The Effects of Pregnancy Spacing After a Miscarriage on Subsequent Pregnancy Outcomes: Evidence from Matlab, Bangladesh

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ABSTRACT

Objective To determine the optimum interpregnancy interval following a miscarriage and to see if findings for a poor, rural area in Bangladesh are similar to those in a recent study of Scottish women.

Design Multivariate analysis of population-based, prospective data from a demographic surveillance system (study cohort).

Setting Pregnancies in Matlab, Bangladesh, between1977 and 2008.

Participants 9,214 women with 10,453 pregnancies that ended in a miscarriage and were followed by another pregnancy outcome.

Main outcome measures Outcome of pregnancy following the miscarriage was singleton live birth, stillbirth, miscarriage, or induced abortion. For pregnancies that ended in live birth, whether the child died in first week of life, in the next three weeks, or between 29 days and one year of age.

Results Compared with interpregnancy intervals (IPIs) of 6-12 months, pregnancies that were conceived less than three months after a miscarriage were more likely to result in a live birth and less likely to result in a miscarriage (adjusted odds ratio 0.70, 95% confidence interval 0.57 to 0.86) or induced abortion (0.50, 0.29 to 0.89). Induced abortions were significantly more likely following IPIs of 18-24 months (2.36, 1.48 to 3.76), 36-48 months (2.73, 1.50 to 4.94), and more than 48 months (3.32, 1.68 to 2.95), and miscarriages were more likely following IPIs of 12-17 months (1.25, 1.01 to 1.56) and more than 48 months (1.90, 1.40 to 2.58)**.** No significant effects of IPI duration are seen on the risks of a stillbirth. These results are remarkably similar to those Love et al. found for Scottish women. However, we find a different pattern when we consider whether the infant born at the end of the IPI died: Compared to IPIs of 6-12 months, the shortest IPIs following a miscarriage (≤3 months) are associated with significantly higher late neonatal mortality (adjusted relative risk ratio 1.74, 1.06 to 2.84), and IPIs of 12-18 months are associated with a significantly lower unadjusted risk of post-neonatal mortality (0.54, 0.30 to 0.96).

Conclusions The shorter the IPI following a miscarriage, the more likely the subsequent pregnancy is to result in a live birth. However, very short IPIs may not be advisable in poor countries like Bangladesh because they are associated with a higher risk of mortality for the infants born after them.

WHAT IS ALREADY KNOWN ABOUT THIS TOPIC

Most previous studies of the effects of pregnancy spacing have considered intervals following live births

A recent study of Scottish women finds that after an initial miscarriage, women had the best pregnancy outcomes if they conceived again within six months and the worst outcomes if they didn't conceive until at least 24 months after the miscarriage

It is not known whether this is also true for women in poor developing countries

WHAT THIS STUDY ADDS

As was found in the study of Scottish women, after a miscarriage, Bangladeshi women had the best pregnancy outcomes if they conceived again within six months and the worst if they didn't conceive until at least 24 months after the miscarriage

In Bangladesh pregnancy outcomes after a miscarriage were best for even shorter intervals (≤3 months) than considered in the study of Scotland and worst for even longer intervals (>48 months)

However, patterns are different for infant survival outcomes: Compared to intervals of 6-12 months, the shortest intervals following a miscarriage (≤3 months) are associated with significantly higher late neonatal mortality, and intervals of 12-18 months are associated with a significantly lower risk post-neonatal mortality

INTRODUCTION

An article published in this journal last year[1] sought to identify the optimum interpregnancy interval (IPI) following a miscarriage. Using data on women who delivered in Scottish hospitals between 1981 and 2000, the study found that women who conceived within six months after a miscarriage had better outcomes of the subsequent pregnancy than women who waited longer to conceive again; e.g., they were less likely to have a voluntary pregnancy termination (induced abortion) or another miscarriage and were less likely to have a preterm delivery or to give birth to a low-birthweight baby. In this paper we investigate whether these same findings are seen in a very different setting – among poor women in rural Bangladesh. We also investigate whether infants born at the end of the intervals died before their first birthday. Women in Bangladesh are much more likely to be malnourished than those in Scotland,[2] and hence may be more likely to be depleted by a pregnancy, even one that ends in miscarriage. We use high-quality longitudinal data from the Matlab Demographic Surveillance System (DSS).

