Does Contraceptive Use Reduce Neonatal and Infant Mortality?
Findings from a Multi-Country Analysis

Amy O. Tsui and Andreea A. Creanga
Population, Family and Reproductive Health Department
Johns Hopkins Bloomberg School of Public Health

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Abstract

This study examines the effectiveness of contraceptive use in lengthening birth-to-pregnancy intervals and reducing infant mortality, from the early neonatal through neonatal and post-neonatal stages. We conduct a multi-country empirical analysis of data from the reproductive and contraceptive calendars collected in 19 Demographic and Health Surveys. We fit Cox proportional hazard models to examine the risk of pregnancy, neonatal and infant mortality during closed, birth-to-pregnancy and open, birth-to-censoring intervals, and Poisson regression models to explore the incidence of neonatal and infant death during closed birth intervals. We summarize the results from the 19 countries using meta-analytic techniques. Among the 19 countries, we find that the risks of pregnancy and infant death are reduced by a pooled average of 6.8% and 2.6% for each month of contraceptive use that is not accompanied by breastfeeding, while the same risks are reduced by 6.9% and 5.7% for each month when contraception and breastfeeding overlap during closed and open birth intervals. Restricting the analysis to the sample of closed birth intervals only provides a conservative test of contraception's hypothesized effects on infant mortality. We find that the risk of infant death is significantly reduced for each month when contraception use and breastfeeding overlap (pooled incidence rate ratio=0.965; 95%CI = 0.95, 0.98), while only marginally reduced for one month of contraception use alone (pooled incidence rate=0.996; 95%CI=0.99, 1.00). By and large, the impact of contraceptive use during the birth interval is visible in countries with significant use and attenuated or embedded with breastfeeding in several sub-Saharan African countries. This information is important for evidence-based advocacy to expand family planning care in low-resource settings.

Background and Significance

Family planning is popularly and rightly promoted as a valuable maternal and child health intervention, especially appropriate for low-income countries where the burden of child and maternal mortality is high. There is widespread belief in contraception's role in lengthening birth intervals, assisting with child spacing, and contributing to the reduction of neonatal and infant mortality levels. The research literature on the strength of these relationships, however, needs updating and on the whole is remarkably sparse. Most of the available research for developing country settings does not explicitly address or quantify the contribution of contraceptive method use either to birth spacing or maternal and child health and survival. Instead, published research centers around the effects of birth interval length on pregnancy and infant health, sometimes adjusting for prior or current contraceptive use.

As is well known (see Bongaarts and Potter, 1983), the length of the birth interval can be affected by a variety of factors, such as breastfeeding (Jain and Bongaarts, 1981; Huffman and Martin, 1994), voluntary and involuntary sexual abstinence (Kirk and Pillet, 1998; Benefo, 1995), maternal nutritional status (Fall et al., 2003), early and unreported fetal loss (DaVanzo et al., 2008) or secondary infertility (Orji et al., 2004). A recent systematic literature review examined the effect of contraceptive use on birth intervals (Yeakey et al., 2009). Overall, the results of the articles included in this systematic review suggest a trend toward longer birth intervals among women who use modern methods of contraception. In some cases there is a dramatic difference in birth interval lengths between users and non-users of contraception (Janowitz and Nichols 1983; Forste

1995), while several exceptions to this trend exist -- Ngianga-Bakwin and Stones (2004) found that users had slightly higher odds of having short birth intervals, Feyisetan (1990) found no significant difference in the length of birth intervals among users and non-users of contraception, and DaVanzo and Starbird (1991) observed that while contraceptive use reduces the odds of short birth intervals, the interaction between contraception and breastfeeding leads to dramatically increased odds of short birth intervals. It is worth noting that no single article included in this analysis had an ideal analytic model. Importantly, while many analytic models included breastfeeding as a competing covariate to contraception in its potential to lengthen birth intervals, they do not measure the duration or intensity of breastfeeding nor do they consider the potential overlap with contraceptive use in a standardized way (Yeakey et al., 2009).

Findings of the adverse effects of short birth intervals on infant health outcomes are often generalized as justification for expanding contraceptive practice for childspacing. Moreover, while research findings tend to imply that prolonged contraceptive use will positively impact the health and survival of mothers and their infants (e.g., Marston and Cleland, 2003; Cleland et al. 2006; Conde-Agudelo et al. 2006), better quantification of this impact is much needed. What is the mechanism by which contraception, whether involving the use of artificial or natural methods, influences the survival of the subsequent birth, independent of other factors?

Clearly its direct effect is to prevent conception over the period of effective use and if a permanent method is used, then in all probability no births will ensue and deaths from

high-risk pregnancies will be averted. While hormonal and intrauterine device methods provide high levels of use-effectiveness (i.e. low percentages of women becoming accidentally pregnant in a year of continuous use of such methods), the conditions and durations of typical use are understudied. Between births, the contraceptive methods of choice are short-term in nature, that is, they require resupply, are used intermittently or jointly with other methods and their use can be easily terminated or abandoned. This can lead to highly variable durations of use. In order to examine whether contraceptive use demonstrates a discernible effect on the survival of subsequent birth, the duration of contraceptive method use will need to be sufficiently long to contribute protection above and beyond other determinants, particularly lactational amenorrhea and in some countries, post-partum sexual abstinence.

At the population level, contraceptive practice can impact the level of infant mortality in two ways: first by preventing unwanted pregnancies, some of which, if born, may die prematurely, and second by delaying future births and shifting their timing, thus initially lowering aggregate fertility rates. Another possible and potentially important pathway by which use of contraception influences infant survival is at the individual level. By delaying a first pregnancy, very young women become physically prepared to sustain a pregnancy. By lengthening birth intervals, contraceptive use may improve maternal nutritional status, women can regain micronutrient stores lost with previous pregnancies and in turn enhance infants' prospects of survival. As such, by lengthening the time to next pregnancy through effective contraceptive use, a woman may increase her absorption of micronutrients (Christian et al., 2008), vitamins (Fawzi et al., 2007;

Murphy et al., 2007), and iron folate (van Eijsden et al., 2008), as well as weight (Gemma et al., 2006) in the non-lactating non-pregnant period which have been shown to improve perinatal, infant and also maternal health outcomes.

Prospective pregnancy history data from Matlab, Bangladesh have been analyzed in a number of studies looking at determinants of infant mortality (DaVanzo and Starbird 1991; Hale et al. 2006; DaVanzo et al. 2007; DaVanzo et al. 2008) but none of these studies explicitly assessed the magnitude of effect from contraceptive use. Contraceptive efficacy studies estimating the probability of a pregnancy in the first 12 months of use of one method or another did not show the effects of use on perinatal or infant outcomes of those pregnancies. Moreover, as Yeakey et al. (2009) recognize, beyond its impact during a closed birth interval, contraception's influence during open birth intervals (uninterrupted time since the last birth) and subsequent infant mortality may be greater, since women contributing these latter births tend to be older, of higher parity, and often have higher risk pregnancies. There are, however, few relevant empirical studies examining open birth intervals. Further, the impact of contraception use on the interval to the first pregnancy and the risk of adverse outcomes, which tend to be higher than at other parities, are even less well studied of late.

Research Questions

The two research questions of interest for this study are: 1) does contraceptive use delay the next pregnancy, and 2) does contraceptive use reduce the risk of neonatal and/or infant mortality? We assess the effect of the duration of contraceptive use after birth on

the probability of a subsequent birth occurring and on the probability that the subsequent birth survives to its first week (early neonatal), 28 days (neonatal), 11 months (post neonatal) and first year (infant) of life. While the answer to the first question seems self-evident, we are interested in the magnitude of effect from a month of contraception use on the time to next pregnancy net of other factors. The answer to the second question of contraception's effect on neonatal and infant mortality is confounded by competing effects from other biological and behavioral factors, more immediately from breastfeeding and aspects prevailing in the social and physical environment after the first month of life. We explore this second question by studying both open (time since last birth censored with the survey's occurrence) and closed (time since last birth that ends with a pregnancy) birth intervals.

Data and Methods

Birth and contraceptive use histories

In a number of countries, the Demographic and Health Surveys (DHS) includes a monthly contraceptive calendar module which retrospectively measures episodes of contraceptive use usually in the 60 months (5 years) preceding the survey. Women first report their pregnancies and the outcomes of these pregnancies and then around these, the months when they started and stopped each episode of contraceptive use; the reasons for ending contraceptive practice, including method failure and accidental pregnancy, are also assessed (Blanc et al., 2002). A full birth history, including dates and outcomes of pregnancies, are also collected from each woman in the core survey. These are then used to construct open, birth-to-censoring (B2C) and closed, birth-to-pregnancy (B2P) intervals. The core survey further obtains maternal reports of pregnancy care during the

prenatal, delivery and postnatal periods for births in the preceding 5 years. Although some recall bias in the reporting of dates is unavoidable, without prospective data at the population level, extraction of empirical measures of durations of exposure to the fertility-reducing and associated health effects of breastfeeding and contraception is helpful for studying their relationships with pregnancy outcomes.

In order to assess and compare contraception's effects on the risk of pregnancy, neonatal and infant mortality across a range of low-income countries we rely on contraceptive calendar and birth history data reported by women in the 5 years before the DHSs. We select the most recent such survey in each country and include all surveys (19) with no missing DHS calendar data.

Analytical methods

We employ Kaplan-Meier survival curves and fit Cox proportional hazard models to study the first and the part of the second research question that analyzes closed (B2P) and open (B2C) birth intervals. The unit of analysis is the interval (in months) to the event of interest, whether the next pregnancy or a neonatal or infant death. For these analyses, the sample is comprised of B2P and B2C intervals contributed by women with at least one birth in the 5 years preceding the survey. For the 5-year period, there are between 2,673 and 61,648 total analytic intervals in Vietnam and India, respectively. The Kaplan-Meier estimate of the survival function is used to estimate the proportion of women who experience a subsequent pregnancy after each birth in the 5 years prior to the survey, and the proportion of all live births in the 5 years preceding the survey who die during the

neonatal and infant period. Log-rank test-statistics are used to examine the difference between the survival curves for women exposed and unexposed to contraceptive use. Multivariate Cox regression models are estimated for the time-varying risk (hazard) of pregnancy and of early neonatal (ENN), neonatal (NN), post-neonatal (PNN) and infant (IM) death controlling for biological and behavioral factors. We conducted tests of the proportionality assumption (i.e. the hazard ratio is proportional over time) with Schoenfeld weighted residuals both for individual covariates and globally, and concluded that the fitted models do not violate the proportional hazard assumption. Thus, the statistical model for the analysis is:

$h(t|X)=h_0(t) * \exp(\beta_1 X_1 + \beta_2 X_2 + \ldots. \beta_n X_n)$, where $h(t|X)$ is the instantaneous hazard for pregnancy and mortality at time t after a birth during the 5 years prior to the survey given the predictor variables X, $h_0(t)$ is the baseline hazard when all covariates are zero, X_1-X_n are covariates included in the model (detailed below), and β_i, i=1,2,3…n are the model parameters, functions of the time representing the time-dependent hazard ratio for a unit increase in the respective covariates.

As a more conservative test of the effect of the duration of contraceptive use on the risk of death to a succeeding birth (birth i+1), we restrict the analysis to the sample of closed birth intervals; these intervals are contributed by women with at least 2 births in the 5-years preceding the surveys. This approach allows us to attempt to capture the potential effects of contraceptive use prior to conception gained by delaying births and assisting maternal nutritional repletion. Because ENN, NN and PNN death counts are infrequent, we use multivariate Poisson regression to model the number of deaths at each stage of

life as a function of the control variables, and perform goodness-of-fit tests comparing model predictions with the observed counts. The statistical model for the analysis is: $\ln(r)=\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots.+ \beta_n X_n$, where r is the incidence rate as a linear function of the predictor variables (X), and β_i, i=1,2,3…n are the model parameters.

Additionally, we use meta-analytic techniques to combine and summarize the results from the 19 countries. The use of this statistical technique is justified given the objective of the analysis. Considering the heterogeneity among the countries, we fit random effects models using the DerSimonian and Laird method (DerSimonian & Laird, 1986). This method has been extensively used in the literature for meta-analyses of randomized controlled trials, cohort, case-control, as well as cross-sectional studies such as DHSs. The pooled hazard and incidence rate ratios estimate the average weighted associations between the exposure to contraceptive use and risk of pregnancy and of neonatal or infant death. We investigated the quantitative and qualitative heterogeneity among the 19 country surveys included in the analysis, as well as the influence of single surveys on the overall meta-analysis estimate through sensitivity analyses. No single survey influences any of the pooled estimates, either hazard ratio or incidence rate ratio, and therefore, no survey was excluded from the meta-analyses.

Since a woman can contribute more than one birth interval to the analysis, we control for possible bias from maternal clustering in all analyses. Additionally, we adjust all estimates using Taylor's linearization method to account for to the complex survey design. All analyses are performed using Stata version 9.1.

Main covariates

Both open and closed birth intervals (measured in months) are first constructed and aligned with the contraceptive calendar, breastfeeding and prenatal care data. The full interval is then decomposed into 4 exposure periods: 1) duration of breastfeeding only (BF), 2) duration of contraceptive use only (CU), 3) duration of contraceptive use overlapping with breastfeeding (CU&BF), and 4) duration when neither breastfeeding nor contraceptive use is reported (NCUBF). Since breastfeeding is initiated soon after birth, we can safely classify any period where contraception began prior to the end of breastfeeding as overlapping (CU&BF). Any additional months of contraceptive use constitute a contraception-only period, to which we add months from other subsequent and discrete episodes of use in the same birth interval. The difference between the length of the birth interval and the sum of months in BF, CU and CU&BF periods constitutes the residual (NCUBF) period. This is best understood visually as shown in Figure 1 below. Three exposure durations (BF, CU and CU&BF) are included in the multivariate regression models, with NCUBF as a reference period.

Other covariates

The following covariates are used as controls in the estimation models: survival of the preceding birth, parity at the start of the interval (continuous measure), maternal education level (none=reference, primary, secondary, or higher), household wealth quintile (poorest=reference), residence (urban=reference), maternal stature (>145cm=reference, women denoted as short if under 145 cm), and receipt of each of 3 prenatal interventions for the index birth (tetanus toxoid immunization, malaria

prophylaxis, and iron folate supplementation). The latter 3 predictor variables are only included in the Poisson regression models using closed birth intervals.

