24 months, the children with PBI <24 months had 2.108 times higher odds of under-five mortality (AOR = 2.018, 95% CI: 1.969 - 2.068, $P < 0.001$) (Model 3, Table 1). Counterintuitively, compared with the children with birth order ≤3, children with birth order >3 had 0.911 times lower odds of child mortality (AOR = 0.911, 95% CI: 0.892 - 0.930, $P < 0.001$) (Model 4, Table 1).

Table 1: About here

Any single high-risk fertility behaviour

With regards to the reference category of the women who had no HRFB, any single HRFB (mother's age <18 or >34 or the birth interval <24 months or the birth order >3) was associated with 1.066 times higher odds of under-five mortality (AOR = 1.066, 95% CI: 1.042 - 1.090, $P < 0.001$) (Table 2). An increase in the education of both father and mother, as well as an increase in the household wealth status, were significantly associated with smaller odds of child mortality. In contrast, maternal work was associated with higher odds of child mortality (AOR = 1.070, 95% CI: 1.043 - 1.099, $P < 0.001$), father's working status, as well as the residential status of the child, had no significant impact on the odds of child mortality.

Table 2: About here

Multiple high-risk fertility behaviour

Dividing women among the groups with no HRFB, single HRFB, and multiple HRFB shows that compared with the women who did show any risky fertility behaviour, the women in the single HRFB category were associated with 1.068 times higher odds of child mortality (AOR = 1.068, 95% CI: 1.045 - 1.092, $P < 0.001$), and the women in the category of multiple HRFB were associated with 1.392 times higher odds of child mortality (AOR = 1.392, 95% CI: 1.355 - 1.431, $P < 0.001$) (Table 3).

Table 3: About here

Specific combinations of risk factors of high-risk fertility behaviour

Table 4 shows multiple risk factors for child mortality. The young age of the mother at the birth of the index child (<18 years) and shorter preceding birth interval (<24 months) was associated with 2.069 times higher odds of under-five mortality (AOR = 2.069, 95% CI: 1.881 - 2.276, $P < 0.001$). The young age of the mother at the birth of index child (<18 years) and the number of birth order >3 were associated with 1.824 times higher risk of under-five mortality (AOR = 1.824, 95% CI: 1.105 - 3.009, $P < 0.05$). The young age of the mother at the birth of the index child (<18 years) and short PBI (<24 months) and the number of birth order >3 was associated with 1.997 times higher risk of under-five mortality (AOR = 1.997, 95% CI: 1.101 - 3.620, $P < 0.05$). Older age of the mother at the birth of the index child (>34) and shorter preceding birth interval (<24 months) was associated with 1.993 times higher risk of under-five mortality (AOR = 1.933, 95% CI: 1.828 - 2.045, $P < 0.001$).

Though older age of the mother at the birth of the index child (>34) and birth order >3 had no significant impact on the odds of child mortality, the older age of the mother at the birth of index child (>34) and birth order >3 and shorter preceding birth interval (<24 months) were associated with 1.951 times higher risk of under-five mortality (AOR = 1.951, 95% CI: 1.843 - 2.065, $P < 0.001$) suggesting that PBI <24 was the most important risk factor of under-five mortality. Shorter preceding birth interval (<24 months) and birth order >3 were associated with

1.819 times higher risk of under-five mortality (AOR = 1.819, 95% CI: 1.765 - 1.876, $P < 0.001$).

Table 4: About here

Figure 3 gives the country-level odds ratios of the under-five mortality regressed on mother's age <18 or >34 years at the birth of index child. Logistic regression-based subgroup analysis shows that out of 32 countries, there was a significant and positive association between mother's age <18 or >34 years at the birth of the index child and under-five mortality in 19 countries. In the rest of the countries, the association was insignificant. Overall, the odds of child mortality were 1.24 times higher for mothers whose age was <18 or >34 years at the birth of the index child than the mothers aged 18 to 34 at the birth of the index child (AOR = 1.24, 95% CI: 1.21 – 1.27). The highest risk of child mortality was observed in Egypt (AOR = 1.53, 95% CI: 1.34 – 1.75) and smallest risk of child mortality was found in Zambia (AOR = 1.16, 95% CI: 1.03 – 1.30).

Figure 3: About here

As the effect of young maternal age at the time of birth of index child (<18 years) was different from the effect of older maternal age at the time of birth of index child (>34 years) as shown in Table 1, Figure 4 gives the country-level odds ratios of the under-five mortality regressed separately on mother's age <18 *and* >34 years at the birth of index child.

In 23 out of 32 countries, younger maternal age at the time of the birth of index child (<18 years) was significantly associated with higher odds of under-five mortality compared to the women aged 18 or higher. However, older maternal age at the time of the birth of index child

(>34 years) was a significant risk factor of under-five mortality in only three countries, but a significant protective factor against under-five mortality in six countries.

Figure 4: About here

Out of the 32 countries studied, the preceding birth interval of <24 months significantly increased the risk of under-five mortality in 31 countries (Figure 5). The association between PBI < 24 months and under-five mortality was positive but insignificant in Namibia. Overall, the odds of child mortality were 1.98 times higher for the children whose preceding birth interval was less than 24 months than the children with PBI ≥24 (AOR = 1.98, 95% CI: 1.93 – 2.03). When the preceding birth interval of <24 months, the highest risk of child mortality was observed in Mozambique (AOR = 2.75, 95% CI: 2.33 – 3.24) and the smallest risk of child mortality was in Jordan (AOR = 1.50, 95% CI: 1.24 – 1.82).

Figure 5: About here

Out of the 32 countries, the number of birth order > 3 significantly decreased the risk of under-five mortality in 11 countries (Burundi, Burkina Faso, Senegal, Rwanda, Mali, Cameroon, Uganda, Malawi, Bangladesh, Mozambique, Zambia) but increased the risk of under-five mortality in two countries (Myanmar and Egypt) (Figure 6). There was no significant association between the number of birth order >3 and under-five mortality in 19 countries. Overall, the odds of child mortality were 0.94 times lower for the children whose birth order was >3 (AOR = 0.94, 95% CI: 0.92 – 0.96), with the lowest risk in Zambia (AOR = 0.70, 95% CI: 0.64 – 0.76), and the highest risk in Myanmar (AOR = 1.74, 95% CI: 1.05 – 2.86).

Figure 6: About here

Discussion

This study aimed to investigate factors associated with child mortality concerning HRFB using DHS data from 32 countries. Child mortality rates revealed significant geographical and temporal differences. The average child mortality from 32 countries was 77 per 1000 live births from 1986 to 2017. The lowest child mortality rate was in Jordan (22 per 1000 live births), and the highest rate was in Niger (125 per live1000 lives). Over time there was a decrease in child mortality. The average child mortality rates in our sample were approximately 93, 77 and 52 per 1000 live births during 1986-2000, 2001-2010, and 2011-2017 respectively.

Logistic regression analysis found that mother's age at the birth of the index child <18 years and preceding birth interval (PBI) <24 months were significant risk factors of under-five mortality, while a child's birth order >3 was a protective factor against under-five mortality. Mother's age at the birth of the index child >34 was not a significant risk factor of under-five mortality. Presence of any single HRFB was associated with 1.067 times higher risk of under-five mortality. Presence of multiple HRFBs was associated with 1.392 times higher risk of under-five mortality. Some specific combinations of risky fertility behaviour such as younger maternal age (<18 years) and short preceding birth interval (PBI <24) significantly increased the odds of under-five mortality.

Our major finding that mother's age at the birth of index child <18 years was a risk factor of under-five mortality is consistent with many previous studies linking young mothers with high under-five mortality [33-37]. Multiple mechanisms have been suggested in the existing literature to explain the link between a mother's young age and the risk of child mortality.

It is shown that children born to younger mothers are vulnerable to malnutrition and morbidity, leading to a higher risk of mortality than their counterparts born to adult mothers. Young mothers are not fully matured physically and deprived of nutritional and biological advantages, which directly affect foetal development [38]. Later, the children born to younger mothers are associated with adverse birth outcomes, such as low birth weight, childhood stunting, and other adverse neonatal and infant health problems, including childhood mortality [39-41]. Unintentional injuries, the third leading cause of under-five mortality in the world [42], may also contribute to under-five child mortality. Unintentional injuries-related deaths include drowning, traffic accidents, and accidental asphyxia, poisoning and falls [43]. As younger mothers are not experienced, their children may be more vulnerable to unintentional injuries. A study in the US found that [44]younger maternal age (15-24 years) was associated with a significantly higher risk of sudden unexpected infant death rates than older maternal age (>30 years) [45].

A study found that the children born to the mothers who are married as minors were significantly more likely to suffer from repeated episodes of diarrhoea than the children born to women married as adults [46]. Diarrhoea has been found to be one of the leading causes of under-five mortality [47].

Women married at younger ages have little decision-making power with respect to their health and the health of their children in developing countries [48]. It is also shown that child brides have smaller bargaining power within the households compared with their adult counterparts [49]. As the women are not allowed to visit the doctor without a male family member in some contexts [46], access to the healthcare at a critical time may be difficult in the cases where the mother is married young [46].

In some resource-constrained settings, girl brides may themselves have limited access to adequate nutrition [50] which may, in turn, result in an adequate foetal nutrition and reduced breastfeeding. Consequently, the combined effect of foetal malnutrition and suboptimal breastfeeding may increase the chance of child mortality.

In our study, the mother's age at the birth ≥34 years was not significantly related to under-5 mortality. Some previous studies have, however, found older maternal age as a risk factor of under-five mortality because older mothers have a higher risk of maternal anxiety, hormonal disorder, and low uteroplacental blood flow which increases the risk of congenital and chromosomal abnormalities, which further cause complications to the child [51, 52].

Benchmarking the older age at 34 years may be the reason why older maternal age is not a risk factor. A study found that child mortality risk was significantly higher when maternal age was ≥40 compared with the child mortality risk when mothers were in the 35-39 age group [53]. In our sample, 86% of the women were less than 34 years when they gave birth to the last child, and 97% gave birth to the last child before reaching 40. The fact that very few women gave birth at the age, which is most strongly associated with the risk of child mortality might explain the insignificant association between maternal age ≥34 and child mortality.

The preceding birth interval <24 months appeared to be the strongest predictor of under-five death in our study. The odds of child mortality among the children with PBI <24 months were nearly twice those of children with PBI ≥24 months. Many previous studies found a similar association between short preceding birth interval and increased risk of child mortality [7, 34, 54-57].

Different mechanisms have been proposed in the existing literature to explain the link between short inter-pregnancy interval and child mortality. The maternal depletion hypothesis suggests that if there is a short interval between two consecutive pregnancies, a woman cannot recover her nutritional stores which results in the malnutrition in the second pregnancy [58]. The malnutrition may result in depletion of folate stores, and her reproductive tissues may lose their muscle tone, resulting in the stunting of foetal growth [59, 60]. The folate insufficiency is, in turn, associated with increased risk of neural tube defects, anaemia, pre-eclampsia, stunted intrauterine growth and premature delivery [60-62]. Faced with malnutrition, a woman's body is known to prioritise its own needs over the nutritional needs of the foetus [63].