METHODS

We use data from the Matlab DSS. Matlab is a rural sub-district of Bangladesh that is well known for its DSS and its MCH-FP project, which operates in half of the area covered by the DSS to provide intensive and quality family planning and maternal/child health services.[3,4,5] The other half, known as Comparison Area, is typical of much of Bangladesh in contraceptive use,[6] fertility and childhood mortality,[7] and maternal mortality.[8] The MCH-FP Area has lower fertility rates[9] and lower rates of abortion,[10] miscarriage,[11] and stillbirth,[12] and greater coverage of antenatal care and better access to basic and emergency obstetric care than the Comparison Area.[9 12]

The Matlab DSS contains for both areas of Matlab longitudinal records of pregnancy and infant outcomes to household members. During their regular visits to each household, fortnightly between 1966 and 1999, monthly between 2000 and 2006, and bimonthly since 2007, the community health workers (CHWs) record pregnancy status at the time of the visit and any pregnancy outcomes or household deaths that occurred prior to the visit.

The DSS provides information on 245,091 pregnancies that occurred between 1974 and 2008. In this study we consider the 10,435 pregnancies documented in the DSS that began with a miscarriage in January 1977 or later and were followed by another pregnancy outcome (here called the "focal pregnancy") other than a multiple live birth not later than December 2008. Before 1977, the DSS did not distinguish between spontaneous and induced abortions. In the DSS, a miscarriage (spontaneous abortion) is defined as a spontaneous fetal loss prior to 28 weeks gestation. Like the Love et al. study, we exclude from the sample focal pregnancies that ended with multiple live births; 246 pregnancies are excluded for this reason.

We consider the following outcomes of the focal pregnancies that follow the IPI after a miscarriage: singleton live birth, stillbirth, miscarriage, and induced abortion. (Unlike the Scottish data, the Matlab data do not distinguish ectopic pregnancies, so we are not able to consider this outcome.) In the DSS, a *live birth* is the delivery of a live baby at any gestational age; a *stillbirth* is a fetal loss at 28 weeks or longer gestation; as noted above, a spontaneous abortion, or *miscarriage*, is a spontaneous fetal loss prior to 28 weeks; and induced abortion is self-reported. Early-gestation pregnancy termination is legal in Bangladesh if performed in a medical setting before the pregnancy is clinically confirmed. Such pregnancy terminations are done by manual vacuum aspiration by trained female paramedics at the government Health and Family Welfare Centers and are known as "menstrual regulation" or "MR". MR can be performed only within eight weeks of the last menstrual period. MR has been available through government and other medical facilities in Bangladesh since the late 1970s, when the government agreed to permit such pregnancy terminations in an effort to replace the practice of unsafe abortion. Pregnancy termination in a non-medical setting or after pregnancy is clinically confirmed is prohibited in Bangladesh except when done to save a woman's life. Our "induced abortion" category includes both MRs and voluntary pregnancy terminations by other means. (Method of pregnancy termination has been distinguished in the DSS since 1989. Since then, 52% of terminations have been by MR, 3% by D&C, and 45% by other means.) The data on induced and spontaneous abortion (miscarriage) in the DSS are likely to be of high quality and not to suffer from underreporting. In their many years of work in the community the CHWs have established themselves as trustworthy and in a good position to collect reliable information on pregnancy outcomes and, because of their frequent household visits, they are likely to elicit accurate information.[3]

The Love et al. study also considered maternal and perinatal complications (pre-eclampsia, placenta praevia, induction of labour, Caesarean delivery, pre-term delivery, very pre-term delivery, and low birthweight) for women whose pregnancies lasted at least 24 weeks. Such information is either not available in the Matlab data or is only available for subsamples too small to permit their consideration here. However, we do consider mortality of the children born in the focal pregnancies during three subperiods of the child's first year of life – early neonatal (first week of life), late neonatal (next three weeks of life), and post-neonatal (the rest of the first year of life) – which should be correlated with some of the indicators that Love et al. consider. For example, low birthweight has been widely found to be associated with mortality during infancy.[13-14] The sample for our analyses of early neonatal mortality is the 8,705 pregnancy intervals that began with a miscarriage and ended with a live birth. The sample for late neonatal mortality is the 8,401 of these that survived the first week of life and were still living in Matlab, and the sample for post-neonatal mortality is the 8,268 of these that survived the first four weeks of life and were still living in Matlab.