Results

Table 1 provides the means, standard deviations, and medians for the full birth interval (B2P/B2C) and the 4 components (BF, CU, CU&BF, NCUBF) for each country. The mean length of the birth interval ranges from 20.03 months in Indonesia to 30.79 months in Vietnam, and is 24 months or longer in 13 of the 19 countries. There is considerable variation around the means with standard deviations of around 18 months in Colombia (18.86), Turkey (18.20) and Vietnam (18.53). The components with the longest durations are non-exposure (NCUBF) and breastfeeding (BF), with the former having median values that range from a low of 1 month in India, Indonesia, Morocco and Nepal to a high of 20 months in Tanzania. Breastfeeding in turn has median values ranging from a low of 2 months in the Dominican Republic, Morocco, and Turkey, to a high of 15 months in Nepal. What is striking is how short the durations of exposure to contraceptive use only (CU) are, with means from a low of 1.55 months in Ethiopia, 2.17 months in Uganda and 2.81 months in Malawi to higher values of 14.33 months in Morocco, 14.52 months in Colombia and 14.73 months in Turkey, with the highest being 17.28 months in Vietnam. Because contraceptive use often overlaps with breastfeeding, the average durations of CU&BF intervals can be as short as 1.43 months (Ethiopia) or 1.69 months (Uganda) and as long as 9.04 months in Indonesia. CUBF interval's variation can be significant, as in Ethiopia where the standard deviation (SD) of 4.96 months is greater

than the mean of 1.43 months, India (mean= 5.04 months, SD= 8.94 months) or Nepal (mean=5.31 months, SD=9.40 months).

Figure 2 presents the Kaplan-Meier (KM) estimates of pregnancy risk by duration since last birth for the 19 countries differentiated by whether contraception was used or not in the interval and also if use occurred while the mother was breastfeeding. The log rank test statistics for all KM curves are statistically significant at $p<0.05$. The upper curves in each graph in the left column of Figure 2 are associated with contraceptive use and show a slower tempo to the next pregnancy at all durations since last birth. At 36 months, the probability of preventing the next pregnancy if contraception is used ranges around 0.65-0.68 versus 0.27-0.30 for non-use in Kenya, Malawi and Tanzania, for example. Using these 3 countries as illustrations, the median number of months to pregnancy, when contraceptive is used, is highest in Kenya at 54 months, next highest in Tanzania at 42 months and 40 months in Malawi.

Table 2 presents the hazard ratios (HRs) and 95% confidence intervals, results from the multivariate Cox regression models of time to next pregnancy as a function of the 3 exposure durations (CU, BF, CU&BF) with NCUBF as a reference period and adjusted for the other covariates. One month of contraceptive use (CU) is estimated to reduce the risk of pregnancy by as much as 9% in Egypt and Uganda and as little as 6% in Bangladesh, the Dominican Republic, Honduras, and another 7 countries. One month of breastfeeding (BF) reduces the risk of pregnancy by as much as 11% in Vietnam and as little as 4% in the Dominican Republic, Malawi and the Philippines. One month of

exposure to the combination of contraception use during period of breastfeeding (CU&BF) reduces pregnancy risk by as much 12% in Vietnam and 10% in Nepal and as little as 5% in Malawi and Tanzania. The magnitude of these effects is relatively similar across countries and seems reasonable for the relationship of interest. All adjusted HRs are statistically significant at $p<0.05$. Extrapolated to 12 months of use, the impact of contraceptive use itself (CU) represents anywhere from a 72% to a full (100%) reduction in the risk of pregnancy, values that approximate one-year use-effectiveness levels of the various contraceptive methods.

The Cox regression results are more easily visualized in the forest plots presented in Figure 3 for each of the CU, BF and CU&BF intervals. The meta-analysis, weighted by the sample size of birth intervals for each country, shows pooled protective effects against pregnancy for one month of contraceptive use, breastfeeding and overlapping contraception and breastfeeding (pooled HR=0.932 for CU, HR=0.939 for BF, and HR= 0.931 for CU&BF), all with 95% confidence intervals not overlapping 1.0. By itself, 12 months of contraceptive use only translates into 81.6% reduction in the risk of pregnancy. The same duration effect for overlapping contraception and breastfeeding is nearly identical (81.8%) and for breastfeeding alone is 73.2%.

Using the same birth interval sample, we calculated the KM curves for infant survival by duration since birth and present them in Figure 4 differentiated by use/non-use of contraception preceding the pregnancy. Only the KM curve for infant mortality is shown, although the curves have also been calculated for ENN, NN and PNN mortality. In 16 of

the 19 countries, log-rank statistics for the KM curve trends by contraceptive use are statistically significant at $p < 0.05$ for infant mortality; they are not statistically different in Peru, Vietnam and Uganda. In addition, the log-rank statistics are statistically significant for a majority of countries for PNN mortality but not for ENN or NN mortality. This is somewhat unexpected since the effect of contraceptive use through allowing maternal nutritional deposit-repletion is presumably stronger for ENN and NN survival than later in the first year of life. As shown in Figure 4, the contraceptive use differential in infant mortality over time is visually greatest for Egypt, Ethiopia, Malawi, Morocco, Turkey and Zimbabwe.

Table 3 provides the adjusted hazard ratios (HR) and their 95% confidence intervals obtained after fitting multivariate Cox regression models to estimate the effects of one month of exposure to the three main durations (CU, BF, CU&BF) on the risk of neonatal and infant mortality. As a reminder, the analytic sample is all open and closed birth intervals. Thus this analysis captures both the demographic impact of the CU and CU&BF components on reducing pregnancies, some of which may have resulted in infant deaths, as well as the health effect by reducing the risk of infant death through birth spacing. Relative to NCUBF, we see that all 3 exposure durations lower the risk of ENN mortality in one country or another; however, only in Indonesia do all 3 show a protective and statistically significant effect. Contraceptive use durations in Colombia, the Dominican Republic, Egypt, India and Indonesia lower the incidence of early neonatal, neonatal, postneonatal and infant deaths fairly consistently. Breastfeeding has the most consistent and statistically significant negative effect in reducing ENN, NN,

PNN and IM in Ethiopia and India (with the exception of ENN). By and large, the impact of contraceptive use during the birth interval is visible in countries with significant use and attenuated or embedded with breastfeeding (CU&BF) in several sub-Saharan African countries. Thus, between 1-11 months of age, all adjusted HRs show a mortality-reducing effect from contraception and overlapping contraceptive use and breastfeeding.

Again these results are visually clear in the meta-analysis performed on the country-specific coefficients, shown in Figure 5. The overall weighted effect on infant mortality risk is 0.974 for CU only, 0.975 for BF, and 0.943 for CU&BF, all pooled estimates are statistically significant at $p<0.05$. When translated to 12-months of exposure, these effects suggest that a year of contraceptive use in the absence of breastfeeding can reduce infant mortality by 31.2%, overlapping contraception and breastfeeding by 68.4% and breastfeeding alone by 30%.

In Table 4, we present the means, standard deviations and medians of the four exposure durations and overall B2P intervals when the analytic sample is limited to closed birth intervals. Overall, in comparison with the values shown in Table 1, the mean durations of BF are longer and those for CU and CU&BF are shorter. Longer periods of non-exposure to contraception or breastfeeding (NCUBF) are also visible among the birth intervals. These values suggest that the likelihood of contraceptive impact on neonatal and infant mortality within closed birth intervals is constrained by their relatively defined length, ranging across means of 24.62 months (Philippines) to 33.18 months (Zimbabwe), and

the competing influence of breastfeeding, with means ranging from 5.34 months (Dominican Republic) to 16.03 months (Nepal).

In Table 5, we show results from the multivariate Poisson regression modeling, similar to those presented earlier in Table 3, but using only the closed birth interval sample and additionally controlling for 3 prenatal interventions (tetanus toxoid immunization, malaria prophylaxis, and iron folate supplementation). What is striking in the results in this table is the sporadic statistical influence of the 3 interval components (CU, BF and CU&BF) relative to the non-exposure one (NCUBF). In India, Indonesia, and Malawi, CU&BF exhibits a statistically significant negative effect on post-neonatal and overall infant mortality and BF itself shows a negative effect on early, neonatal and infant mortality. The non-robust and adjusted patterns of influence of the CU and BF suggest that their variation within a closed birth interval may be too marginal to lengthen birth spacing appreciably.

As mentioned in describing Table 2, the distributions of intervals with contraception, as compared to breastfeeding, exposure are quite skewed. We tested natural log transformations of all duration measures and observed no difference in the results and only marginal improvement in model fit. For ease of interpretation, we have retained their original metrics in months. The skewed distributions also increase the likelihood that the standard errors for the variable coefficients are large, thus generating higher p values and fewer statistically significant IRR values.

The meta-analysis of country-level regression model results from Table 5 is graphically presented in Figure 6. The confidence intervals around each country's incidence rate ratio (IRR) estimate for all 3 main exposure durations (CU, BF, CU&BF) influencing infant mortality are much wider than when the full birth sample was analyzed. The overall weighted IRR for CU is 0.996 (95%CI= 0.99, 1.00), for BF is 0.979 (95%CI= 0.97, 0.99), and for CU&BF is 0.965 (95%CI= 0.95, 0.98). Thus the CU-only effect is not statistically significant, although that of CU&BF is so. Extrapolated over 12 months, CU&BF's conservatively estimated impact is a 42% reduction of the risk of infant mortality.

Table 6 summarizes the results from all meta-analyses for effects of CU, BF and CU&BF relative to NCUBF, on pregnancy risk and infant mortality for the full sample of all birth intervals and for infant mortality risk with the sample of only closed birth intervals (last column).

Discussion

These findings generate evidence of the benefits of contraceptive use on neonatal and infant survival, suggesting that it works through demographic and health-related pathways. In the first case, contraceptive use prevents unwanted pregnancies, some of which may have resulted in infant death. The more extensive and effective the use of contraception, the larger is the number of prevented births and premature deaths likely to be. The second pathway is through reducing the mortality risk of births born after longer interval since the preceding one. Here contraception's effect is visible and statistically robust if it overlaps with breastfeeding since durations when contraception is used

independently are relatively short within the usual 24-36 month intervals. There are some settings where the use of contraception has a significant effect within the birth interval, and these tend to be countries where overall contraceptive use is a well established behavior, e.g., Colombia, the Dominican Republic, and Indonesia.

The analyses behind Table 5 represent a conservative test of contraception's hypothesized effects on infant mortality, since the inter-birth intervals come from women with 2 or more births in the 5 years prior to the survey. These women will be the most fecund and in prime ages of childbearing. Their overall exposure time between births will be shorter on average and this constrains the number of months of extended use of contraception. The frequency of infant deaths is also, fortunately speaking, low and thus its risk sensitivity to the influence of different covariates is challenging to detect empirically. Because we do observe reduced risks for neonatal and infant mortality independently related to contraceptive use exposure, we can surmise that there are benefits from sustained use both through delayed and foregone births.

Some mention of the quality of event history data is warranted. There is significant heaping in maternal reports of dates of or ages at events, which is a well known reporting bias associated with retrospective recall. Thus the precision of the coefficients underlying the hazard and incidence rate ratios shown, as well as the standard errors and confidence intervals around the estimates, must be interpreted cautiously.

We have not characterized the quality of contraceptive practice, e.g., in terms of the use-effectiveness of methods, which can be measured over the periods of exposure. However, in the absence of also knowing the intensity and frequency of breastfeeding, periods of coital activity, nutritional intake, and presence of temporary or permanent impairments of fecundity, this information may not be additionally helpful. Our attempt to control for contraceptive use-effectiveness yielded similar results as what has been presented here. Also we observe similar average durations of CU and CU&BF intervals, which suggest that mothers in these samples were motivated to take up contraception postpartum. Postpartum abstinence traditions have been declining in sub-Saharan Africa (Benefo, 1995), and contraception may provide women with the opportunity to resume sexual activity with their partners while also continuing to breastfeed. Injectable contraception is especially popular in this region, enabling women to avoid pregnancy and demonstrate their diversion from tradition. To the extent injectables and other modern methods of contraception are being used between births to resume sexual activity, we may be observing a substitution effect of contraception in more effectively delaying the next pregnancy and lowering the risk of a subsequent infant death.

In sum, the responsible promotion of contraceptive use, as in "family planning saves lives" (Smith et al., 2009) should be based on rigorous evidence of the net effect of contraceptive use on the length of the birth-to-pregnancy interval and subsequently on infant mortality. This multi-country study has endeavored to contribute to this evidence base.

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Figure 1
Decomposition of Birth-to-Pregnancy Interval into Duration of Exposure to Breastfeeding and Contraception

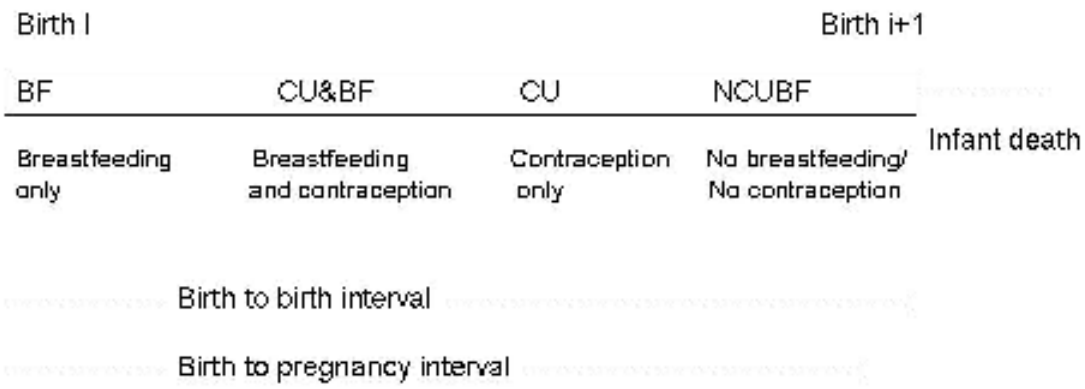
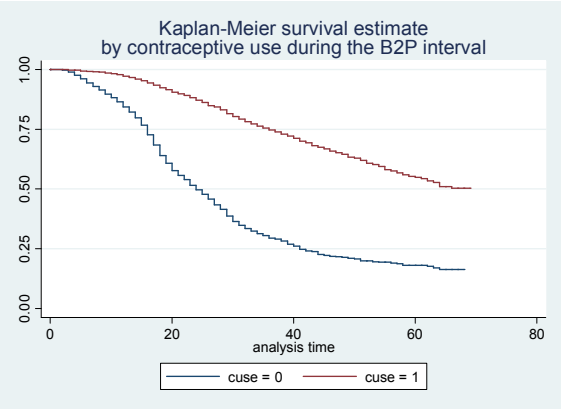
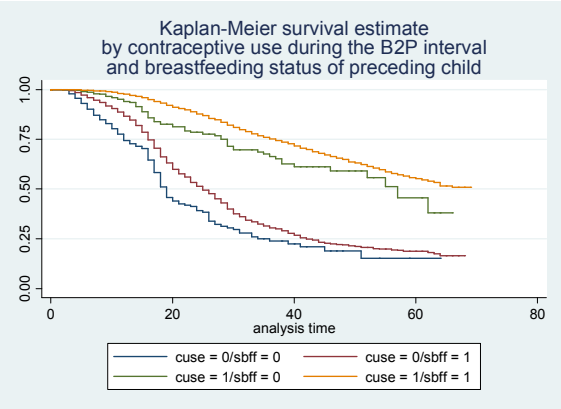