The sibling rivalry hypothesis is another theoretical justification that relates a short interpregnancy interval with the risk of child mortality. The sibling rivalry hypothesis suggests that closely spaced children can compete for the attention of the parents as well as scarce resources [60] resulting in the weekend immune system, and increased risk of infectious diseases and mortality [64] among children. The stunted growth of the neonate, as well as decreased quality and quantity of the breastmilk, may mediate the relationship between interpregnancy interval and child mortality [65].

The short inter-pregnancy interval is associated with an increased risk of premature membrane rupture, rupture of the uterus when women try vaginal delivery after caesarean, antepartum haemorrhage, anaemia, placental abruption, which ultimately increases the risk of foetus mortality [62, 66]. Depression of the mother due to previous neonatal death may increase the risk of subsequent mortality of neonates [67].

Unintentional injuries, the third leading cause of under-five mortality in the world [42], may also interact with shorter birth intervals to increase the odds of under-five child mortality. Evidence suggests that older siblings have a crucial role as the caretaker of younger siblings [68]. However, taking care of two siblings of similar age may put an additional drag on the mother's attention. A study in Australia found that supervision lapses, which were partly due to indoor household duties, outdoor household duties, and talking/socialising, were the major reason behind fatal unintentional drownings of children [44]. So there is a reason to believe that the chances of unintentional fatal injuries are higher in cases where the birth interval between two siblings is short because the quality of maternal supervision is compromised.

Children of the birth order >3 were found to be a protective factor against under-five mortality. This finding contradicts the dominant view that suggests that higher birth order increases the risk of child mortality [55, 69-72]. Some studies have shown that the risk of under-five mortality increases with the increased birth order of two [73-76], while some other studies find that the risk of mortality begins to increase only when birth order is ≥4 [57, 77, 78]. Evidence also suggests an inverse-U shaped relationship between birth order and risk of child mortality, with second-born and third-born children being at highest risk [9].

Though an increase in the age of the mother in high parity births could be a risk factor of child mortality, it is plausible to think that mothers learn from the experience of bringing up older children which helps them take care of higher birth order children more effectively [79]. Parenting difficulties of first-born children such as sleep deprivation are also well documented in the previous literature [80]. A study found that experienced parents coped with parental stress more effectively than first-time parents [81].

One other reason could be that women in the developing world are often married young, and the majority of them are stay-at-home mothers. One result is that most of the women are relatively young even after giving birth to a fourth and fifth child, and the decline of physical resources that are often associated with increased risk of child mortality have not started yet. This hypothesis is corroborated by the data used in this study. The mean age of women giving birth to fifth children in our sample is 32 years. Our sample also showed that maternal age ≥34 was not associated with significantly increased risk of child mortality. The relatively young age of the mother even in high parity cases may explain the protective effect of higher-order births against the risk of child mortality.

Higher child mortality among children of higher birth order is also explained by the fact that children with higher birth order have more limited access to healthcare than early-born children [82]. But it is also true that health services in most of the developing countries have been expanding over time [83], making access to healthcare facilities for children of higher birth order easier. This may also explain the smaller odds of child mortality for high parity births.

This study has some limitations. Different geographic regimes have different social, cultural, and economic dynamics. Various health vulnerabilities and country and region-specific hereditary characteristics of the participants could be a potential source of bias. As the exposure variables were based on interviews and self-reported accounts of the events occurring in the previous five years, there is a likelihood of recall bias. Being a cross-sectional study, data from DHS cannot assess causality between the predictors and under-five mortality.

Conclusions

This study analysed the link between HRFB (HRFB) (mother's age at the birth of index child <18 years or > 34 years, preceding birth interval (PBI) <24 months, child's birth order >3) and under-five mortality using DHS data from 32 countries. An individual analysis of the three indicators of HRFB suggested that younger maternal age and short preceding birth interval significantly increase the risk of under-five mortality. In contrast, higher birth order was associated with a smaller risk of child mortality. Maternal age >34 did not turn out to be a risk factor of child mortality. The HRFB analysis also showed that presence of *any* single risk factor of HRFB as well as multiple risk factors of HRFB (such as younger maternal age *and* short PBI) significantly increased the risk of child mortality. These findings highlight the need for effective legislation to curb child marriages and increased public investment in reproductive healthcare with a focus on higher contraceptive use for an optimal interpregnancy interval.

List of abbreviations

AOR; Adjusted Odds Ratio, CI; Confidence Interval, HRFBs; High-risk fertility behaviours, DHS; Demographic and Health Survey, SDGs; Sustainable Development Goals, UNIGME; United Nations Inter-Agency Group for Child Mortality Estimation, USAID; United States Agency for International Development

DECLARATIONS

Ethics approval and consent to participant

All countries analysed in this paper granted ethical permission from the ethical review board of ICF and DHS program requested to conduct the survey after obtaining ethical approval from the concerned ethical review board of respective countries.

Consent for publication

Prior consent was taken from the Measure DHS program for the use and publication of this manuscript

Availability of data and materials

The data supporting this manuscript are available upon request from the DHS program website at https://dhsprogram.com/data/

Competing interests

The authors declare no competing interest regarding the publication of this paper.

Funding

None

Author's contributions

RAD and AR have conceived the research idea of this paper. RAD and LN have analysed the data and estimated the model. AR, UG, and MU have written the introduction, discussion, and results. RAD and LN have written methods. UG, RAD, LN have critically evaluated the paper. All authors have agreed on the final version of the manuscript.

Acknowledgements

We would like to acknowledge IPUMS-DHS for granting access to datasets for this study.

References

1. Under-five mortality [https://www.who.int/gho/child_health/mortality/mortality_under_five_text/en/]
2. World Health Organization (WHO). Levels & Trends in Child Mortality: Sustainable development goals. [http://childmortality.org/files_v22/download/UN%20IGME%20Child%20Mortality%20Report%202018.pdf]
3. World Health Organization (WHO). United Nations sustainable development summit: Sustainable development goals [http://www.who.int/topics/sustainable-development-goals/targets/en/]
4. Corman H, Grossman M: Determinants of neonatal mortality rates in the US: A reduced form model. *Journal of Health Economics* 1985, 4(3):213-236.
5. Erdoğan E, Ener M, Arıca F: The strategic role of infant mortality in the process of economic growth: an application for high income OECD countries. *Procedia-Social and Behavioral Sciences* 2013, 99:19-25.
6. Amiri A, Gerdtham U-G: Impact of maternal and child health on economic growth: New evidence based granger causality and DEA analysis. *Newborn and Child Health, Study Commissioned by the Partnership for Maternal, Lund University, Sweden* 2013.
7. Habimana-Kabano I, Broekhuis A, Hooimeijer P: The Effect of Pregnancy Spacing on Fetal Survival and Neonatal Mortality in Rwanda: A Heckman Selection Analysis. *J Biosoc Sci* 2016, 48(3):358-373.
8. Santhya KG, Ram U, Acharya R, Jejeebhoy SJ, Ram F, Singh A: Associations between early marriage and young women's marital and reproductive health outcomes: evidence from India. *International perspectives on sexual and reproductive health* 2010:132-139.
9. Uddin M: Child Mortality in a Developing Country: A Statistical Analysis. *Journal of Applied Quantitative Methods* 2009, 4(3):270-283.
10. Rahman M, Haque SE, Zahan S, Islam J, Rahman M, Asaduzzaman M, Haque N, Islam AZ, Huda D, Mostofa G: Maternal high-risk fertility behavior and association with chronic undernutrition among children under age 5 y in India, Bangladesh, and Nepal: Do poor children have a higher risk? *Nutrition* 2018, 49:32-40.
11. Rahman M, Islam MJ, Haque SE, Saw YM, Haque MN, Duc NHC, Al-Sobaihi S, Saw TN, Mostofa MG, Islam MR: Association between high-risk fertility behaviours and the likelihood of chronic undernutrition and anaemia among married Bangladeshi women of reproductive age. *Public health nutrition* 2017, 20(2):305-314.
12. Finlay JE, Norton MK: Adolescent Fertility and Child Health: The Interaction of Maternal Age, Parity and Birth Intervals in Determining Child Health Outcomes. *International Journal of Child Health and Nutrition* 2017, 6(1):16-33.
13. Gurmu E, Tariku D: Correlates of High Risk Fertility Behaviour in Ethiopia: A Multilevel Analysis of the 2011 Ethiopian Demographic and Health Survey Data *Journal of Health, Medicine and Nursing* 2017, Vol.39, 2017
14. Mekonnen Y, Ayalew T, Dejene A: High-risk birth, fertility intention, and unmet need in Addis Ababa. *The Ethiopian Journal of Health Development (EJHD)* 2017, 12(2).
15. Loaiza E, Wong S: Marrying too young: end child marriage. In. New York: United Nations Population Fund; 2012.
16. IIPS: International Institute for Population Sciences and Macro International. National Family Health Survey (NFHS-3), 2005–06: India. Mumbai: IIPS; 2007. 2007.

17. World Bank: Fertility rate, total (births per woman) - Sub-Saharan Africa, South Asia, East Asia & Pacific (excluding high income), Latin America & Caribbean. In: *World Development Indicators.* Washington: World Bank Group, 2020; 2020.
18. World Bank: Population growth (annual %). In: *World Development Indicators.* Washington: World Bank Group, 2020; 2020.
19. Memiah P, Bond T, Opanga Y, Kingori C, Cook C, Mwangi M, Gitahi-Kamau N, Mubangizi D, Owuor K: Neonatal, infant, and child mortality among women exposed to intimate partner violence in East Africa: a multi-country analysis. *Bmc Womens Health* 2020, 20(1):10.
20. Memiah P, Opanga Y, Bond T, Cook C, Mwangi M, Fried J, Joseph MA, Owuor K, Mochache V, Machira YW: Is sexual autonomy a protective factor for neonatal, child, and infant mortality? A multi-country analysis. *PLoS One* 2019, 14(2):e0212413.
21. Amini Rarani M, Rashidian A, Arab M, Khosravi A, Abbasian E: Measuring Socioeconomic Inequality Changes in Child Mortality in Iran: Two National Surveys Inequality Analysis. *Iran J Public Health* 2018, 47(9):1379-1387.
22. Akachi Y, Steenland M, Fink G: Associations between key intervention coverage and child mortality: an analysis of 241 sub-national regions of sub-Saharan Africa. *Int J Epidemiol* 2018, 47(3):740-751.
23. Afshan K, Narjis G, Qureshi IZ, Cappello M: Social determinants and causes of child mortality in Pakistan: Analysis of national demographic health surveys from 1990 to 2013. *J Paediatr Child Health* 2020, 56(3):457-472.
24. Iqbal N, Gkiouleka A, Milner A, Montag D, Gallo V: Girls' hidden penalty: analysis of gender inequality in child mortality with data from 195 countries. *BMJ Glob Health* 2018, 3(5):e001028.
25. Fenta SM, Fenta HM: Risk factors of child mortality in Ethiopia: Application of multilevel two-part model. *PLoS One* 2020, 15(8):e0237640.
26. Sankar MJ, Sinha B, Chowdhury R, Bhandari N, Taneja S, Martines J, Bahl R: Optimal breastfeeding practices and infant and child mortality: a systematic review and meta-analysis. *Acta Paediatr* 2015, 104(467):3-13.
27. Samari G: First birth and the trajectory of women's empowerment in Egypt. *BMC Pregnancy Childbirth* 2017, 17(Suppl 2):362.
28. Yildizhan R, Adali E, Kolusari A, Kurdoglu M, Yildizhan B, Sahin G: Domestic violence against infertile women in a Turkish setting. *International Journal of Gynecology & Obstetrics* 2009, 104(2):110-112.
29. Anyamele OD, Ukawuilulu JO, Akanegbu BN: The role of wealth and mother's education in infant and child mortality in 26 sub-Saharan African countries: Evidence from pooled Demographic and Health Survey (DHS) data 2003–2011 and African Development Indicators (ADI), 2012. *Soc Indic Res* 2017, 130(3):1125-1146.
30. Murray S, MacKay D, Stock S, Pell J, Norman J: Association of Gestational Age at Birth With Risk of Perinatal Mortality and Special Educational Need Among Twins. *JAMA Pediatr* 2020, 174(5):437-445.
31. Bucher-Koenen T, Farbmacher H, Guber R, Vikstrom J: Double Trouble: The Burden of Child-rearing and Working on Maternal Mortality. *Demography* 2020, 57(2):559-576.
32. World Health Organization: Estimation method for child mortality Used in: Level and Trends of Child mortality In. Geneva: WHO, UNICEF, UN Population Division and World Bank; 2013.