The duration of the IPI is defined by measuring the amount of time between the preceding miscarriage and the estimated date of conception of the focal pregnancy. For the 5,914 cases for which we know the date of the last menstrual period (DLMP), we estimate the date of conception as occurring two weeks after the DLMP before the focal pregnancy. For cases for which DLMP was not reported, we estimate the duration of the IPI as the amount of time between the miscarriage and the end of the focal pregnancy less the estimated duration of the focal pregnancy, based on the outcome of that focal pregnancy. Our estimate of duration of each type of pregnancy outcome is the average duration of all pregnancies that ended with that outcome for which we know DLMP. These averages are 36 weeks for live births, 33 weeks for stillbirths, 11 weeks for miscarriages, and 8 weeks for induced abortions. We have also done all estimation only for the cases for which DLMP was reported, and the sizes of the odds ratios are similar to those reported here.

We control for confounding factors as similar as possible to those considered by Love et al – the woman's age, a proxy for socioeconomic status (SES), and calendar year. We measure woman's age at the time of the focal outcome with a series of dichotomous indicators (age < 20, 20-24, 25-29, 30-34, 35-39, and 40+) to allow for non-linear effects. (The Love et al. article treats maternal age as a continuous variable and measures it at the time of the miscarriage that began the interval.) We measure SES by the woman's educational attainment. (We also considered the husband's education and housing size as additional measures of SES, but they never had statistically significant associations with pregnancy outcome. Love et al. use the Carstairs index as their measure of SES; such a measure is not available in our data.) We consider approximately 10-year bands of the calendar year of the focal outcome. (We used interactions to explore whether the IPI effects varied over time, but these were never statistically significant.) In addition, we control for the gravidity of the focal pregnancy (since we consider all pregnancies, whereas Love et al. considered only first pregnancies that ended in miscarriages) and for whether the woman lived in the MCH-FP Area or the Comparison Area. Data on maternal age, gravidity, area, and calendar year all come from the DSS. Information on women's education is from periodic censuses conducted by ICDDR,B in the Matlab area. Most of the potential confounders vary significantly with IPI, as can be seen in Table 1. Women's ages at both the beginnings and ends of the IPI are positively related to IPI duration, and longer IPIs are more likely to be for higher gravidity and to occur in the later years covered by the data.

Statistical analysis

We assess the effects of the duration of the IPI on the outcome of the subsequent pregnancy and on mortality during subperiods of infancy with both crude and adjusted odds ratios. The odds ratios derive from univariate and multivariate multinomial logistic regressions for the pregnancy outcomes and Cox proportional hazards models for the mortality outcomes estimated by Stata 9.0. The hazard model allows for censoring due to moving out of the Matlab area. The multivariate analyses control for the variables mentioned above. Of the women in our sample, 7,698 are represented once, and 1,516 have more than one observation (i.e., had more than one miscarriage that was followed by another pregnancy outcome). In order to adjust standard errors for the fact that we have more than one pregnancy for some women, we used the cluster command in Stata 9.0.

We consider the same categories of IPI durations considered by Love et al. -- ≤6 months (0 to 24 weeks), 6-12, months (25-52 weeks), 12-18 months (53 -76 weeks), 18-24 months (77-104 weeks), and >24 months (105 or more weeks). Like Love et al., 6-12 months is the reference category, and each category includes the upper bound but not the lower bound. We also conduct analyses that consider additional categories of IPIs, breaking the shortest Love et al. category into ≤3 months (0-12 weeks) and 4-6 months (13 -24 weeks) to assess the effects of very short intervals, and breaking the longest Love et al. category into 24-36 months, 36-48 months, and >48 months, since other studies have found different effects of such longer intervals.[15]