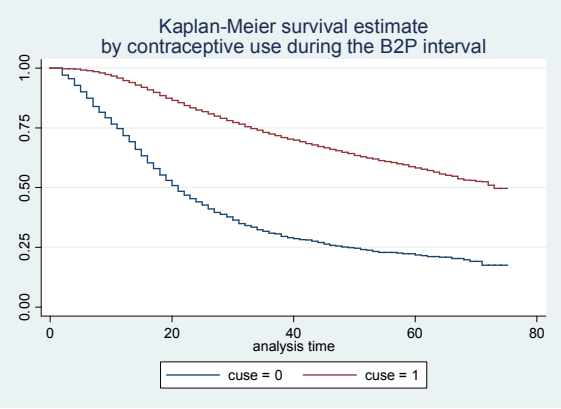
Figure 2
Kaplan-Meier Estimates of Pregnancy Risk during Birth-to-Pregnancy (B2P) Intervals
by Exposure to Breastfeeding and Contraception

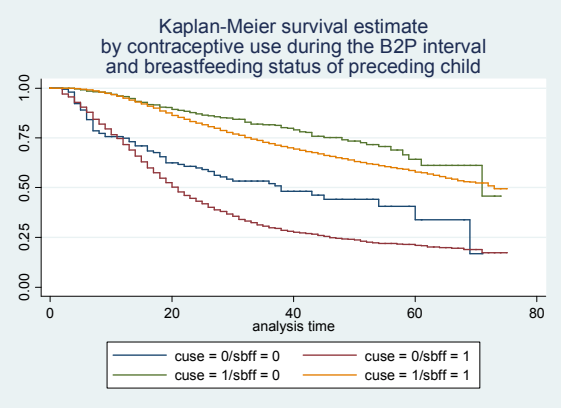
Bangladesh





Colombia





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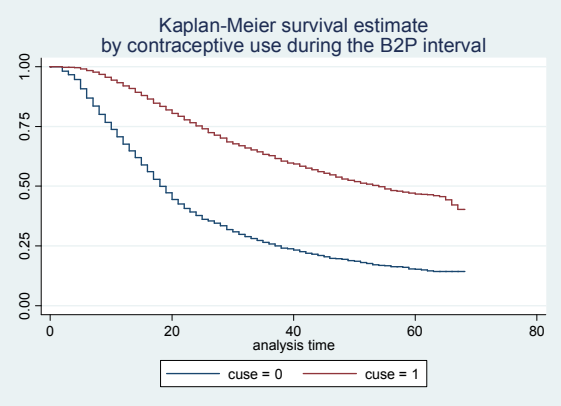

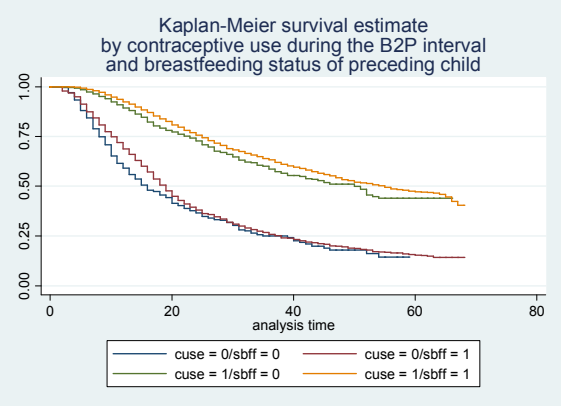

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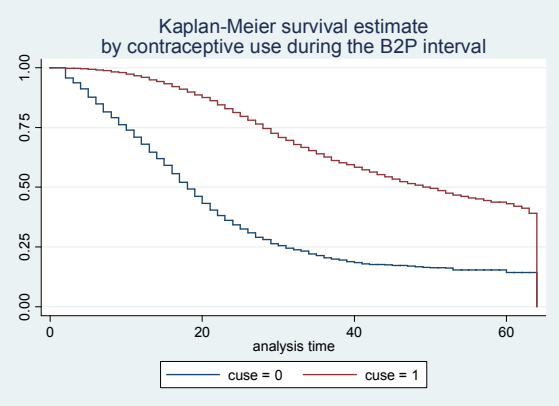

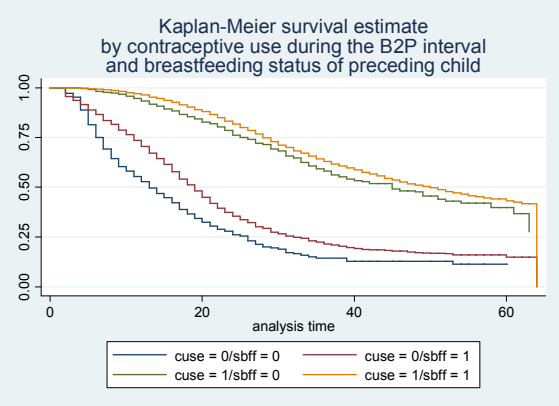

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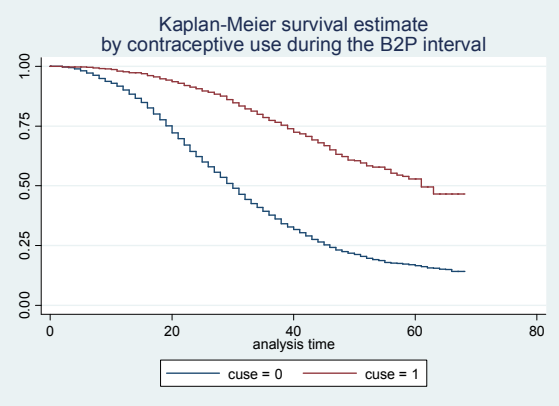

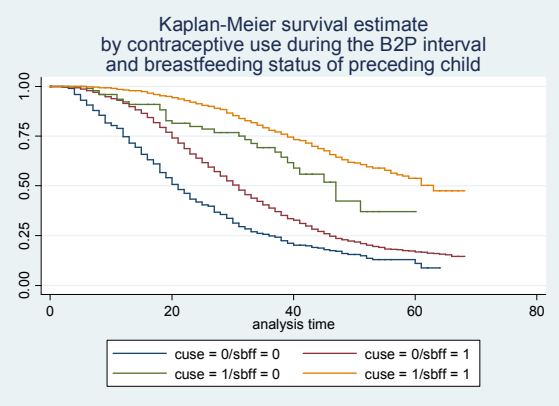

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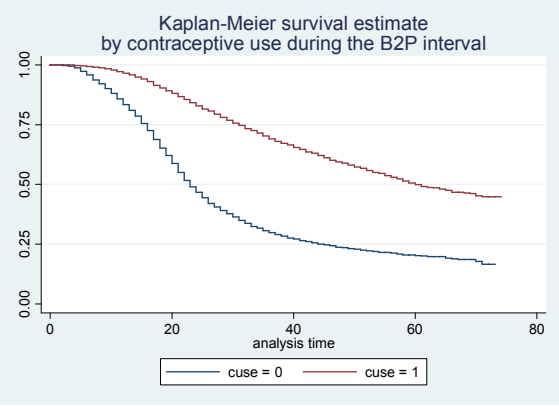

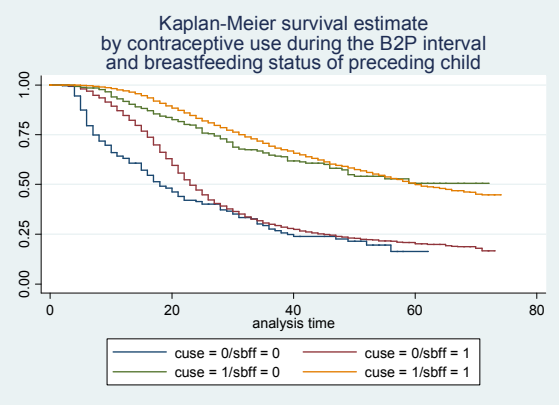

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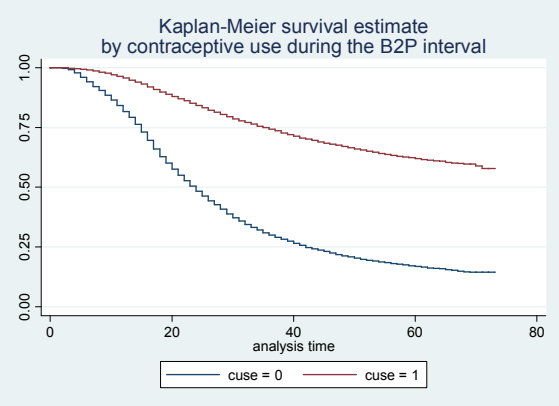

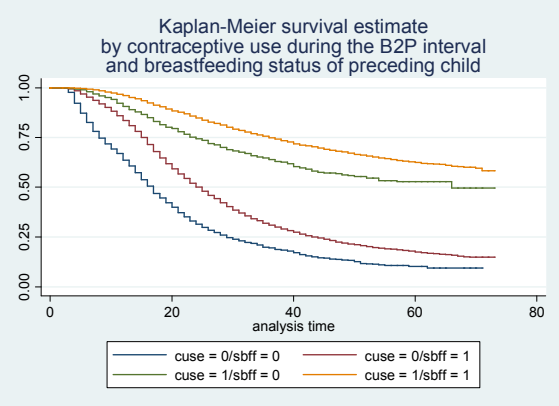

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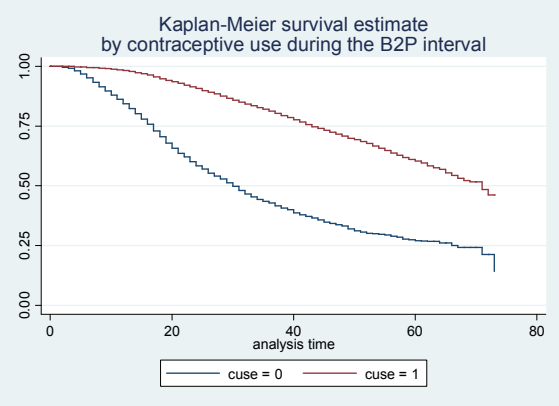

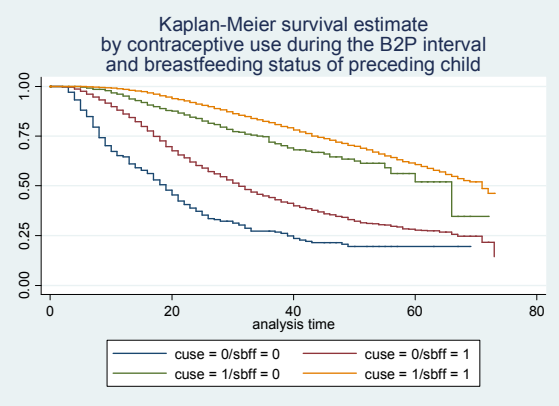

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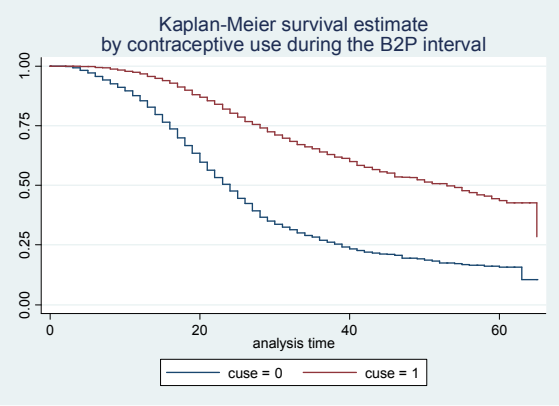

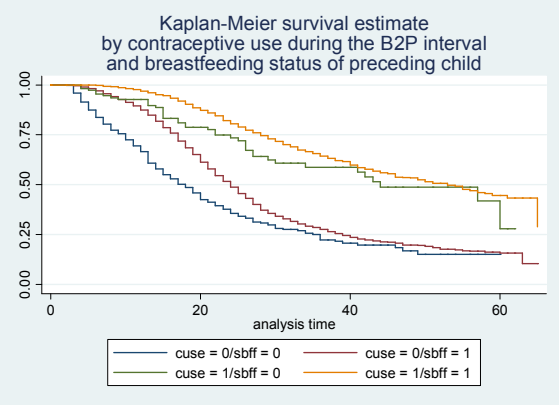

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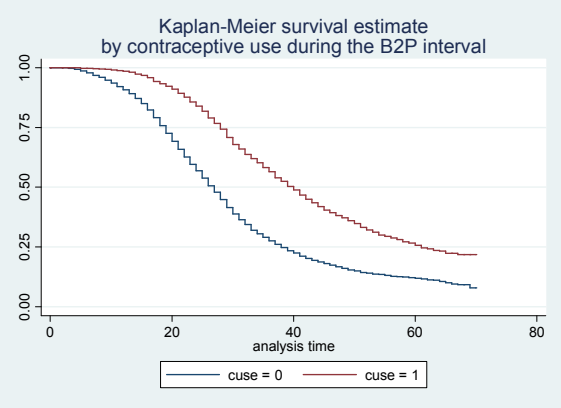

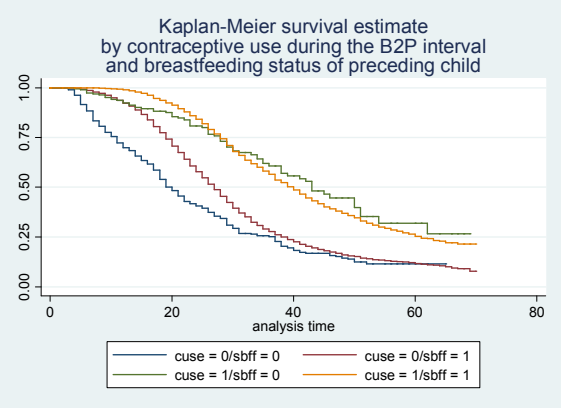

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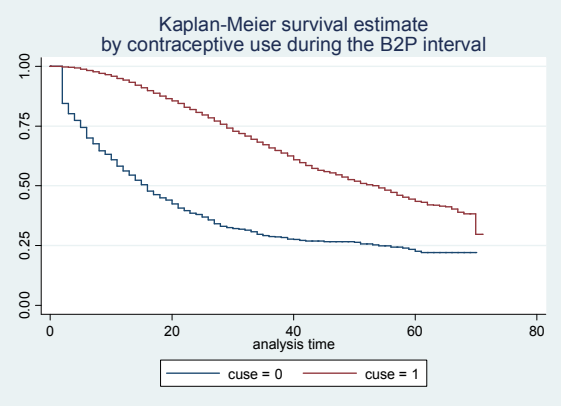