33. Alam N: Teenage motherhood and infant mortality in Bangladesh: maternal age-dependent effect of parity one. *Journal of biosocial science* 2000, 32(2):229-236.
34. Raj A, McDougal L, Rusch ML: Effects of young maternal age and short interpregnancy interval on infant mortality in South Asia. *Int J Gynaecol Obstet* 2014, 124(1):86-87.
35. Perin J, Walker N: Potential confounding in the association between short birth intervals and increased neonatal, infant, and child mortality. *Glob Health Action* 2015, 8:29724.
36. Wilson N: Child mortality risk and fertility: evidence from prevention of mother-to-child transmission of HIV. *Journal of Development Economics* 2015, 116:74-88.
37. Kravdal O: New evidence about effects of reproductive variables on child mortality in sub-Saharan Africa. *Popul Stud (Camb)* 2018, 72(2):139-156.
38. de Vienne CM, Creveuil C, Dreyfus M: Does young maternal age increase the risk of adverse obstetric, fetal and neonatal outcomes: a cohort study. *European Journal of Obstetrics & Gynecology and Reproductive Biology* 2009, 147(2):151-156.
39. Ganchimeg T, Ota E, Morisaki N, Laopaiboon M, Lumbiganon P, Zhang J, Yamdamsuren B, Temmerman M, Say L, Tunçalp Ö: Pregnancy and childbirth outcomes among adolescent mothers: a World Health Organization multicountry study. *BJOG: An International Journal of Obstetrics & Gynaecology* 2014, 121:40-48.
40. Alio AP, Mbah AK, Grunsten RA, Salihu HM: Teenage pregnancy and the influence of paternal involvement on fetal outcomes. *Journal of pediatric and adolescent gynecology* 2011, 24(6):404-409.
41. Chen X-K, Wen SW, Fleming N, Demissie K, Rhoads GG, Walker M: Teenage pregnancy and adverse birth outcomes: a large population based retrospective cohort study. *International journal of epidemiology* 2007, 36(2):368-373.
42. He C, Liu L, Chu Y, Perin J, Dai L, Li X, Miao L, Kang L, Li Q, Scherpbier R: National and subnational all-cause and cause-specific child mortality in China, 1996–2015: a systematic analysis with implications for the Sustainable Development Goals. *The Lancet Global Health* 2017, 5(2):e186-e197.
43. Yao M, Wu G, Zhao Z, Luo M, Zhang J: Unintentional injury mortality among children under age five in urban and rural areas in the Sichuan province of west China, 2009–2017. *Scientific reports* 2019, 9(1):1-8.
44. Peden AE, Franklin RC: Causes of distraction leading to supervision lapses in cases of fatal drowning of children 0–4 years in Australia: A 15-year review. *Journal of paediatrics and child health* 2020, 56(3):450-456.
45. Ferres JML, Anderson TM, Johnston R, Ramirez J-M, Mitchell EA: Distinct populations of sudden unexpected infant death based on age. *Pediatrics* 2020, 145(1).
46. Nasrullah M, Muazzam S, Bhutta ZA, Raj A: Girl child marriage and its effect on fertility in Pakistan: findings from Pakistan Demographic and Health Survey, 2006–2007. *Maternal and child health journal* 2014, 18(3):534-543.
47. Walker CLF, Aryee MJ, Boschi-Pinto C, Black RE: Estimating diarrhea mortality among young children in low and middle income countries. *PloS one* 2012, 7(1):e29151.
48. Raj A: When the mother is a child: the impact of child marriage on the health and human rights of girls. In.: BMJ Publishing Group Ltd; 2010.
49. Parsons J, Edmeades J, Kes A, Petroni S, Sexton M, Wodon Q: Economic impacts of child marriage: a review of the literature. *The Review of Faith & International Affairs* 2015, 13(3):12-22.

50. Raj A, Saggurti N, Winter M, Labonte A, Decker MR, Balaiah D, Silverman JG: The effect of maternal child marriage on morbidity and mortality of children under 5 in India: cross sectional study of a nationally representative sample. *Bmj* 2010, 340:b4258.
51. Weerasekera D, Udugama SG: Pregnancy at 40 and over: a case–control study in a developing country. *Journal of Obstetrics and Gynaecology* 2003, 23(6):625-627.
52. Yogev Y, Melamed N, Bardin R, Tenenbaum-Gavish K, Ben-Shitrit G, Ben-Haroush A: Pregnancy outcome at extremely advanced maternal age. *American journal of obstetrics and gynecology* 2010, 203(6):558. e551-558. e557.
53. Morris JM, Totterdell J, Bin YS, Ford JB, Roberts CL: Contribution of maternal age, medical and obstetric history to maternal and perinatal morbidity/mortality for women aged 35 or older. *Australian and New Zealand Journal of Obstetrics and Gynaecology* 2018, 58(1):91-97.
54. Ezeh OK, Agho KE, Dibley MJ, Hall J, Page AN: Determinants of neonatal mortality in Nigeria: evidence from the 2008 demographic and health survey. *BMC Public Health* 2014, 14:521.
55. Brown W, Ahmed S, Roche N, Sonneveldt E, Darmstadt GL: Impact of family planning programs in reducing high-risk births due to younger and older maternal age, short birth intervals, and high parity. *Semin Perinatol* 2015, 39(5):338-344.
56. Hossain MM, Mani KK, Islam MR: Prevalence and determinants of the gender differentials risk factors of child deaths in Bangladesh: evidence from the Bangladesh demographic and health survey, 2011. *PLoS Negl Trop Dis* 2015, 9(3):e0003616.
57. Ezeh OK: Trends and population-attributable risk estimates for predictors of early neonatal mortality in Nigeria, 2003-2013: a cross-sectional analysis. *BMJ Open* 2017, 7(5):e013350.
58. Molitoris J: The Effect of Birth Spacing on Child Mortality in Sweden, 1878-1926. *Population and Development Review* 2017:61-82.
59. Greenberg JA, Bell SJ, Guan Y, Yu Y-h: Folic acid supplementation and pregnancy: more than just neural tube defect prevention. *Reviews in Obstetrics and Gynecology* 2011, 4(2):52.
60. Conde-Agudelo A, Rosas-Bermudez A, Castaño F, Norton MH: Effects of birth spacing on maternal, perinatal, infant, and child health: a systematic review of causal mechanisms. *Studies in family planning* 2012, 43(2):93-114.
61. Zhu BP: Effect of interpregnancy interval on birth outcomes: findings from three recent US studies. *International Journal of Gynecology & Obstetrics* 2005, 89:S25-S33.
62. Conde-Agudelo A, Rosas-Bermúdez A, Kafury-Goeta AC: Effects of birth spacing on maternal health: a systematic review. *American journal of obstetrics and gynecology* 2007, 196(4):297-308.
63. Ellison PT: Energetics and reproductive effort. *Am J Hum Biol* 2003, 15(3):342-351.
64. Tariku L: Effects of preceding birth intervals on child mortality in Ethiopia; Evidence from the Demographic and Health Surveys, 2016. *Epidemology International Journal* 2019, 3(1).
65. Marquis GS, Penny ME, Zimmer JP, Díaz JM, Marín RM: An overlap of breastfeeding during late pregnancy is associated with subsequent changes in colostrum composition and morbidity rates among Peruvian infants and their mothers. *The Journal of nutrition* 2003, 133(8):2585-2591.

66. Conde-Agudelo A, Belizán JM: Maternal morbidity and mortality associated with interpregnancy interval: cross sectional study. *Bmj* 2000, 321(7271):1255-1259.
67. Stephansson O, Dickman PW, Cnattingius S: The influence of interpregnancy interval on the subsequent risk of stillbirth and early neonatal death. *Obstetrics & gynecology* 2003, 102(1):101-108.
68. Wikle JS, Jensen AC, Hoagland AM: Adolescent caretaking of younger siblings. *Soc Sci Res* 2018, 71:72-84.
69. Conde-Agudelo A, Rosas-Bermúdez A, Kafury-Goeta AC: Birth spacing and risk of adverse perinatal outcomes: a meta-analysis. *Jama* 2006, 295(15):1809-1823.
70. DaVanzo J, Hale L, Razzaque A, Rahman M: The effects of pregnancy spacing on infant and child mortality in Matlab, Bangladesh: how they vary by the type of pregnancy outcome that began the interval. *Population studies* 2008, 62(2):131-154.
71. Akinyemi JO, Bamgboye EA, Ayeni O: New trends in under-five mortality determinants and their effects on child survival in Nigeria: A review of childhood mortality data from 1990-2008. *African Population Studies* 2013, 27(1).
72. Fotso JC, Cleland J, Mberu B, Mutua M, Elungata P: Birth spacing and child mortality: an analysis of prospective data from the Nairobi urban health and demographic surveillance system. *Journal of biosocial science* 2013, 45(6):779-798.
73. Saha UR, van Soest A: Contraceptive use, birth spacing, and child survival in Matlab, Bangladesh. *Stud Fam Plann* 2013, 44(1):45-66.
74. Stover J, Ross J: Changes in the distribution of high-risk births associated with changes in contraceptive prevalence. *BMC Public Health* 2013, 13 Suppl 3:S4.
75. Selemani M, Mwanyangala MA, Mrema S, Shamte A, Kajungu D, Mkopi A, Mahande MJ, Nathan R: The effect of mother’s age and other related factors on neonatal survival associated with first and second birth in rural, Tanzania: evidence from Ifakara health and demographic surveillance system in rural Tanzania. *BMC Pregnancy Childbirth* 2014, 14:240.
76. Chadoka-Mutanda N, Odimegwu CO: Maternal Health-Seeking Behaviour and under-Five Mortality in Zimbabwe. *J Biosoc Sci* 2017, 49(3):408-421.
77. Sahu D, Nair S, Singh L, Gulati BK, Pandey A: Levels, trends & predictors of infant & child mortality among Scheduled Tribes in rural India. *Indian J Med Res* 2015, 141(5):709-719.
78. Deb AK, Dutta S, Hnichho C, Vanlalpeki M, Phosa HT, Rakhu K, Fanai SL, Chakrabarti M, Panda S: A case control study investigating factors associated with high infant death in Saiha district of Mizoram, India bordering Myanmar. *BMC Pediatr* 2017, 17(1):23.
79. Handa S, Koch S, Ng SW: Child mortality in eastern and southern Africa. *Population Review* 2010, 49(1).
80. Fuse K: Gender and Parenting Difficulty of the First-Born: Implications for Parity Progression among Japanese Couples. *J Comp Fam Stud* 2019, 50(2):116-138.
81. Richter D, Krämer MD, Tang NK, Montgomery-Downs HE, Lemola S: Long-term effects of pregnancy and childbirth on sleep satisfaction and duration of first-time and experienced mothers and fathers. *Sleep* 2019, 42(4):zsz015.
82. Sonneveldt E, Plosky WD, Stover J: Linking high parity and maternal and child mortality: what is the impact of lower health services coverage among higher order births? *BMC Public Health* 2013, 13(S3):S7.