RESULTS

The middle of Table 2 shows the cross-tabulation of IPI duration and outcome of the focal pregnancy for the IPI categories considered by Love et al. The rows above that show the finer breakdown of the shortest IPI category considered by Love et al., and the rows below that show the finer breakdown of the longest IPI category considered by Love et al. Of the 10,435 cases in our sample, 4,596 (44.0%) conceived 6 months or less after the miscarriage (20.5% within 3 months or less and 23.5% in 4-6 months). The next largest percentage is for IPIs of 6-12 months (28.0%). The percentages for IPIs of 12-18 and 18-24 months are 9.5% and 6.5%, respectively. IPIs longer than 24 months comprise 12.0% of the sample (5.5% are 24-36 months long, 2.8% are 36-48 months, and 3.7% are longer than 48 months). We find a somewhat higher incidence of short intervals (of 12 months or less) and a somewhat lower incidence of long intervals (more than 24 months) than Love et al. find for Scottish women, but the IPI distributions are generally fairly similar, as can be seen in the right-hand column of Table 2.

Of all IPIs that began with a miscarriage, 2.1% ended with an induced abortion, 10.6% ended with another miscarriage, 3.9% ended with a stillbirth, and 83.4% ended with a live birth (Table 2). The percentage of post-miscarriage pregnancies that end with a live birth decreases as the length of the IPI increases. It is highest for the shortest IPIs (85.9% for IPI ≤6 months and 87.7% for IPI ≤3 months) and lowest for the longest IPIs (77.1% for IPI >24 months and 71.1% for IPI >48 months). The percentages for induced abortion and miscarriage each increase nearly monotonically as IPI increases, but there is little systematic pattern for stillbirths. Love et al. find a similar pattern, as can be seen in Table 2, though the incidence of stillbirth is lower in their data and the incidence of induced abortion higher than we find for Matlab, Bangladesh.

Of all IPIs that began with a miscarriage and ended with a live birth, 292 of those live-born children died in their first week of life (33.5 early neonatal deaths per 1,000 live births). Of those who survived the first week, 13.1/1,000 died in the next three weeks. And of those who survived the first four weeks, 26.6/1,000 died before their first birthday (Table 3). The patterns of how mortality varies with duration of IPI are not a smooth as those for pregnancy outcomes, but they show that the risks of mortality are often higher for the shorter IPIs and lower for the longer IPIs. The percentage of babies known to be alive at one year is below the sample average for IPI ≤3 months and above the sample average for all IPI categories of longer than 3 months and less than 36 months.

Figure 1 shows the unadjusted and adjusted odds ratios of the outcome of the focal pregnancy in our data and how they compare to those in Love et al. The patterns for Matlab are quite similar to those that Love et al. found for Scottish women. In both their study and ours the unadjusted odds of induced abortion increase monotonically as IPI duration increases, being lowest for IPIs of less than 6 months (for Matlab unadjusted OR for IPI ≤6 months = 0.59, 95% confidence interval 0.40 to 0.86, relative to IPI=6-12 months) and highest for IPIs of at least 24 months (for Matlab unadjusted OR= 3.07 [2.11 to 4.46] relative to IPI=6-12 months). The patterns are very similar in the two studies for the shortest IPIs, but the pernicious effects of long intervals on the unadjusted odds are larger for Matlab than in Scotland. Adjusting for other variables generally has more effect in our data from Matlab than it did in Love et al.'s data from Scotland. In the Matlab data, the effect of adjustment is greatest for the longest intervals, so much so that the adjusted odds ratio for IPIs of at least 24 months is slightly lower for Matlab than for Scotland.

Figure 2 shows unadjusted and adjusted odds ratios of the outcome of the focal pregnancy for our finer breakdown of IPI categories. It shows that the same patterns persist *within* the IPI ≤6 months and IPI >24 months categories, though the odds for 24-36 months are lower than those for 18-24 months. Compared with interpregnancy intervals (IPIs) of 6-12 months, pregnancies that were conceived less than three months after a miscarriage were more likely to result in a live birth and less likely to result in a miscarriage (adjusted odds ratio 0.70,

95% confidence interval 0.59 to 0.86) or induced abortion (0.50, 0.29 to 0.89). Induced abortions were more likely following IPIs of 18-24 months (2.36, 1.48 to 3.75), 36-48 months (2.73, 1.50 to 4.94), and more than 48 months (3.32, 2.05 to 5.38), and miscarriages were more likely following IPIs of 12-17 months (1.25, 1.01 to 1.56) and more than 48 months (1.90, 1.40 to 2.58). Again, adjustment has a greater effect the longer the IPI. No significant effects of IPI duration are seen on the risks of a stillbirth. These results are remarkably similar to those Love et al. found for Scottish women.