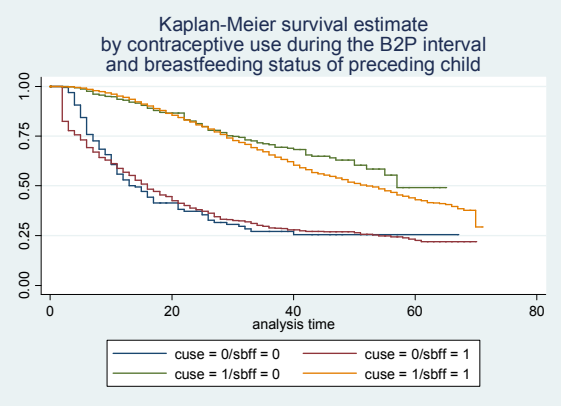

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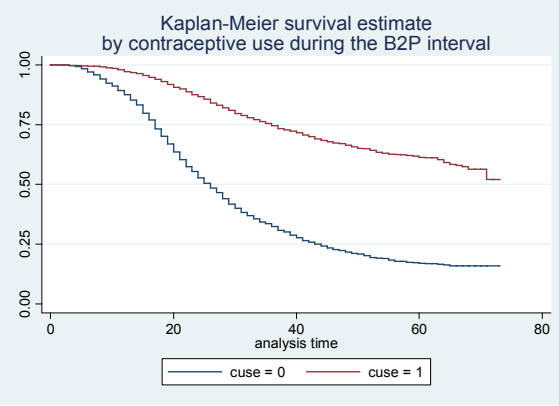

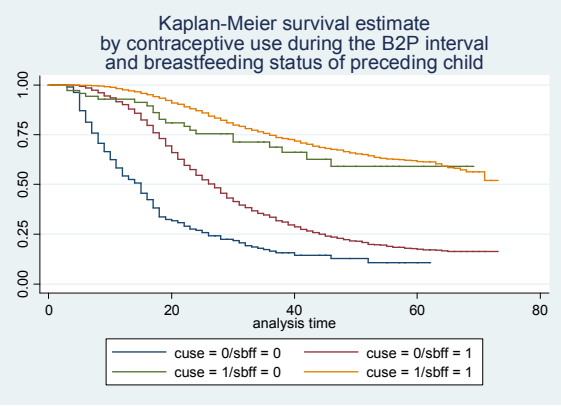

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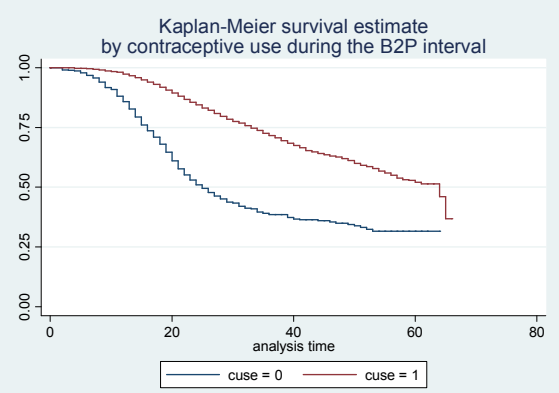
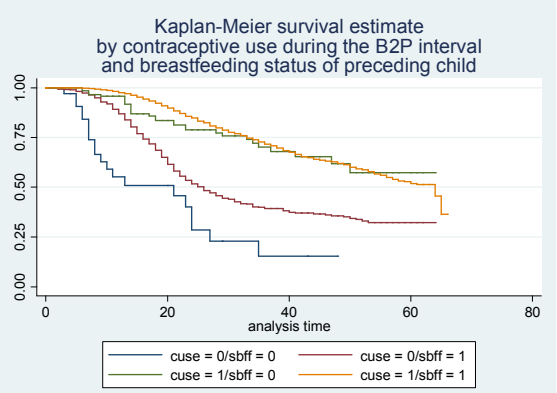
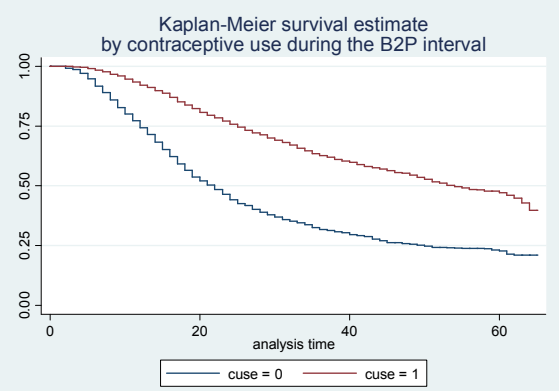
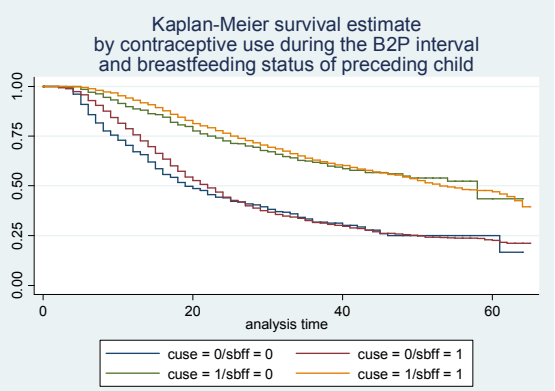