83. Albutt K, Sonderman K, Citron I, Nthele M, Bekele A, Makasa E, Maongezi S, Rwamasirabo E, Ameh E, Andriamanjato HH: Healthcare leaders develop strategies for expanding national surgical, obstetric, and anaesthesia plans in WHO AFRO and EMRO regions. *World journal of surgery* 2019, 43(2):360-367.

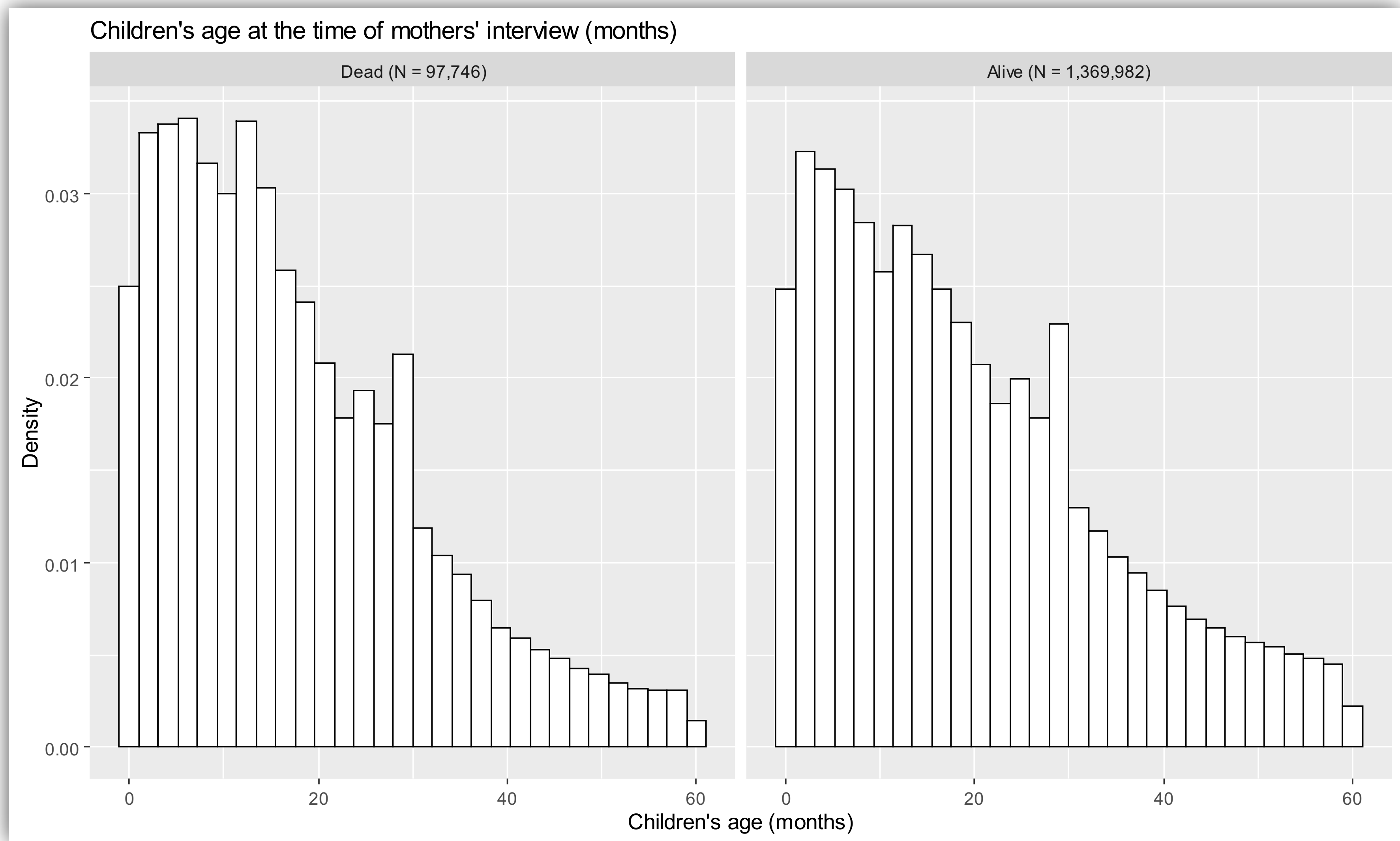

Figure 1: Age distribution of under-five children in 32 countries
Source: IPUMS-DHS

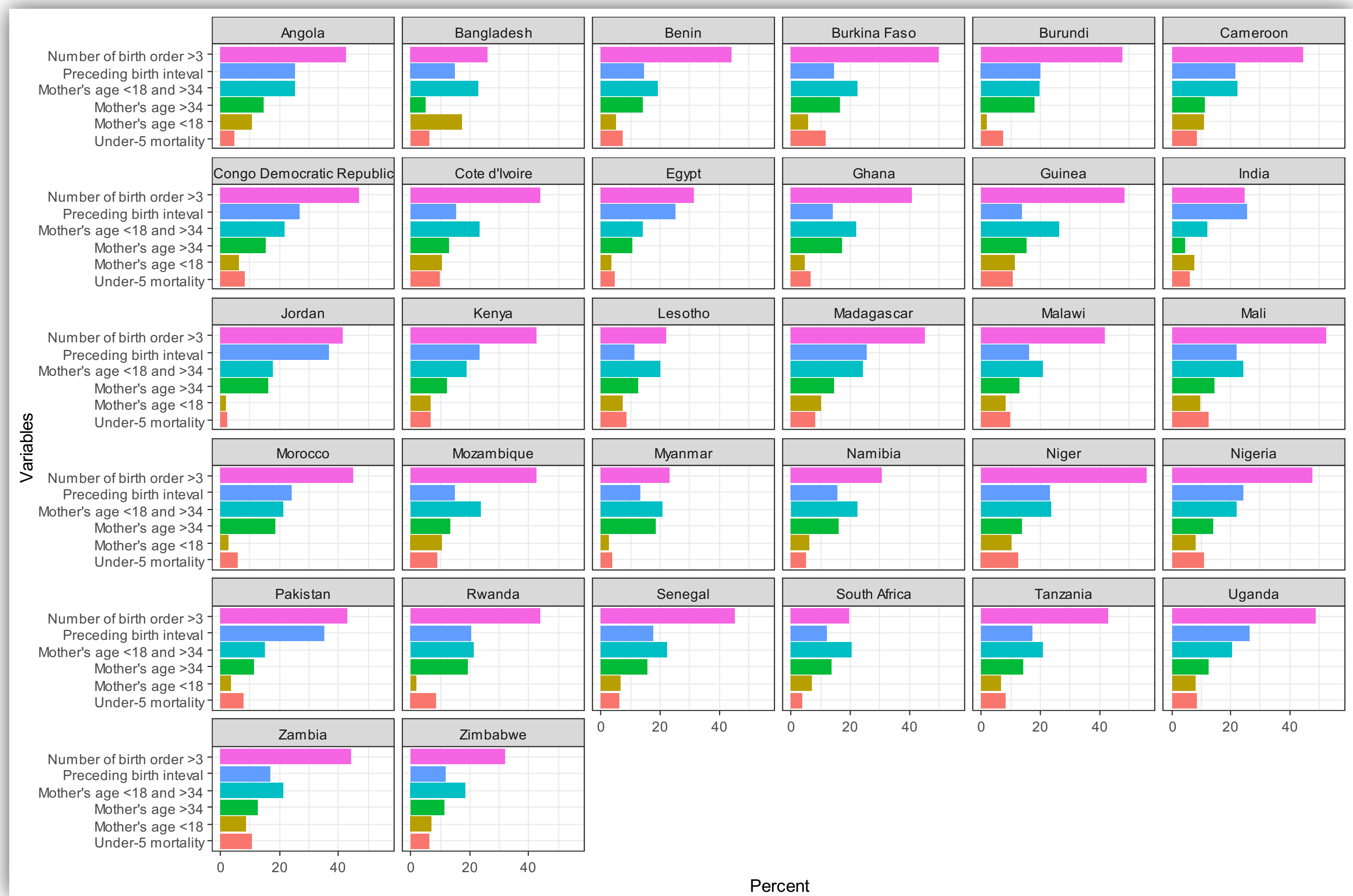

Figure 2: Rates of under-five child mortality and various indicators of high-risk fertility behavior (HRFB)
Source: IPUMS-DHS