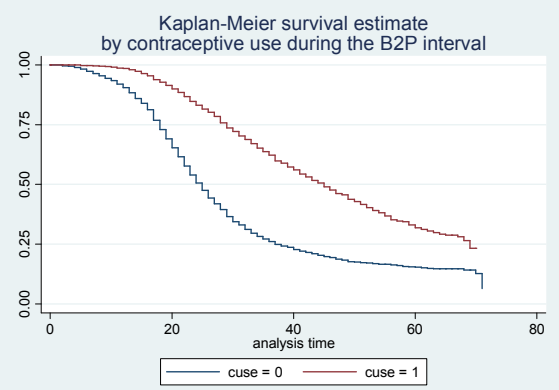


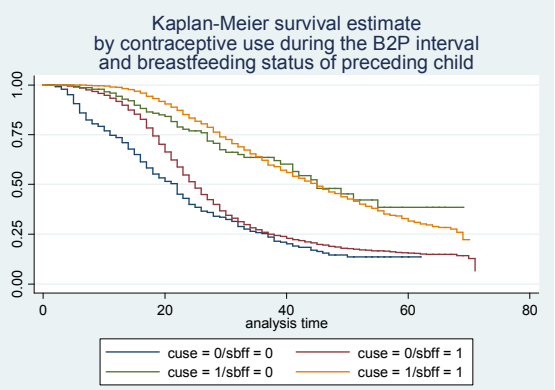
Philippines



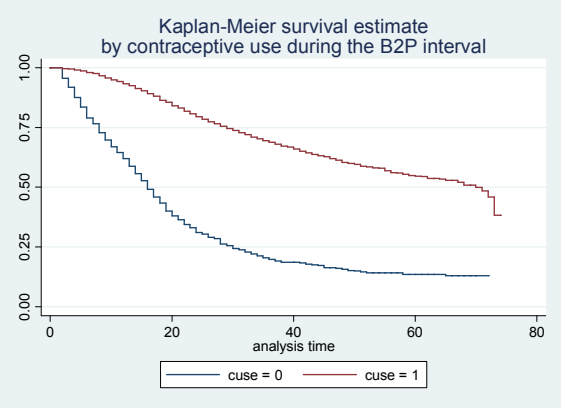


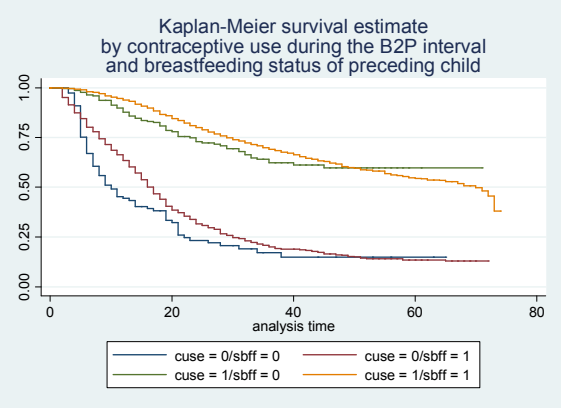
Tanzania



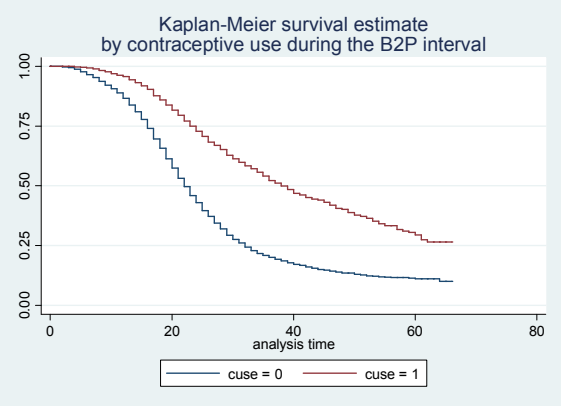


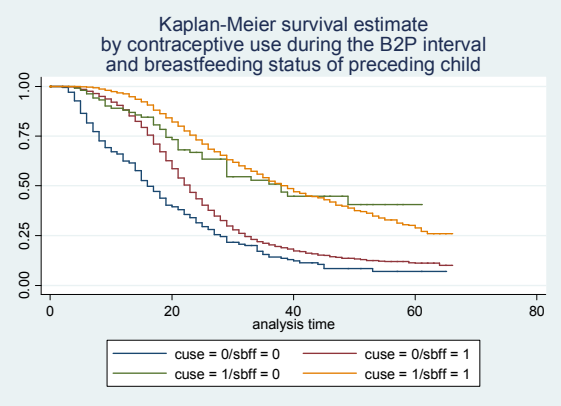
Turkey



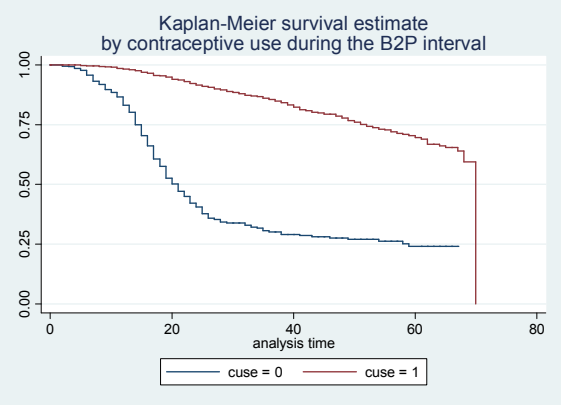


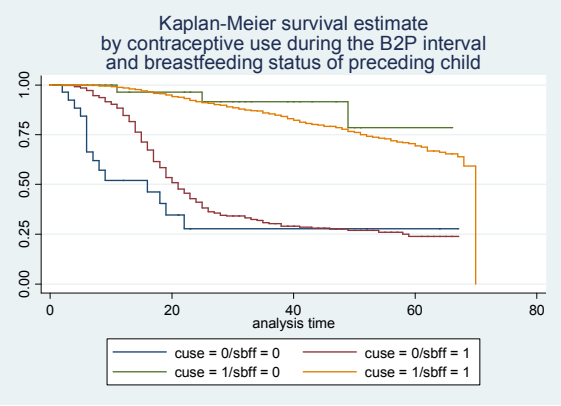
Uganda



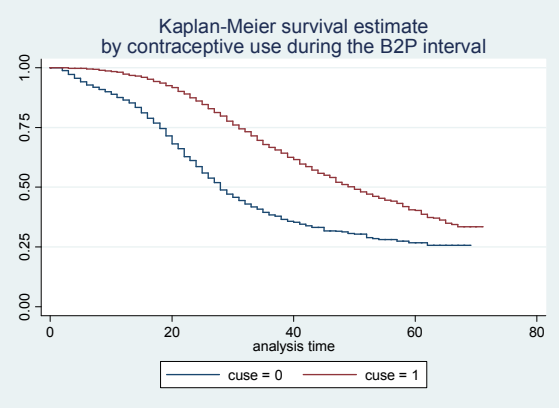


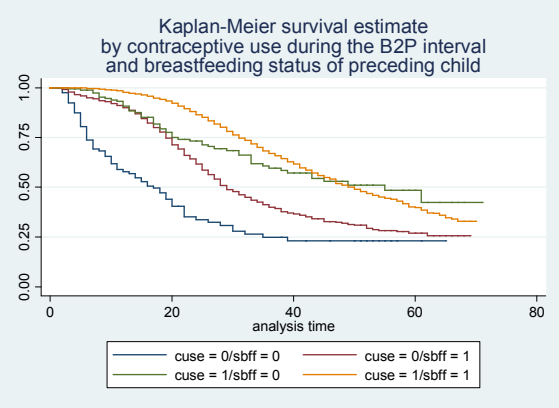
Vietnam





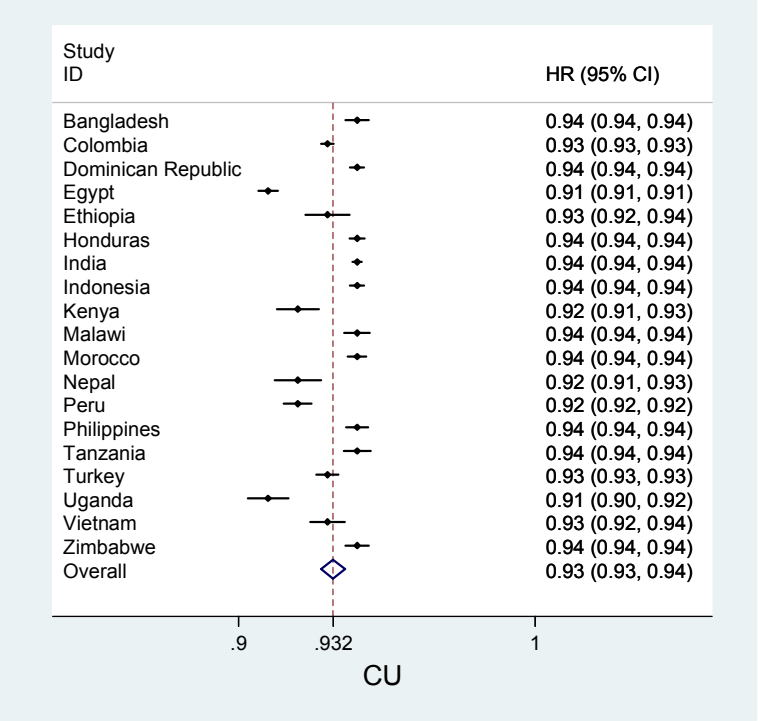
Zimbabwe

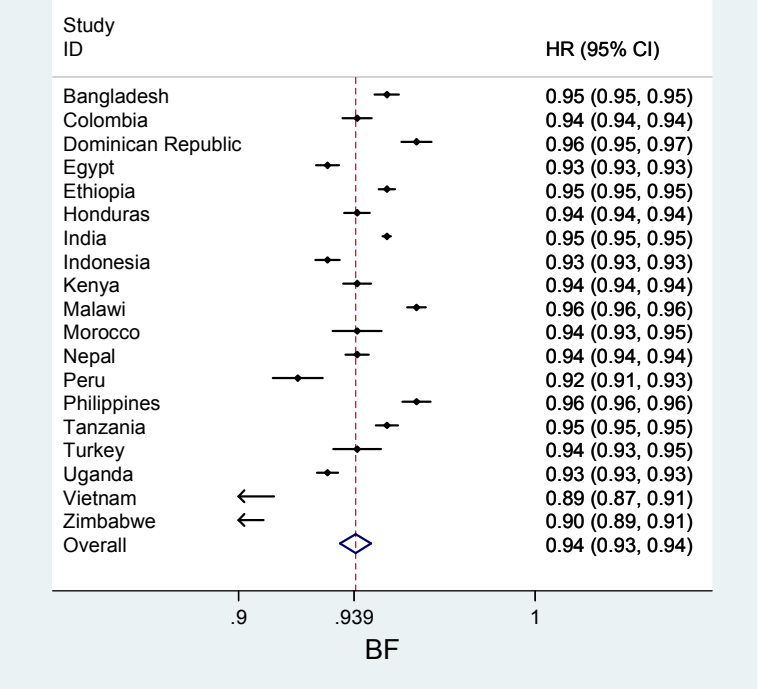


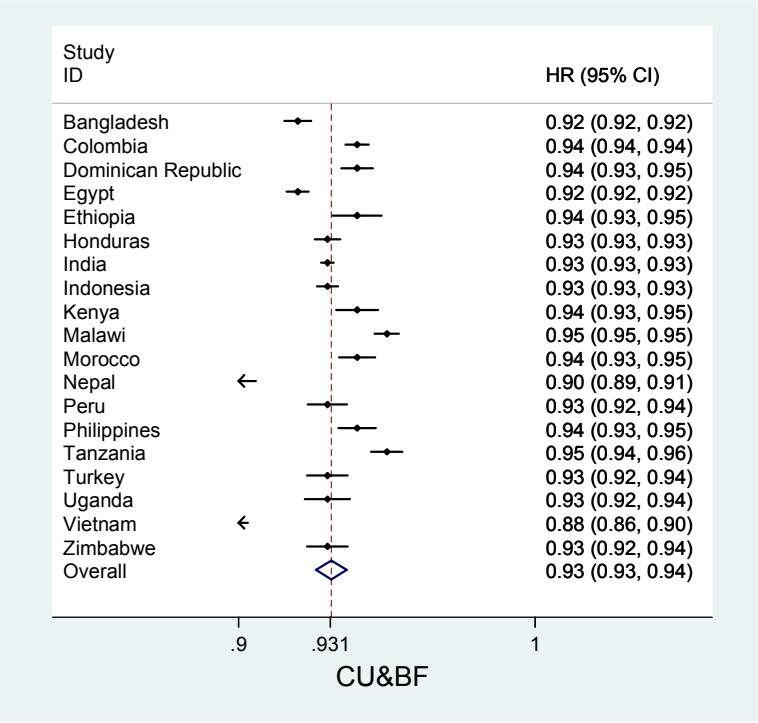


Note: The Kaplan-Meier survival estimate is the cumulative probability of a woman not becoming pregnant during birth-to-pregnancy intervals by the duration of exposure to contraceptive use alone and in combination with breastfeeding following births reported in the 5 years prior to DHS in 19 countries; all log-rank test statistics are statistically significant at $p < 0.05$ level.

Figure 3
Meta-analysis Results for Pregnancy Risk during Birth-to-Pregnancy Intervals by Exposure to Breastfeeding and Contraception



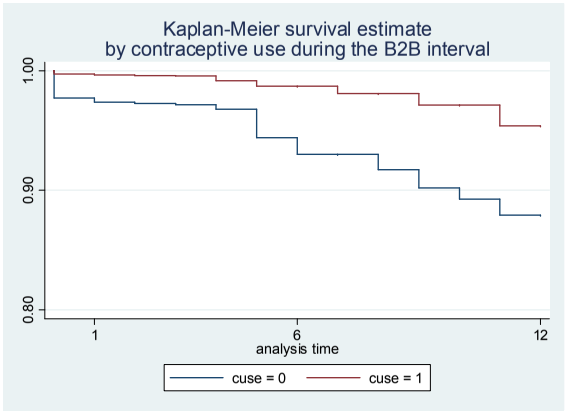




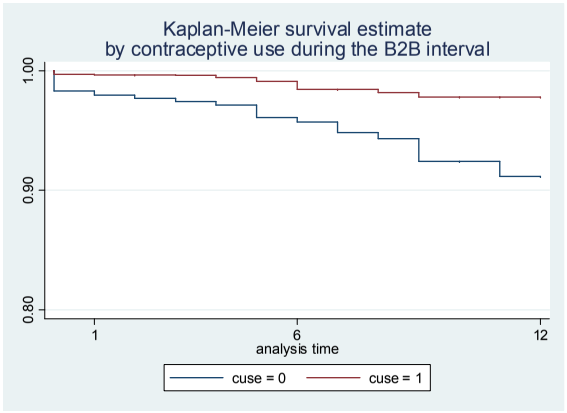
Note: CU = contraceptive use only; BF = breastfeeding only; CU&BF = overlapping breastfeeding and contraceptive use; NCUBF = no contraceptive use nor breastfeeding.

Figure 4
Kaplan-Meier Estimates for Infant Mortality by Contraceptive Use during
the Birth-to-Pregnancy (B2P) or Birth-to-Censoring (B2C) Intervals in 19 Countries

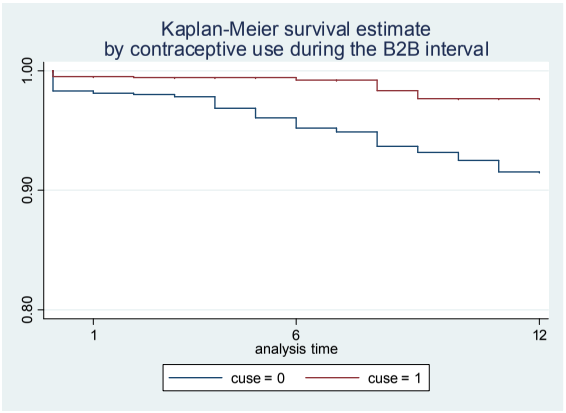
Bangladesh



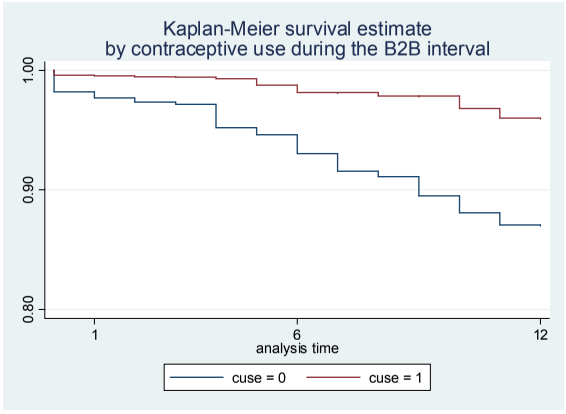
Colombia



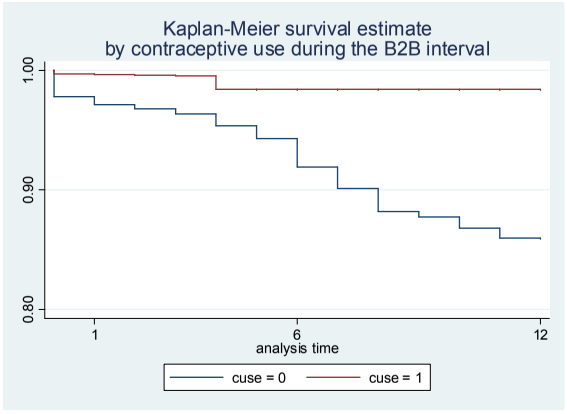
Dominican Republic



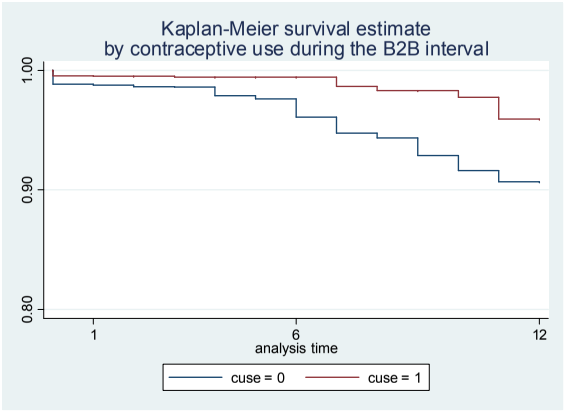
Egypt



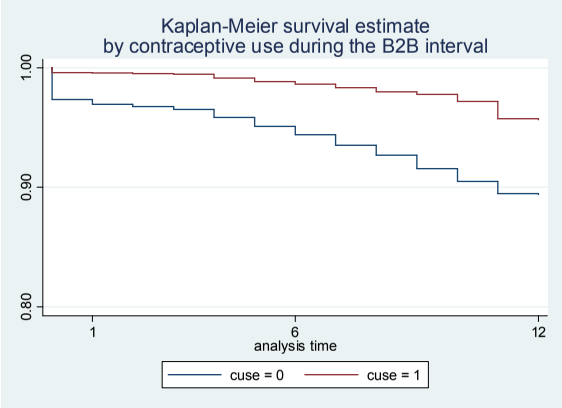
Ethiopia



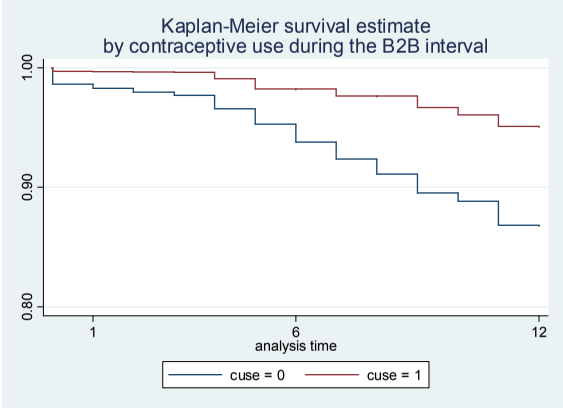
Honduras



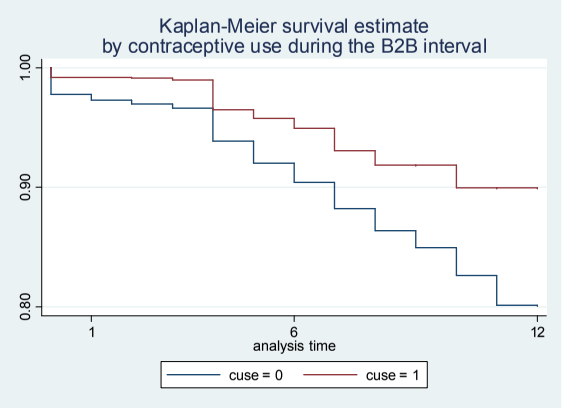
India



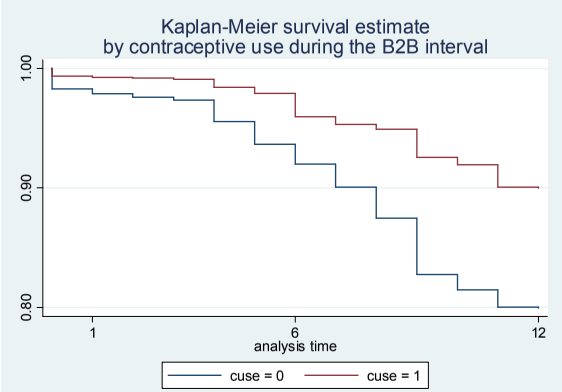
Indonesia



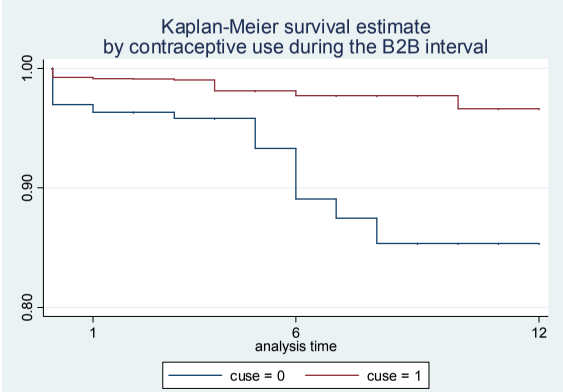
Kenya



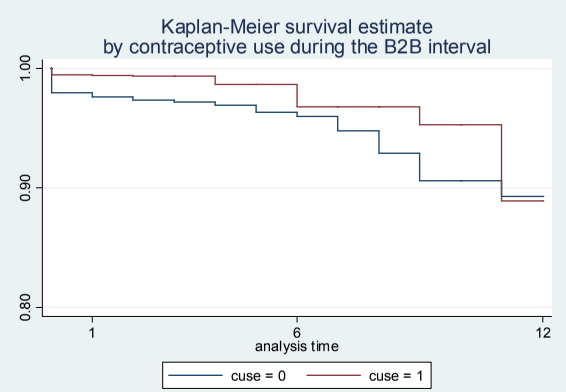
Malawi



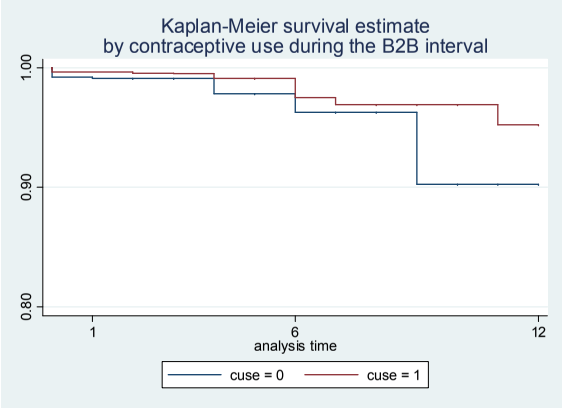
Morocco



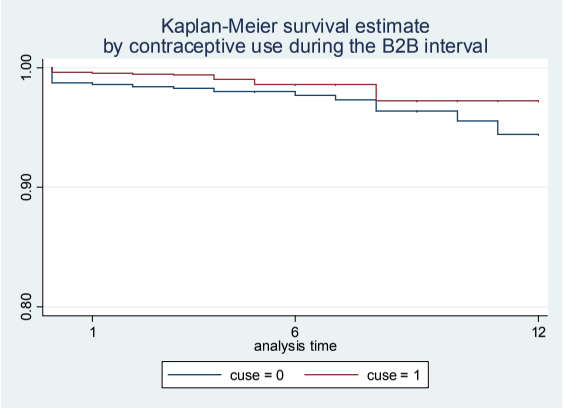
Nepal



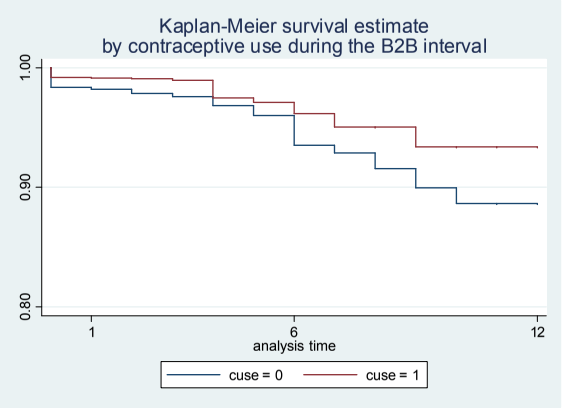
Peru*



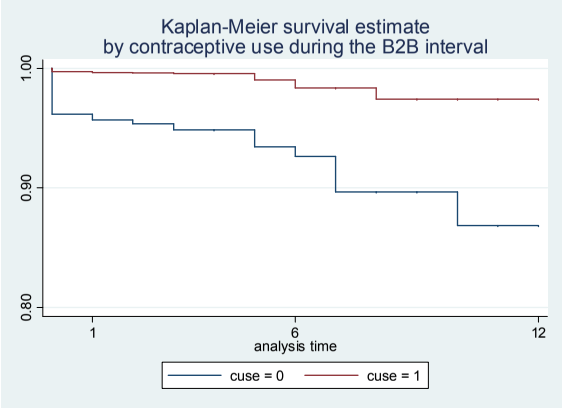
Philippines



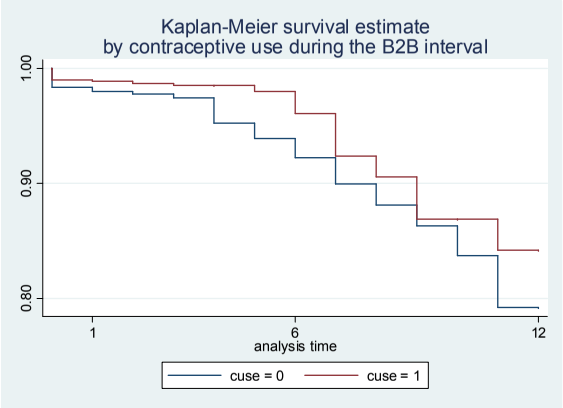
Tanzania



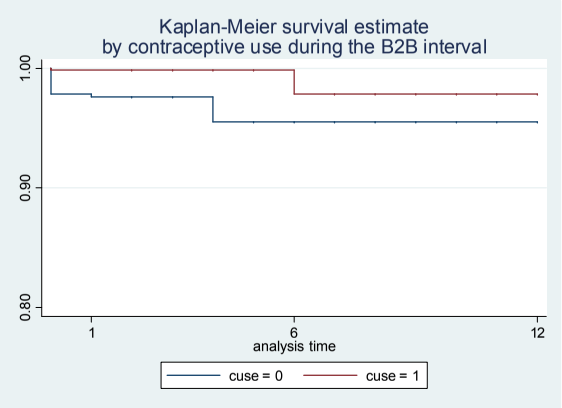
Turkey



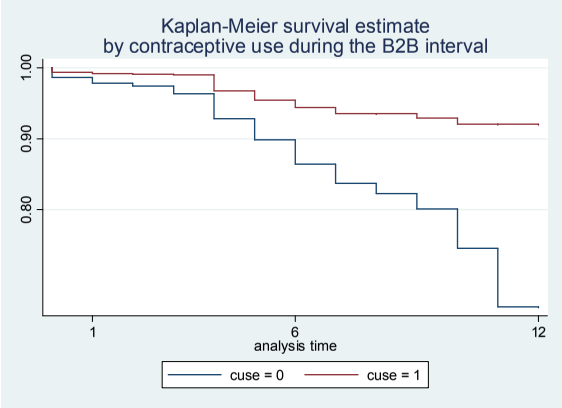
Uganda*



Vietnam*

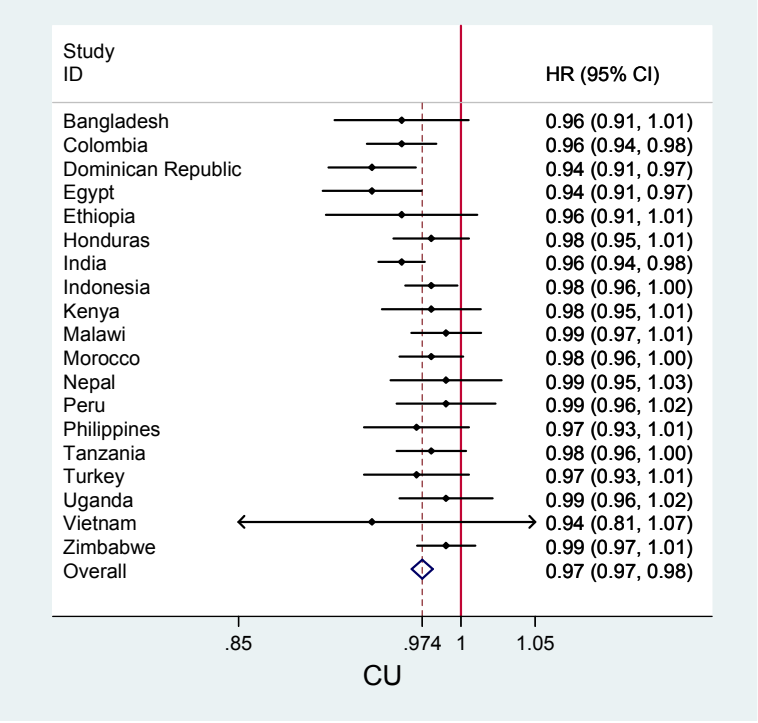


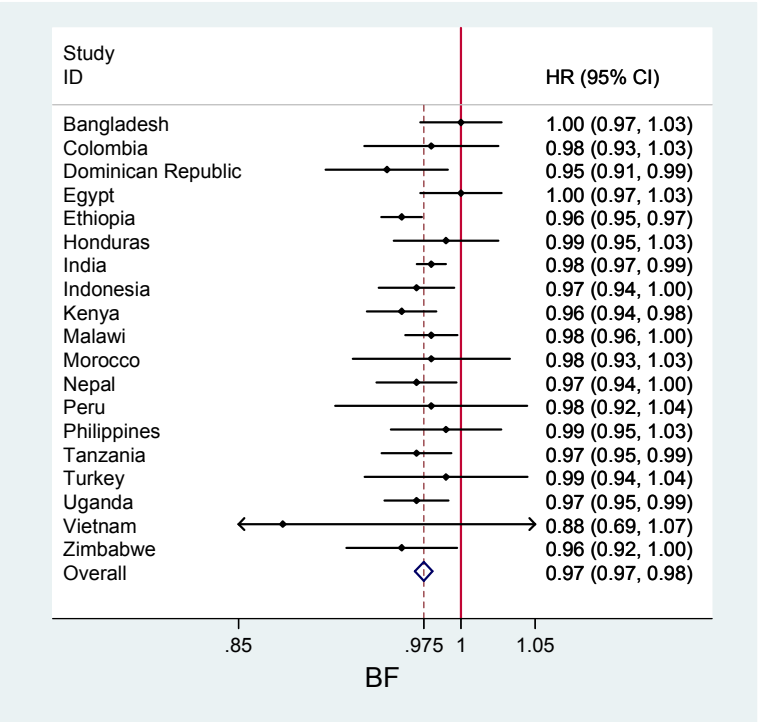
Zimbabwe

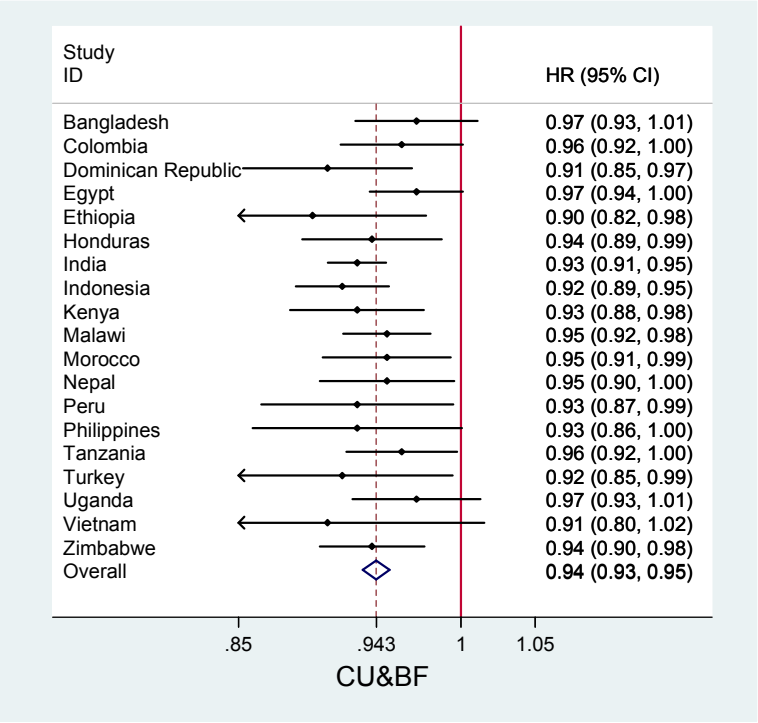


Note: * Log-rank test statistics are NOT statistically significant at $p < 0.05$.

Figure 5
Meta-analysis Results for Infant Mortality Risk during Birth-to-Pregnancy Intervals by Exposure to Breastfeeding and Contraception

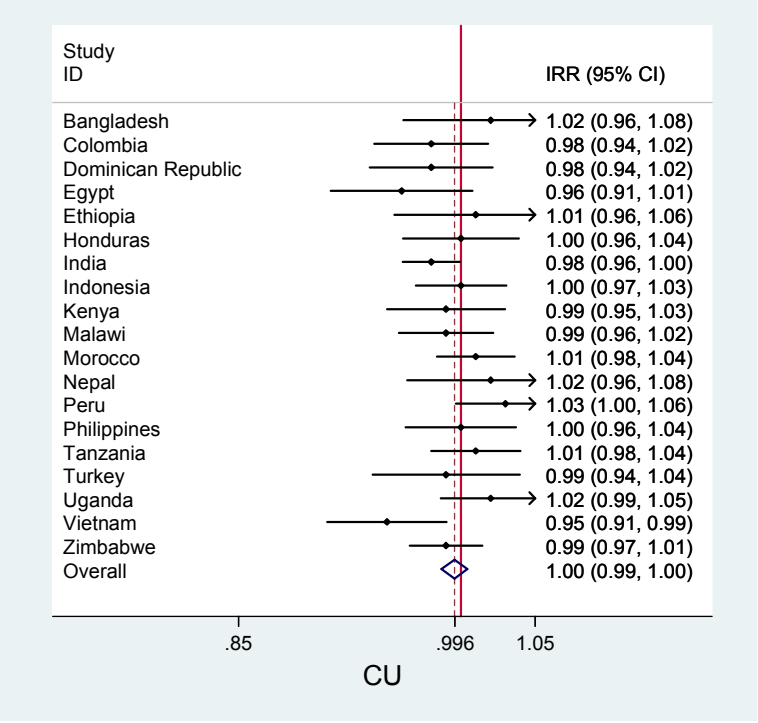


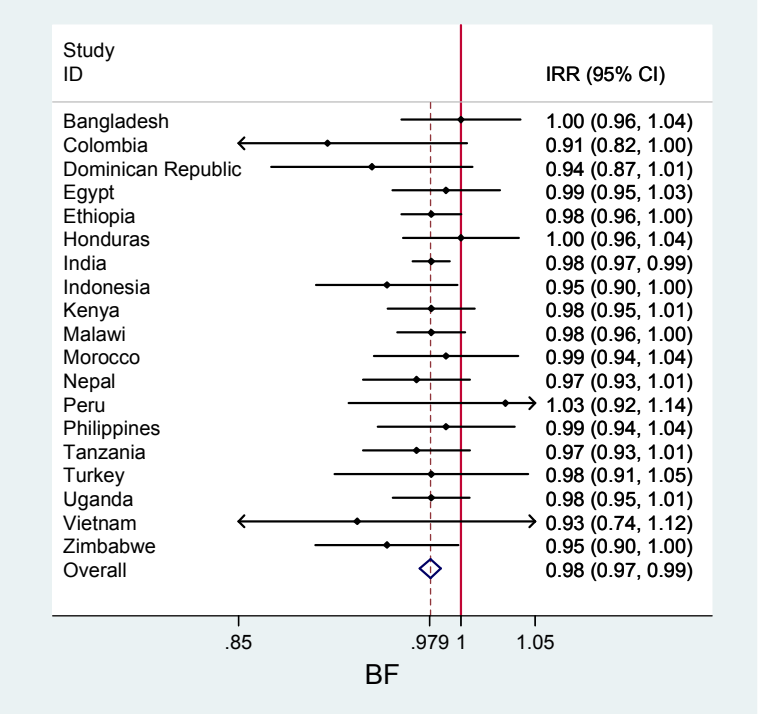


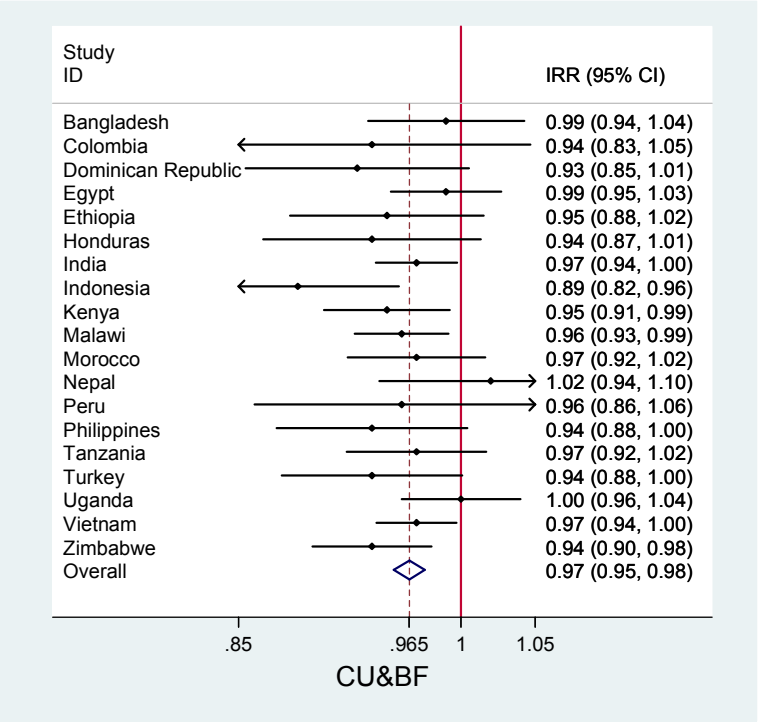


Note: CU = contraceptive use only; BF = breastfeeding only; CU&BF = overlapping breastfeeding and contraceptive use; NCUBF = no contraceptive use nor breastfeeding.

Figure 6
Meta-analysis Results for Infant Mortality
by Exposure to Breastfeeding and Contraception







Note: CU = contraceptive use only; BF = breastfeeding only; CU&BF = overlapping breastfeeding and contraceptive use; NCUBF = no contraceptive use nor breastfeeding.