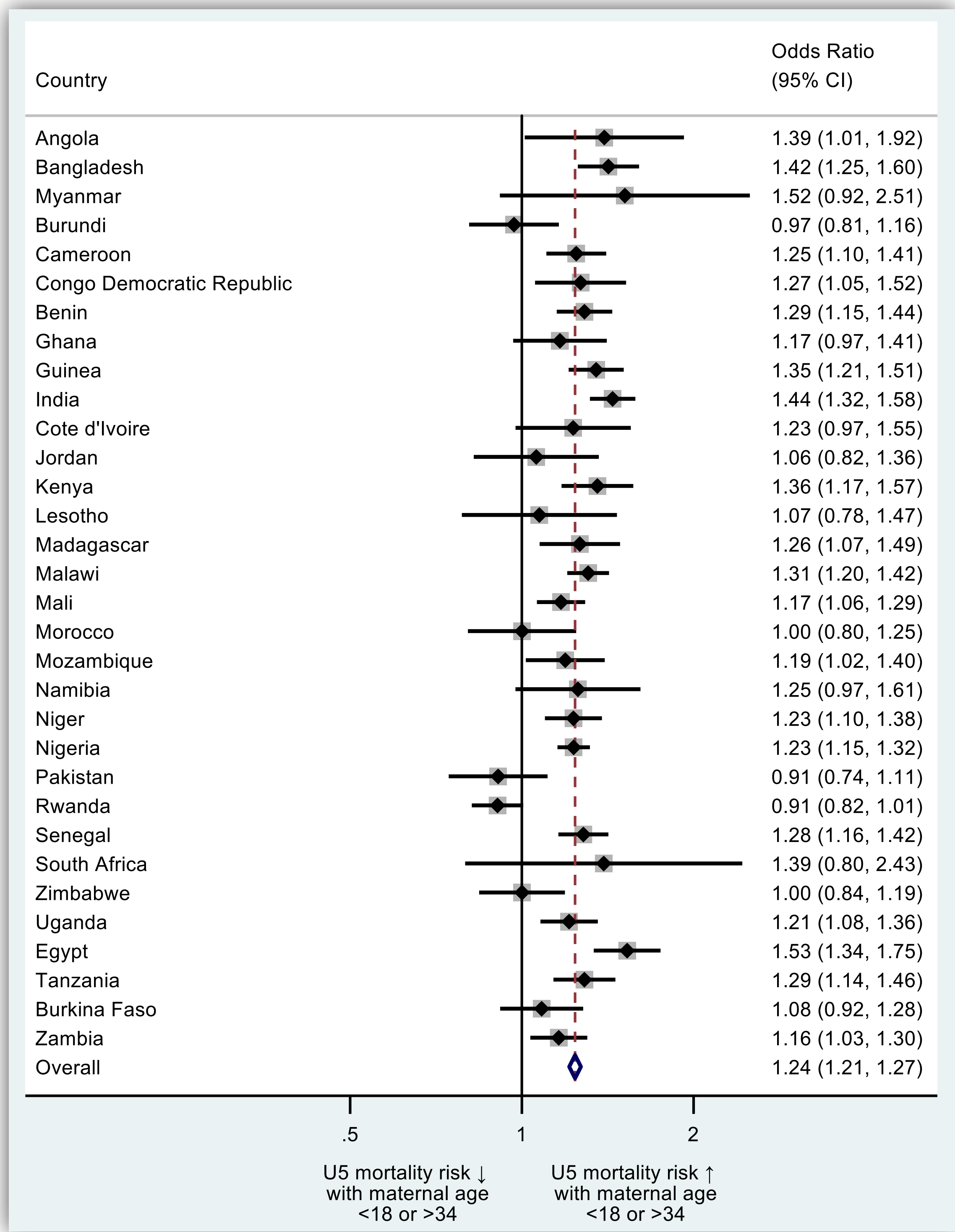

Figure 3: Country-level odds ratios: mother's age at birth of index child <18 or >34 years as the risk factor of under-five child mortality

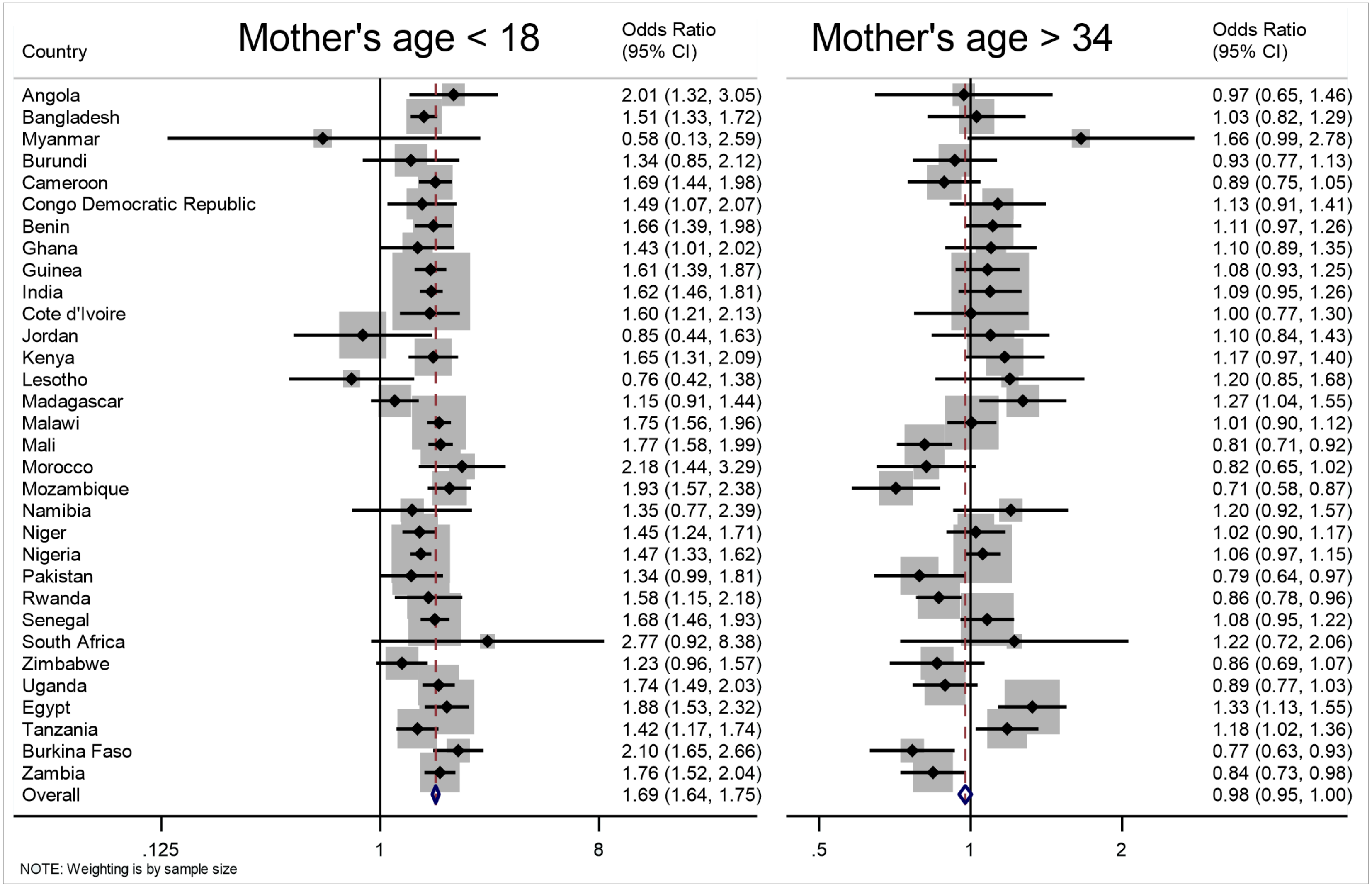

Figure 4: Country-level odds ratios: mother's age at birth of index child <18 or >34 years as the risk factor of under-five child mortality

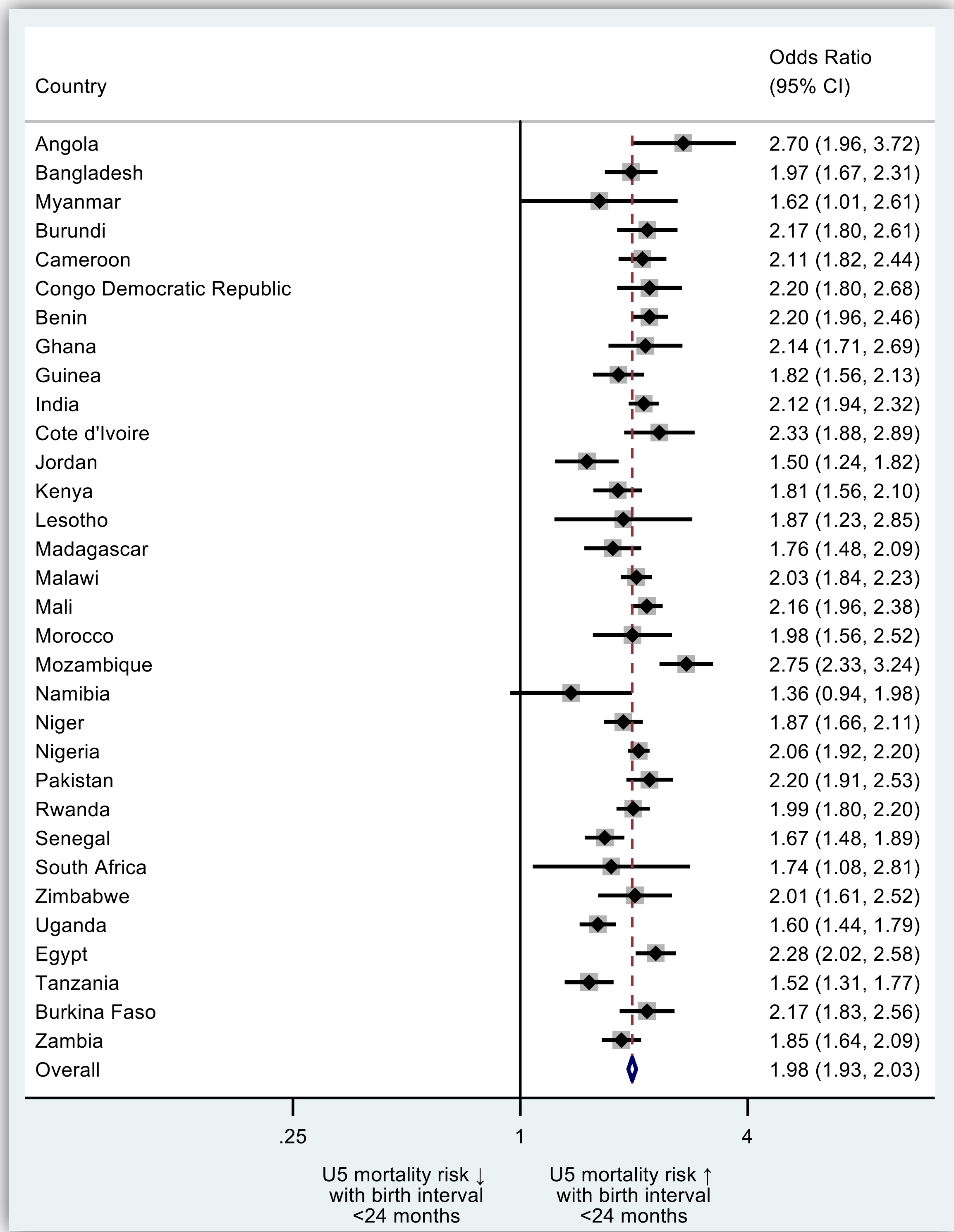

Figure 5: Country-level odds ratios: preceding birth interval (PBI) <24 months as the risk factor of under-five child mortality