Table 1
Means, Standard Deviations and Medians of Exposure Durations* and Birth-to-Pregnancy (B2P) or Birth-to-Censoring (B2C) Intervals
in the 5 Years Prior to DHS in 19 Countries

Country (N)	BF	CU	CU&BF	NCUBF	B2P/B2C
Bangladesh (8148)					
Mean (mos)	10.82	7.00	7.77	6.74	27.38
SD	9.86	12.69	10.55	9.79	16.87
Median (mos)	9	1	1	6	24
Colombia (18083)					
Mean (mos)	5.42	14.52	6.49	6.75	28.58
SD	5.54	17.98	7.85	10.84	18.86
Median (mos)	4	6	5	4	25
Dominican Republic (13162)					
Mean (mos)	4.30	12.35	3.52	9.38	24.50
SD	5.09	16.26	6.08	11.89	16.64
Median (mos)	2	5	0	6	20
Egypt (14640)					
Mean (mos)	6.14	8.24	8.29	5.82	23.92
SD	6.71	12.48	7.98	8.52	15.26
Median (mos)	3	3	7	2	21
Ethiopia (11219)					
Mean (mos)	15.26	1.55	1.43	10.71	24.38
SD	10.27	6.29	4.96	12.80	14.80
Median (mos)	13	0	0	6	22
Honduras (13652)					
Mean (mos)	8.03	10.20	5.54	8.61	27.71
SD	7.15	15.85	7.70	11.80	17.86
Median (mos)	6	1	1	5	24
India (61648)					
Mean (mos)	11.07	6.13	5.04	8.02	25.05
SD	9.11	13.16	8.94	11.58	16.56
Median (mos)	10	0	0	1	21
Indonesia (18546)					
Mean (mos)	6.69	10.79	9.04	6.65	20.03
SD	7.47	15.63	9.58	11.25	17.75
Median (mos)	3	11	8	1	27
Kenya (6391)					
Mean (mos)	10.63	3.93	3.80	8.95	22.58
SD	8.12	9.29	6.85	10.69	14.22
Median (mos)	10	0	0	6	20
Malawi (12487)					
Mean (mos)	12.05	2.81	4.05	9.67	23.80
SD	8.26	7.69	6.90	11.55	14.15

Median (mos)	11	0	0	7	22
Morocco (7174)					
Mean (mos)	3.54	14.33	6.79	6.32	26.26
SD	4.62	16.64	6.87	10.12	17.44
Median (mos)	2	8	5	1	23
Nepal (7228)					
Mean (mos)	15.80	3.59	5.31	6.91	26.61
SD	10.55	10.29	9.40	10.61	16.63
Median (mos)	15	0	0	1	23
Peru (5483)					
Mean (mos)	7.15	10.93	7.90	5.26	27.03
SD	6.59	14.61	8.52	8.35	16.26
Median (mos)	5	2	6	4	24
Philippines (8014)					
Mean (mos)	7.28	8.01	3.21	9.69	23.26
SD	7.57	13.63	6.62	12.29	15.61
Median (mos)	5	0	0	6	19
Tanzania (10173)					
Mean (mos)	12.40	3.27	2.97	28.13	24.14
SD	7.81	8.34	6.00	7.13	14.65
Median (mos)	10	0	0	20	22
Turkey (5556)					
Mean (mos)	4.52	14.73	5.84	6.32	26.47
SD	5.24	18.16	7.21	9.96	18.20
Median (mos)	2	6	4	5	23
Uganda (9367)					
Mean (mos)	12.98	2.17	1.69	9.49	21.10
SD	7.75	6.86	4.37	10.19	12.67
Median (mos)	12	0	0	8	19
Vietnam (2673)					
Mean (mos)	7.39	17.28	5.41	4.98	30.79
SD	4.35	18/68	5.28	9.36	18.53
Median (mos)	6	9	5	3	27
Zimbabwe (5967)					
Mean (mos)	9.25	10.37	5.33	7.07	27.60
SD	7.64	13.94	6.27	10.11	16.62
Median (mos)	10	3	2	3	25

Note: *Durations are: CU=contraceptive use; BF=breastfeeding; CU&BF=breastfeeding and contraceptive use; NCUBF=no contraceptive use nor breastfeeding.

Table 2
Adjusted Hazard Ratios and 95% Confidence Intervals for Exposure Durations:
Cox Regression Results for Probability of Pregnancy in 19 Countries

Country	CU exposure		BF exposure		CU&BF exposure	
	Adj HR	95% CI	Adj HR	95% CI	Adj HR	95% CI
Bangladesh	**0.94**	0.93, 0.94	**0.95**	0.95, 0.96	**0.92**	0.92, 0.93
Colombia	**0.93**	0.93, 0.94	**0.94**	0.93, 0.94	**0.94**	0.93, 0.94
Dominican Republic	**0.94**	0.94, 0.94	**0.96**	0.95, 0.96	**0.94**	0.94, 0.95
Egypt	**0.91**	0.91, 0.92	**0.93**	0.93, 0.94	**0.92**	0.91, 0.92
Ethiopia	**0.93**	0.93, 0.94	**0.95**	0.95, 0.95	**0.94**	0.93, 0.95
Honduras	**0.94**	0.94, 0.94	**0.94**	0.93, 0.94	**0.93**	0.93, 0.94
India	**0.94**	0.93, 0.94	**0.95**	0.95, 0.95	**0.93**	0.92, 0.93
Indonesia	**0.94**	0.94, 0.94	**0.93**	0.93, 0.94	**0.93**	0.92, 0.93
Kenya	**0.92**	0.92, 0.93	**0.94**	0.94, 0.95	**0.94**	0.94, 0.95
Malawi	**0.94**	0.93, 0.94	**0.96**	0.95, 0.96	**0.95**	0.95, 0.96
Morocco	**0.94**	0.93, 0.94	**0.94**	0.93, 0.95	**0.94**	0.93, 0.94
Nepal	**0.92**	0.91, 0.93	**0.94**	0.93, 0.94	**0.90**	0.89, 0.91
Peru	**0.92**	0.92, 0.93	**0.92**	0.91, 0.93	**0.93**	0.92, 0.93
Philippines	**0.94**	0.93, 0.94	**0.96**	0.95, 0.96	**0.94**	0.94, 0.95
Tanzania	**0.94**	0.93, 0.94	**0.95**	0.95, 0.95	**0.95**	0.94, 0.96
Turkey	**0.93**	0.92, 0.93	**0.94**	0.93, 0.95	**0.93**	0.92, 0.93
Uganda	**0.91**	0.90, 0.95	**0.93**	0.93, 0.94	**0.93**	0.93, 0.94
Vietnam	**0.93**	0.93, 0.94	**0.89**	0.87, 0.91	**0.88**	0.86, 0.90
Zimbabwe	**0.94**	0.93, 0.94	**0.90**	0.89, 0.91	**0.93**	0.92, 0.94

Note: Models adjusted for survival of preceding birth, parity and maternal age at start of interval, maternal education, residence, stature (height < 145 cm), and household wealth quintile. Figures in bold are statistically significant at $p < 0.05$ level.

Table 3
Adjusted Hazard Ratios and 95% Confidence Intervals for Contraceptive Use and Breastfeeding Durations:
Cox Regression Results for Probability of Neonatal and Infant Death in 19 Countries

Country/Exposure	Mortality Outcome							
	Early neonatal		Neonatal		Post neonatal		Infant	
	Adj HR	95% CI	Adj HR	95% CI	Adj HR	95% CI	Adj HR	95% CI
Bangladesh								
CU	0.98	0.93, 1.04	0.96	0.90, 1.02	0.97	0.90, 1.04	**0.96**	0.92, 1.00
BF	1.03	0.98, 1.07	1.02	0.98, 1.06	0.98	0.94, 1.02	1.00	0.97, 1.03
CU&BF	0.95	0.88, 1.03	0.96	0.90, 1.02	0.97	0.91, 1.03	0.97	0.92, 1.01
Colombia								
CU	**0.97**	0.94, 0.99	**0.96**	0.93, 0.99	**0.96**	0.92, 1.00	**0.96**	0.94, 0.98
BF	0.98	0.92, 1.05	0.98	0.93, 1.04	0.97	0.90, 1.06	0.98	0.94, 1.03
CU&BF	0.97	0.92, 1.03	0.97	0.92, 1.02	0.94	0.87, 1.02	0.96	0.92, 1.00
Dominican Republic								
CU	**0.92**	0.88, 0.97	**0.94**	0.90, 0.97	**0.96**	0.91, 1.00	**0.94**	0.91, 0.97
BF	0.94	0.86, 1.00	0.96	0.91, 1.02	0.94	0.87, 1.01	**0.95**	0.91, 0.99
CU&BF	0.94	0.87, 1.01	0.94	0.89, 1.00	0.84	0.68, 1.15	**0.91**	0.85, 0.97
Egypt								
CU	0.96	0.93, 1.00	**0.95**	0.91, 0.99	**0.91**	0.84, 0.98	**0.94**	0.90, 0.97
BF	1.01	0.96, 1.06	1.00	0.96, 1.04	0.99	0.96, 1.03	1.00	0.97, 1.03
CU&BF	0.97	0.92, 1.02	0.96	0.93, 1.01	0.97	0.93, 1.02	**0.97**	0.93, 0.99
Ethiopia								
CU	0.81	0.60, 1.10	0.93	0.86, 1.02	0.98	0.952, 1.04	0.96	0.91, 1.01
BF	**0.96**	0.94, 0.99	**0.96**	0.94, 0.98	**0.97**	0.95, 0.99	**0.96**	0.95, 0.98
CU&BF	0.82	0.64, 1.05	0.90	0.80, 1.01	0.90	0.80, 1.02	**0.90**	0.82, 0.98
Honduras								
CU	0.99	0.96, 1.02	0.99	0.96, 1.02	0.96	0.90, 1.02	0.98	0.96, 1.01
BF	0.99	0.93, 1.04	0.98	0.94, 1.03	1.00	0.95, 1.06	0.99	0.96, 1.03
CU&BF	0.96	0.90, 1.03	0.95	0.89, 1.00	0.94	0.87, 1.03	**0.94**	0.90, 0.99
India								
CU	**0.97**	0.95, 0.99	**0.96**	0.94, 0.98	**0.94**	0.91, 0.98	**0.96**	0.94, 0.97
BF	0.99	0.98, 1.00	**0.98**	0.97, 0.99	**0.98**	0.96, 0.99	**0.98**	0.97, 0.99
CU&BF	**0.93**	0.90, 0.96	**0.93**	0.90, 0.95	**0.93**	0.90, 0.97	**0.93**	0.91, 0.95

Indonesia								
CU	**0.95**	0.91, 0.99	**0.96**	0.93, 0.99	0.99	0.97, 1.02	**0.98**	0.96, 1.00
BF	**0.95**	0.91, 0.99	**0.97**	0.93, 1.00	**0.97**	0.93, 1.00	**0.97**	0.94, 0.99
CU&BF	**0.94**	0.90, 0.99	**0.94**	0.90, 0.98	**0.88**	0.83, 0.93	**0.92**	0.89, 0.95
Kenya								
CU	0.97	0.89, 1.04	0.99	0.94, 1.04	0.98	0.93, 1.03	0.98	0.95, 1.01
BF	0.97	0.91, 1.04	0.96	0.91, 1.01	0.96	0.93, 0.99	**0.96**	0.94, 0.99
CU&BF	0.94	0.84, 1.05	0.97	0.91, 1.04	0.90	0.82, 0.97	**0.93**	0.89, 0.98
Malawi								
CU	1.00	0.96, 1.04	1.00	0.97, 1.04	0.98	0.95, 1.02	0.99	0.97, 1.02
BF	0.99	0.96, 1.03	1.01	0.98, 1.04	**0.96**	0.94, 0.98	**0.98**	0.96, 0.99
CU&BF	**0.94**	0.89, 1.00	**0.94**	0.90, 0.99	**0.95**	0.91, 0.99	**0.95**	0.92, 0.98
Morocco								
CU	0.99	0.96, 1.02	0.98	0.95, 1.00	0.99	0.96, 1.03	0.98	0.96, 1.00
BF	0.95	0.86, 1.06	0.97	0.90, 1.04	1.00	0.92, 1.09	0.98	0.93, 1.04
CU&BF	0.97	0.90, 1.03	0.96	0.91, 1.01	**0.92**	0.85, 1.00	**0.95**	0.91, 0.99
Nepal								
CU	0.99	0.95, 1.05	0.99	0.94, 1.04	0.99	0.93, 1.05	0.99	0.95, 1.03
BF	0.96	0.92, 1.00	0.97	0.94, 1.01	0.96	0.92, 1.01	**0.97**	0.94, 0.99
CU&BF	0.92	0.85, 1.00	0.94	0.88, 1.00	0.97	0.91, 1.04	**0.95**	0.91, 0.99
Peru								
CU	0.98	0.93, 1.03	0.98	0.94, 1,03	0.99	0.94, 1.04	0.99	0.96, 1.02
BF	0.93	0.83, 1.05	0.98	0.90, 1.07	0.98	0.89, 1.08	0.98	0.92, 1.05
CU&BF	0.95	0.86, 1.05	0.95	0.87, 1.03	0.90	0.80, 1.02	**0.93**	0.87, 0.99
Philippines								
CU	0.97	0.92, 1.02	0.97	0.92, 1.01	0.97	0.92, 1.04	0.97	0.93, 1.01
BF	0.97	0.92, 1.03	0.99	0.94, 1.04	0.99	0.94, 1.05	0.99	0.96, 1.03
CU&BF	0.93	0.83, 1.04	0.92	0.83, 1.02	0.95	0.85, 1.05	**0.93**	0.87, 1.00
Tanzania								
CU	0.98	0.94, 1.03	0.98	0.94, 1.03	1.02	0.99, 1.06	0.98	0.95, 0.99
BF	0.96	0.92, 1.00	**0.96**	0.93, 0.99	0.99	0.95, 1.02	**0.97**	0.95, 0.99
CU&BF	0.97	0.91, 1.03	0.96	0.91, 1.01	0.97	0.91, 1.02	**0.96**	0.92, 1.00
Turkey								
CU	0.95	0.90, 1.01	**0.94**	0.89, 1.00	0.99	0.96, 1.05	0.97	0.94, 1.01
BF	0.95	0.85, 1.05	1.00	0.93, 1.07	0.99	0.92, 1.08	0.99	0.94, 1.05

CU&BF	0.94	0.85, 1.05	0.91	0.82, 1.02	0.92	0.81, 1.04	**0.92**	0.84, 0.99
Uganda								
CU	1.01	0.97, 1.05	1.00	0.97, 1.04	0.96	0.91, 1.02	0.99	0.95, 1.02
BF	0.98	0.94, 1.03	0.98	0.95, 1.02	**0.97**	0.94, 0.99	**0.97**	0.95, 0.99
CU&BF	0.99	0.92, 1.06	0.98	0.92, 1.05	0.96	0.91, 1.03	0.97	0.93, 1.01
Vietnam								
CU	NA		NA		1.04	0.91, 1.19	0.94	0.85, 1.03
BF	0.88	0.71, 1.10	0.88	0.71, 1.10	1.14	0.81, 1.45	0.95	0.80, 1.14
CU&BF	1.09	0.88, 1.34	1.09	0.88, 1.34	1.09	0.69, 1.70	0.91	0.74, 1.12
Zimbabwe								
CU	1.03	0.99, 1.06	1.02	0.99, 1.05	0.98	0.95, 1.01	0.99	0.98, 1.02
BF	1.03	0.94, 1.11	0.97	0.91, 1.05	0.96	0.92, 1.01	0.96	0.93, 1.00
CU&BF	1.01	0.94, 1.08	0.98	0.82, 1.04	**0.92**	0.88, 0.97	**0.94**	0.90, 0.97

Note: Models adjusted for survival of preceding birth, parity and maternal age at start of interval, maternal education, residence, stature (height < 145 cm), and household wealth quintile. Figures in bold are statistically significant at $p < 0.05$ level.

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Table 4
Means, Standard Deviations and Medians of Exposure Durations* and Birth-to-Birth (B2B) Closed Intervals in the Five Years Prior to DHS in 19 Countries

Country (N)	BF	CU	CU&BF	NCUBF	B2B
Bangladesh (2033)					
Mean (mos)	13.32	2.67	3.39	10.36	29.74
SD	8.44	6.69	6.15	8.74	11.58
Median (mos)	14	0	0	9	28
Colombia (4326)					
Mean (mos)	7.13	5.84	3.78	10.79	27.54
SD	4.39	9.38	4.15	8.28	12.51
Median (mos)	8	0	1	9	25
Dominican Republic (3872)					
Mean (mos)	5.34	4.90	1.98	13.32	25.53
SD	5.13	8.64	3.93	8.88	11.15
Median (mos)	4	1	0	11	24
Egypt (4173)					
Mean (mos)	8.16	3.51	5.44	9.75	26.85
SD	7.13	6.96	6.96	7.06	10.82
Median (mos)	7	0	1	9	26
Ethiopia (4074)					
Mean (mos)	14.24	0.51	0.48	14.19	29.41
SD	8.62	3.09	2.61	10.84	11.09
Median (mos)	13	0	0	12	28
Honduras (4183)					
Mean (mos)	9.44	4.66	3.03	12.56	29.68
SD	6.41	8.93	4.99	8.46	11.84
Median (mos)	10	0	0	10	28
India (18871)					
Mean (mos)	12.0	1.49	1.47	12.30	27.26
SD	7.69	5.17	4.17	9.74	10.80
Median (mos)	12	0	5.17	10	25
Indonesia (3679)					
Mean (mos)	8.32	5.21	4.68	12.64	30.85
SD	7.18	9.61	6.65	9.20	12.94
Median (mos)	7	0	0	11	28
Kenya (2084)					
Mean (mos)	11.17	1.46	2.01	12.37	27.02
SD	7.46	4.51	4.80	8.30	9.50
Median (mos)	11	0	0	10	28
Malawi (4392)					
Mean (mos)	12.86	1.92	2.60	14.18	31.56
SD	8.03	5.59	5.56	9.89	10.32
Median (mos)	12	0	0	12	31

Morocco (1802)					
Mean (mos)	4.41	8.38	4.86	9.91	27.56
SD	4.73	11.02	5.59	7.13	13.45
Median (mos)	2	3	3	9	26
Nepal (2284)					
Mean (mos)	16.03	0.82	1.58	10.69	29.11
SD	8.36	3.53	4.09	8.97	10.78
Median (mos)	17	0	0	9	27
Peru 1084)					
Mean (mos)	8.99	5.03	5.33	10.10	29.45
SD	6.43	8.15	6.64	6.18	10.29
Median (mos)	9	0	2	8	28
Philippines (2541)					
Mean (mos)	7.89	2.92	1.70	12.12	24.62
SD	6.77	6.95	4.05	8.80	10.24
Median (mos)	7	0	0	9	23
Tanzania (3680)					
Mean (mos)	12.34	1.83	1.92	13.64	29.73
SD	7.22	5.65	4.76	9.02	9.94
Median (mos)	11	0	0	11	28
Turkey (1606)					
Mean (mos)	5.84	5.67	3.20	10.60	25.33
SD	5.24	9.80	5.02	7.36	11.85
Median (mos)	4	2	0	9	23
Uganda (3695)					
Mean (mos)	12.77	0.88	0.99	12.40	27.04
SD	7.03	3.66	3.29	8.10	8.90
Median (mos)	12	0	0	11	26
Vietnam (477)					
Mean (mos)	8.95	6.59	2.59	11.37	29.51
SD	4.37	10.71	3.61	6.69	12.18
Median (mos)	11	0	0	10	26
Zimbabwe (1512)					
Mean (mos)	5.90	8.09	7.86	11.33	33.18
SD	6.37	10.52	7.16	6.96	11.89
Median (mos)	3	3	8	9	32

Note: *Durations are CU=contraceptive use; BF=breastfeeding; CU&BF=breastfeeding and contraceptive use; NCUBF=no contraceptive use nor breastfeeding.

Table 5
Adjusted Incidence Rate Ratios and 95% Confidence Intervals from Multivariate Poisson Regression Analyses of Early Neonatal, Neonatal, Post-Neonatal and Infant Deaths on Exposure Durations to Breastfeeding and Contraceptive Use during Birth-to-Birth (Closed) Intervals in 19 Countries

Country/Exposure	Mortality Outcome							
	Early neonatal		Neonatal		Post neonatal		Infant	
	Adj IRR	95% CI	Adj IRR	95% CI	Adj IRR	95% CI	Adj IRR	95% CI
Bangladesh								
CU	1.03	0.97, 1.10	1.00	0.93, 1.08	1.03	0.95, 1.11	1.02	0.94, 1.05
BF	1.05	0.98, 1.11	1.04	0.98, 1.10	0.97	0.92, 1.02	1.00	0.97, 1.05
CU&BF	1.00	0.92, 1.10	1.00	0.94, 1.08	0.97	0.89, 1.07	0.99	0.94, 1.05
Colombia								
CU	0.98	0.93, 1.04	0.98	0.93, 1.03	0.98	0.96, 1.04	0.98	0.95, 1.02
BF	0.99	0.83, 1.20	0.98	0.83, 1.15	0.87	0.75, 1.01	0.91	0.82, 1.01
CU&BF	1.07	0.89, 1.29	1.06	0.89, 1.24	**0.82**	0.70, 0.97	0.94	0.84, 1.05
Dominican Republic								
CU	0.95	0.91, 1.00	0.97	0.93, 100	1.00	0.94, 1.09	0.98	0.94, 1.02
BF	0.95	0.85, 1.06	0.96	0.89, 1.00	0.88	0.80, 1.02	0.94	0.87, 1.01
CU&BF	0.98	0.91, 1.06	0.99	0.93, 1.06	0.87	0.79, 1.03	0.93	0.86, 1.01
Egypt								
CU	1.00	0.94, 1.05	0.96	0.91, 1.02	0.94	0.87, 1.02	0.96	0.91, 1.01
BF	0.98	0.93, 1.03	0.96	0.91, 1.01	1.00	0.96, 1.05	0.99	0.95, 1.02
CU&BF	1.01	0.95, 1.08	1.00	0.95, 1.06	0.97	0.93, 1.02	0.99	0.95, 1.03
Ethiopia								
CU	0.91	0.81, 1.03	0.99	0.90, 1.09	1.03	0.97, 1.09	1.01	0.95, 1.07
BF	0.99	0.95, 1.03	0.98	0.95, 1.01	0.98	0.96, 1.01	0.98	0.96, 1.00
CU&BF	0.91	0.80, 1.03	0.98	0.91, 1.06	0.90	0.79, 1.04	0.95	0.89, 1.02
Honduras								
CU	0.99	0.95, 1.05	1.00	0.97, 1.05	0.99	0.89, 1.05	1.00	0.96, 1.04
BF	0.99	0.94, 1,07	0.99	0.94, 1.05	1.02	0.96, 1.08	1.00	0.96, 1.04
CU&BF	0.98	0.89, 1.09	0.96	0.88, 1.05	0.89	0.77, 1.04	0.94	0.87, 1.01
India								
CU	1.00	0.98, 1.03	1.00	0.98, 1.02	0.95	0.89, 1.00	0.98	0.97, 1.00
BF	0.99	0.97, 1.01	0.99	0.97, 1.00	**0.97**	0.95, 0.99	**0.98**	0.97, 0.99

CU&BF	0.97	0.94, 1.01	0.98	0.95, 1.01	0.96	0.91, 1.01	**0.97**	0.95, 1.00
Indonesia								
CU	0.96	0.89, 1.03	0.99	0.95, 1.03	1.01	0.96, 1.05	1.00	0.97, 1.03
BF	0.95	0.84, 1.07	0.95	0.87, 1.03	0.96	0.90, 1.01	**0.95**	0.91, 1.00
CU&BF	0.98	0.89, 1.08	0.93	0.84, 1.03	**0.87**	0.75, 0.92	**0.89**	0.83, 0.96
Kenya								
CU	0.98	0.91, 1.05	1.01	0.96, 1.07	0.98	0.92, 1.04	0.99	0.95, 1.03
BF	0.99	0.94, 1.06	0.98	0.93, 1.03	0.97	0.94, 1.01	0.98	0.95, 1.00
CU&BF	0.99	0.93, 1.06	1.01	0.95, 1.06	**0.89**	0.83, 0.97	**0.95**	0.91, 0.99
Malawi								
CU	0.99	0.95, 1.04	1.01	0.97, 1.05	0.98	0.94, 1.03	0.99	0.96, 1.02
BF	1.00	0.96, 1.04	1.03	0.99, 1.06	**0.96**	0.93, 0.98	0.98	0.96, 1.00
CU&BF	0.95	0.90, 1.00	0.97	0.93, 1.02	**0.96**	0.92, 0.99	**0.96**	0.93, 0.99
Morocco								
CU	1.01	0.97, 1.05	1.00	0.97, 1.04	1.02	0.97, 1.06	1.01	0.98, 1.04
BF	0.97	0.87, 1.08	0.97	0.90, 1.05	1.00	0.94, 1.07	0.99	0.94, 1.04
CU&BF	0.99	0.91, 1.07	0.99	0.93, 1.04	0.94	0.85, 1.03	0.97	0.93, 1.02
Nepal								
CU	1.05	0.98, 1.12	1.03	0.96, 1.10	1.00	0.90, 1.11	1.02	0.96, 1.08
BF	0.97	0.91, 1.03	0.97	0.92, 1.02	0.97	0.92, 1.03	0.97	0.93, 1.00
CU&BF	0.97	0.87, 1.09	1.04	0.95, 1.15	0.96	0.89, 1.05	1.01	0.94, 1.09
Peru								
CU	1.00	0.94, 1.08	1.02	0.97, 1.08	1.02	0.96, 1.08	1.03	0.99, 1.06
BF	0.92	0.80, 1.05	1.02	0.92, 1.13	0.98	0.88, 1.09	1.03	0.93, 1.14
CU&BF	0.96	0.81, 1.14	0.95	0.81, 1.10	0.91	0.81, 1.04	0.96	0.87, 1.07
Philippines								
CU	1.01	0.96, 1.07	1.01	0.97, 1.06	0.99	0.94, 1.05	1.00	0.97, 1.04
BF	0.99	0.93, 1.04	1.01	0.96, 1.06	0.99	0.91, 1.07	0.99	0.95, 1.05
CU&BF	0.93	0.84, 1.03	0.93	0.85, 1.02	0.96	0.87, 1.06	**0.94**	0.88, 1.00
Tanzania								
CU	0.98	0.93, 1.04	0.98	0.93, 1.03	1.03	0.99, 1.07	1.01	0.98, 1.04
BF	**0.94**	0.89, 0.99	**0.94**	0.89, 0.99	1.00	0.96, 1.05	**0.97**	0.94, 1.00
CU&BF	0.96	0.89, 1.03	0.94	0.88, 1.00	0.99	0.93, 1.05	0.97	0.92, 1.02
Turkey								
CU	0.98	0.89, 1.08	0.97	0.90, 1.06	0.99	0.95, 1.05	0.99	0.94, 1.04

BF	0.92	0.82, 1.03	0.99	0.90, 1.10	0.97	0.89, 1.06	0.98	0.92, 1.05
CU&BF	0.98	0.89, 1.07	0.93	0.85, 1.03	0.95	0.87, 1.04	**0.94**	0.88, 1.00
Uganda								
CU	1.06	0.99, 1.10	1.04	0.99, 1.09	0.99	0.95, 1.04	1.02	0.99, 1.06
BF	0.99	0.95, 1.04	0.99	0.96, 1.04	0.97	0.94, 1.01	0.98	0.96, 1.01
CU&BF	1.03	0.97, 1.10	1.03	0.97, 1.09	0.98	0.92, 1.04	1.00	0.96, 1.04
Vietnam*								
CU	NA		NA		1.09	0.96, 1.23	0.95	0.86, 1/06
BF	0.87	0.69, 1.09	0.87	0.69, 1.09	1.12	0.67, 1.87	0.93	0.75, 1.06
CU&BF	1.13	0.85, 1.50	1.13	0.85, 1.50	0.99	0.52, 1.89	0.97	0.74, 1.28
Zimbabwe								
CU	1.05	1.00, 1.09	1.03	0.99, 1.06	0.98	0.95, 1.01	0.99	0.97, 1.02
BF	1.05	0.95, 1.15	0.97	0.90, 1.05	0.95	0.89, 1.01	0.95	0.90, 1.00
CU&BF	1.04	0.95, 1.13	0.99	0.93, 1.06	**0.92**	0.87, 0.98	**0.94**	0.90, 0.98

Note: Boldfaced IRRs are statistically significant at $p < 0.05$. IRRs adjusted for survival of preceding birth, maternal age and parity at start of interval, maternal education and short stature (height <145 cm), residence, household wealth, prenatal malaria prophylaxis, tetanus toxoid immunization, and iron folate supplementation for index child. *DHS does not include information on malaria prophylaxis and iron supplementation; due to the low number of cases and deaths, the only model that converges is adjusted for survival of preceding birth, maternal age and parity at start of interval, maternal education and household wealth.

Table 6
Summary of Meta-analysis Results for Pregnancy Risk and Infant Mortality

Exposure	Pregnancy risk HR (95% CI)	Infant mortality HR (95% CI)	Infant mortality IRR (95% CI)
CU	0.932 (0.930, 0.940)	0.974 (0.970, 0.980)	0.996 (0.990, 1.000)*
BF	0.939 (0.930, 0.940)	0.975 (0.970, 0.980)	0.979 (0.970, 0.990)
CU & BF	0.931 (0.930, 0.940)	0.943 (0.930, 0.950)	0.965 (0.950, 0.980)

Note: *Pooled estimate is NOT statistically significant at a $p<0.05$ level. HR=hazard risk; IRR=incidence rate ratio.