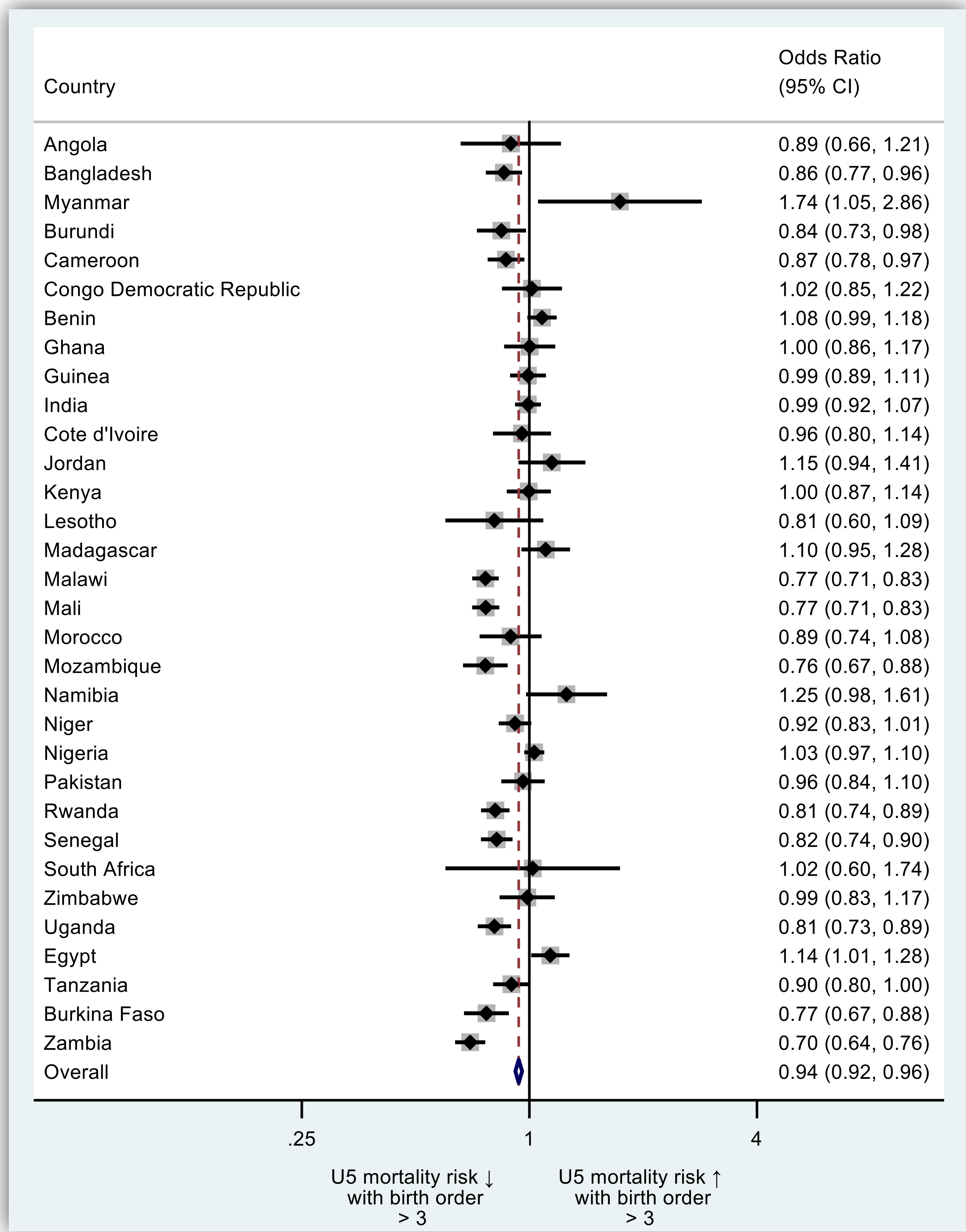

Figure 6: Country-level odds ratios: child’s birth order >3 as the risk factor of under-five child mortality

Table 1: High-risk fertility behavior: individual risk factors

	(1)	(2)	(3)	(4)
Mother's age at birth	AOR#	AOR	AOR	AOR
≥18 years	1			
	[1,1]			
<18 years	1.611***			
	[1.558,1.666]			
Mother's age at birth				
≤34 years		1		
		[1,1]		
> 34 years		0.983		
		[0.955,1.012]		
Length of PBI				
≥24 months			1	
			[1,1]	
< 24 months			2.018***	
			[1.969,2.068]	
Child's birth order number				
First, second, or third born				1
				[1,1]
>3				0.911***
				[0.892,0.930]
Mother's education				
No Education	1	1	1	1
	[1,1]	[1,1]	[1,1]	[1,1]
Primary	0.916***	0.923***	0.912***	0.910***
	[0.891,0.942]	[0.897,0.949]	[0.884,0.941]	[0.886,0.935]
Secondary	0.743***	0.742***	0.727***	0.728***
	[0.714,0.773]	[0.712,0.772]	[0.693,0.763]	[0.699,0.758]
Higher	0.558***	0.549***	0.552***	0.528***
	[0.505,0.616]	[0.497,0.606]	[0.485,0.628]	[0.479,0.582]
Father's education				
No Education	1	1	1	1
	[1,1]	[1,1]	[1,1]	[1,1]
Primary	0.936***	0.935***	0.900***	0.920***
	[0.909,0.963]	[0.908,0.962]	[0.872,0.929]	[0.894,0.947]
Secondary	0.861***	0.863***	0.851***	0.847***
	[0.831,0.891]	[0.833,0.894]	[0.817,0.886]	[0.818,0.876]
Higher	0.749***	0.743***	0.780***	0.738***
	[0.701,0.801]	[0.695,0.794]	[0.722,0.842]	[0.692,0.788]
Mother's working status				
Not currently working	1	1	1	1
	[1,1]	[1,1]	[1,1]	[1,1]
Working	1.089***	1.073***	1.125***	1.087***

	[1.062,1.116]	[1.047,1.099]	[1.094,1.157]	[1.062,1.114]
Father's working status				
Not currently working	1	1	1	1
	[1,1]	[1,1]	[1,1]	[1,1]
Working	0.977	0.969	0.995	0.967
	[0.891,1.072]	[0.884,1.063]	[0.892,1.111]	[0.885,1.056]
Residential status				
Rural	1	1	1	1
	[1,1]	[1,1]	[1,1]	[1,1]
Urban	0.956**	0.953**	0.955*	0.942***
	[0.926,0.987]	[0.924,0.984]	[0.921,0.991]	[0.912,0.972]
Household wealth status				
Poorest	1	1	1	1
	[1,1]	[1,1]	[1,1]	[1,1]
Poorer	0.992	0.993	0.993	0.994
	[0.965,1.021]	[0.965,1.021]	[0.962,1.024]	[0.967,1.022]
Middle	0.924***	0.920***	0.936***	0.942***
	[0.895,0.953]	[0.892,0.949]	[0.903,0.970]	[0.913,0.972]
Richer	0.903***	0.895***	0.944**	0.908***
	[0.873,0.935]	[0.865,0.927]	[0.910,0.980]	[0.878,0.939]
Richest	0.758***	0.747***	0.774***	0.766***
	[0.724,0.794]	[0.713,0.783]	[0.735,0.816]	[0.733,0.802]
Country fixed effects	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes
N	901934	901934	748896	1000229
F	172.0	157.9	168.3	155.0
p	0	0	0	0

Exponentiated coefficients; 95% confidence intervals in brackets

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

\# Adjusted odds ratio

Table 2: High-risk fertility behavior: no vs. any single risk factors

	(1) Adjusted OR	95% CI
Any single high-risk category		
No	1	[1,1]
Any single	1.066***	[1.042,1.090]
Mother's education		
No Education	1	[1,1]
Primary	0.927***	[0.899,0.956]
Secondary	0.770***	[0.737,0.806]
Higher	0.570***	[0.514,0.632]
Father's education		
No Education	1	[1,1]
Primary	0.927***	[0.898,0.956]
Secondary	0.860***	[0.828,0.894]
Higher	0.753***	[0.702,0.809]
Mother's working status		
Not currently working	1	[1,1]
Working	1.070***	[1.043,1.099]
Father's working status		
Not currently working	1	[1,1]
Working	0.926	[0.837,1.025]
Residential status		
Rural	1	[1,1]
Urban	0.967	[0.934,1.001]
Household wealth status		
Poorest	1	[1,1]
Poorer	1.000	[0.969,1.032]
Middle	0.965*	[0.933,0.998]
Richer	0.917***	[0.883,0.952]
Richest	0.775***	[0.737,0.814]
Country fixed effects	Yes	
Time-fixed effects	Yes	
N	819471	
F	130.7	
p	0	

Exponentiated coefficients; 95% confidence intervals in brackets

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Table 3: High-risk fertility behavior: no vs. single vs. multiple risk factors

	(1) Adjusted OR	95% CI
High-risk fertility behavior		
No	1	[1,1]
Single high-risk category	1.068***	[1.045,1.092]
Multiple high-risk category	1.392***	[1.355,1.431]
Mother's education		
No Education	1	[1,1]
Primary	0.941***	[0.916,0.967]
Secondary	0.781***	[0.751,0.813]
Higher	0.581***	[0.527,0.640]
Father's education		
No Education	1	[1,1]
Primary	0.934***	[0.908,0.961]
Secondary	0.875***	[0.845,0.906]
Higher	0.755***	[0.708,0.806]
Mother's working status		
Not currently working	1	[1,1]
Working	1.064***	[1.039,1.090]
Father's working status		
Not currently working	1	[1,1]
Working	0.980	[0.897,1.070]
Residential status		
Rural	1	[1,1]
Urban	0.946***	[0.917,0.976]
Household wealth status		
Poorest	1	[1,1]
Poorer	0.997	[0.970,1.024]
Middle	0.944***	[0.916,0.974]
Richer	0.910***	[0.880,0.940]
Richest	0.770***	[0.736,0.805]
Country fixed effects	Yes	
Time-fixed effects	Yes	
N	1000229	
F	171.6	
p	0	

Exponentiated coefficients; 95% confidence intervals in brackets
* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Table 4: High-risk fertility behavior: specific combinations of risk factors

	(1) Adjusted OR
Age at birth < 18 years and birth interval < 24 months	
No	1
	[1,1]
Yes	2.069^{***}
	[1.881,2.276]
Age at birth < 18 years and birth order > 3	
No	1
	[1,1]
Yes	1.824^{*}
	[1.105,3.009]
Age at birth < 18 years and birth interval < 24 months and birth order > 3	
No	1
	[1,1]
Yes	1.997^{*}
	[1.101,3.620]
Age at birth > 34 years and birth interval < 24 months	
No	1
	[1,1]
Yes	1.933^{***}
	[1.828,2.045]
Age at birth > 34 years and birth order > 3	
No	1
	[1,1]
Yes	0.978
	[0.950,1.008]
Age at birth > 34 years and birth interval < 24 months and birth order > 3	
No	1
	[1,1]
Yes	1.951^{***}
	[1.843,2.065]
Birth interval < 24 months and birth order > 3	
No	1
	[1,1]
Yes	1.819^{***}
	[1.765,1.876]
Country fixed effects	Yes
Time-fixed effects	Yes

Exponentiated coefficients; 95% confidence intervals in brackets
* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Figures

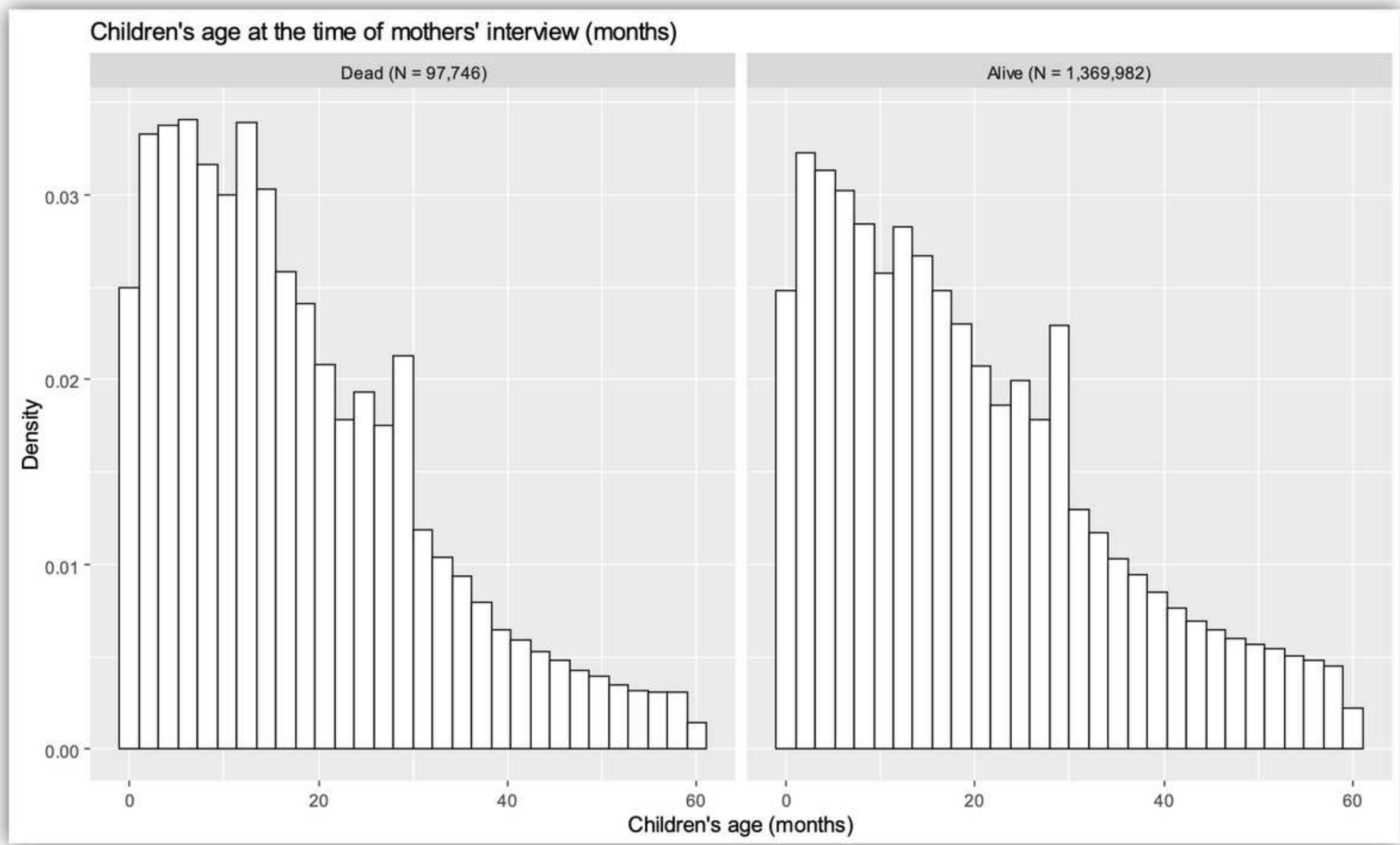

Figure 1

Age distribution of under-five children in 32 countries Source: IPUMS-DHS

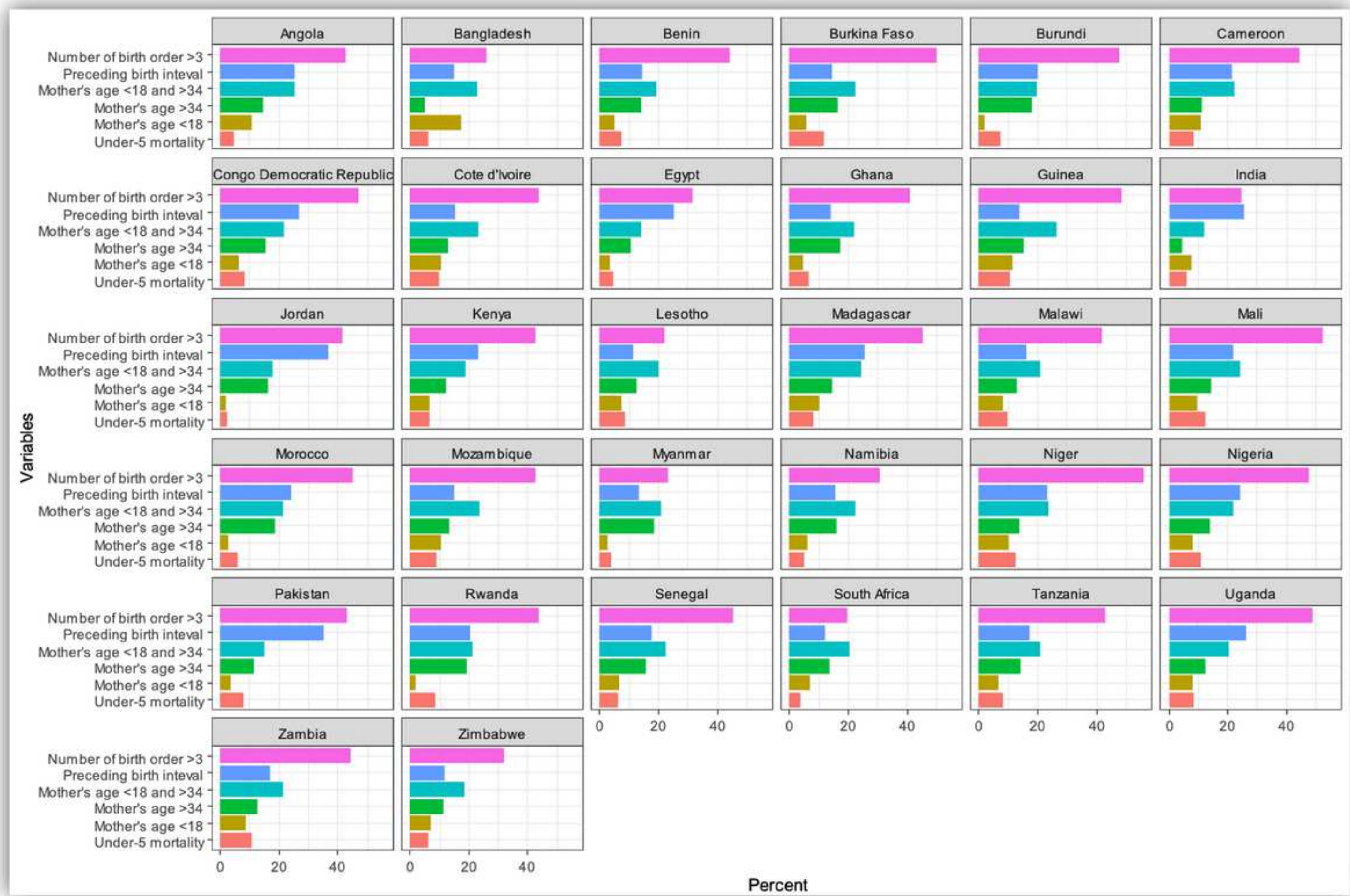

Figure 2

Rates of under-five child mortality and various indicators of high-risk fertility behavior (HRFB) Source: IPUMS-DHS

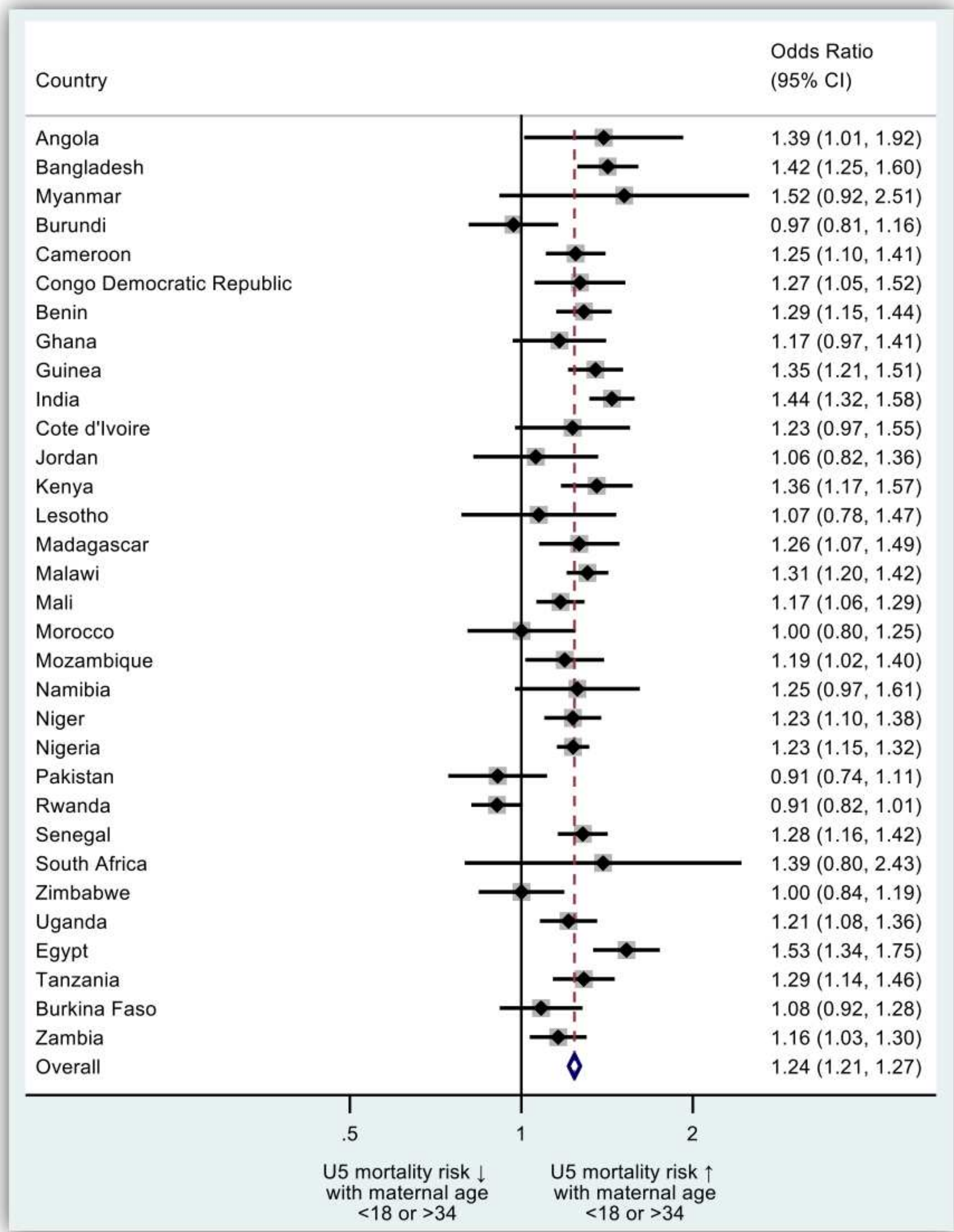

Figure 3

Country-level odds ratios: mother’s age at birth of index child <18 or >34 years as the risk factor of under-five child mortality

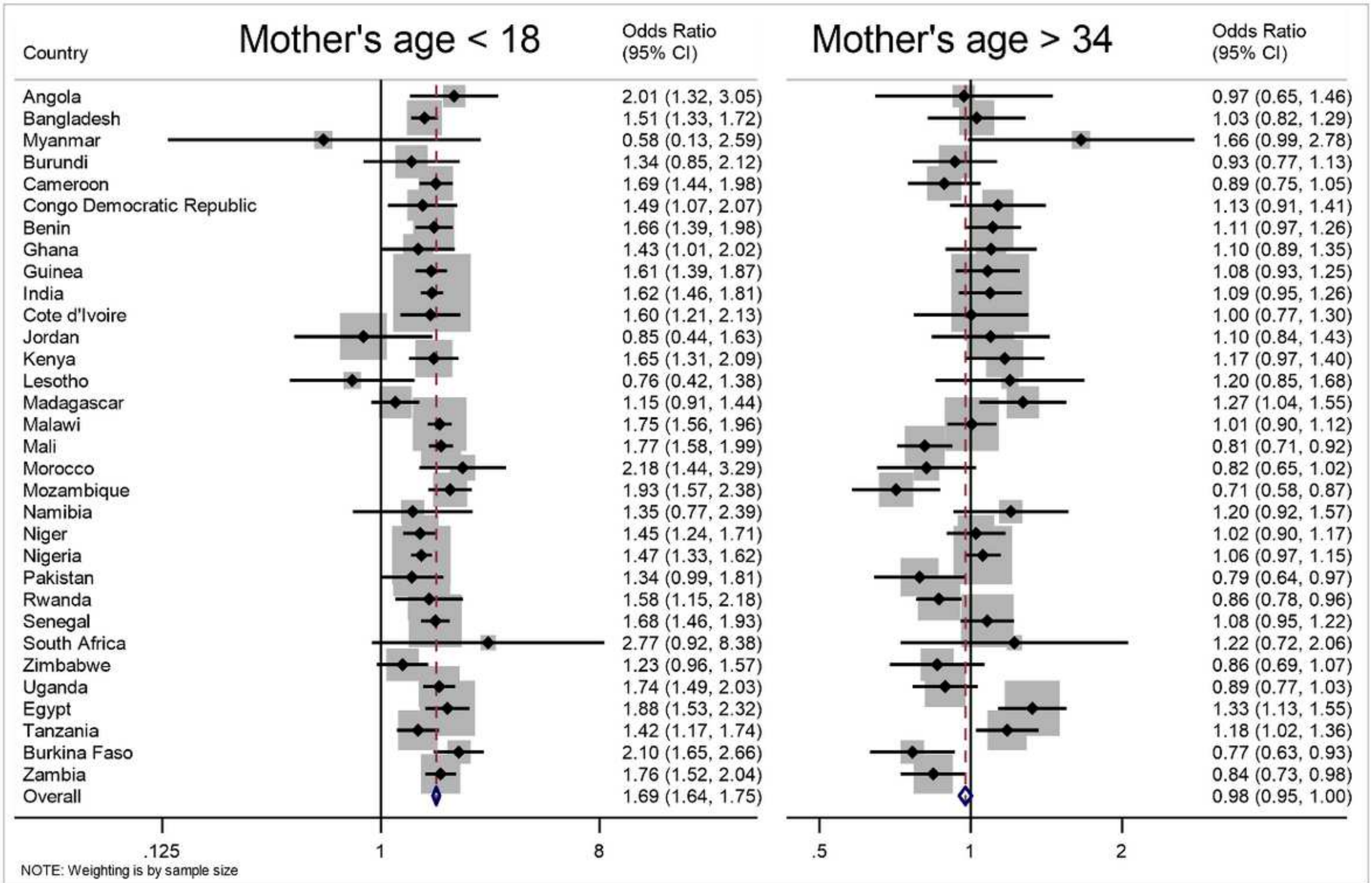

Figure 4

Country-level odds ratios: mother’s age at birth of index child <18 or >34 years as the risk factor of under-five child mortality

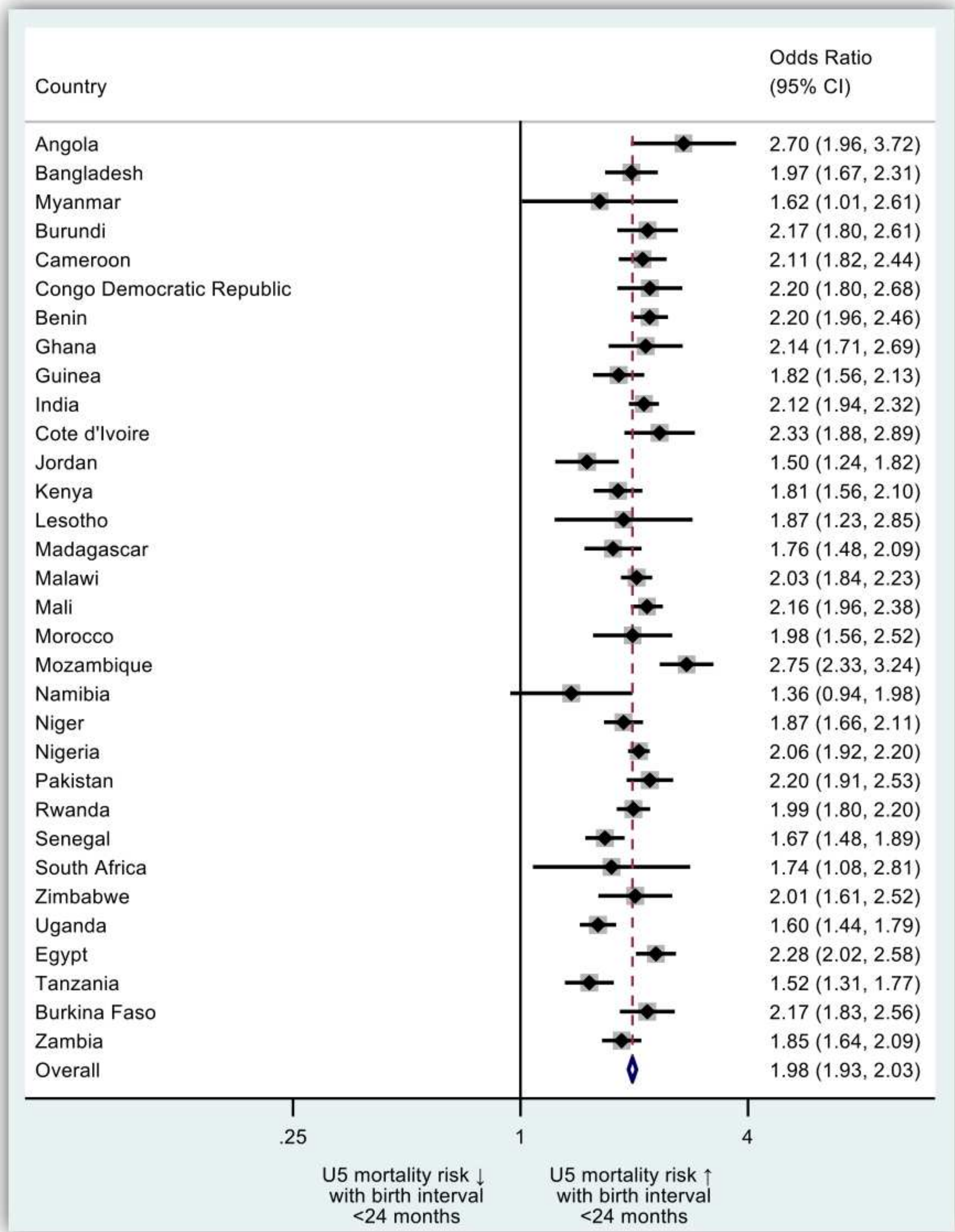

Figure 5

Country-level odds ratios: preceding birth interval (PBI) <24 months as the risk factor of under-five child mortality

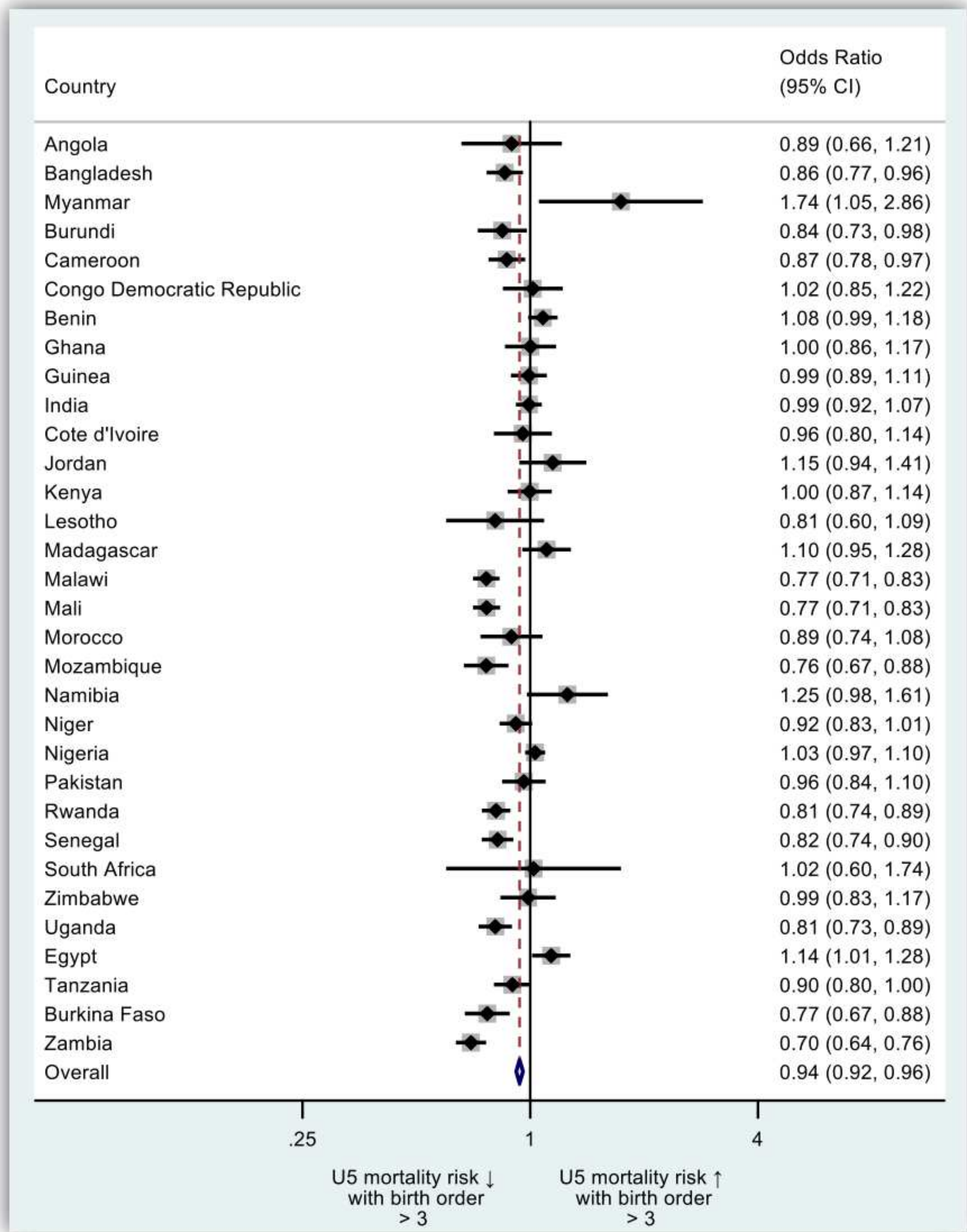

Figure 6

Country-level odds ratios: child’s birth order >3 as the risk factor of under-five child mortality