Figure 3 shows the hazard ratios of mortality during the three subperiods of infancy for our finer breakdown of IPI categories. We find no significant relationships between IPI duration and early neonatal mortality in either our unadjusted or adjusted analyses. However, for late neonatal mortality, in both the unadjusted and the adjusted analyses, we find significantly higher risk of mortality for IPIs of three months of less (adjusted relative risk ratio 1.74, 1.06 to 2.84) and generally see a decline in mortality as IPI duration increases up to 36 months. We find a significantly lower unadjusted risk of post-neonatal mortality (between the 5th and 52nd week of life) for IPIs of 12-18 months compared to those of 6-12 months (0.54, 0.30 to 0.96). (The adjusted risk ratio is nearly significant [0.56, 0.31 to 1.01].)

DISCUSSION

The shorter IPI following a miscarriage, the more likely the subsequent pregnancy is to result in a live birth. Women with IPIs of at least 18 months following a miscarriage, and especially those with intervals of at least 48 months have a much higher likelihood of having an induced abortion or experiencing another miscarriage. The odds of an induced abortion following a miscarriage are particularly high for the longest IPI category (unadjusted OR for IPI>48 months = 5.02 [3.13 to 8.03] and adjusted OR = 3.32 [2.05 to 5.38]). Adjusting for the effects of demographic and socioeconomic variables reduces the effect of long intervals on induced abortion, but they remain large and significant. No significant effects of interval duration are seen on the risks of a stillbirth.

However, although the relationships are generally not statistically significant, we see quite different patterns when we consider the effect of pregnancy spacing on early and late neonatal and post-neonatal mortality. Compared to IPIs of 6-12 months the shortest IPIs following a miscarriage (≤3 months) are associated with significantly *higher* late neonatal mortality, and IPIs of 12-18 months are associated with a significantly lower risk of post-neonatal mortality. Hence, we find some evidence that such short IPIs are associated with higher mortality between the first week and the end of the first year of life for the children born after a miscarriage. It appears that children born after very short IPIs following a miscarriage are able to survive the first week of life but then are at higher risk of dying in the rest of the first year. Our results for infant mortality (but not our and Love et al.'s findings for pregnancy outcomes) are consistent with the idea that pregnancies that result in miscarriages nutritionally deplete vital nutrients and that women require time to replete them in order to give birth to a healthy child that will survive its first year. Our finding of a pernicious effect for children but not for women is consistent with studies that show that the effects of maternal depletion can be different for the mother and the fetus, with the fetus being affected more than the mother in cases of severe nutritional deficiencies.[16]

Comparison to other studies

We have constructed our analyses to be as similar as possible to those of Love et al.[1], and our results for pregnancy outcomes are remarkably similar to theirs. As in their study of Scottish women, we find that short IPIs following a miscarriage are associated with lower risks of a subsequent miscarriage or an induced abortion in Matlab, Bangladesh, and long intervals are associated with higher risks of these outcomes. We, like they, find no significant effects of the duration of the interpregnancy interval following a miscarriage on the risk of stillbirth.

We also examine even shorter and longer IPIs durations than Love et al. do and show that the very shortest intervals we consider (≤ 3 months) are associated with the lowest risks of induced abortion and miscarriage and the longest (>48 months) are associated with the highest risks of these outcomes. For example, for the likelihood of another miscarriage, we do not see the significant "beneficial" effect of IPI ≤6 months (relative to IPI = 6-12 months) found by Love et al., but we do see a beneficial effect when we consider IPI ≤3 months (adjusted odds ratio 0.70, 95% confidence interval 0.57 to 0.86). In addition, we find stronger detrimental effects of longer IPIs than Love et al. did.

Adjusting for the effects of demographic and socioeconomic variables reduces the effects of long intervals on the likelihood of induced abortion more for Matlab than it did in Love et al.'s study of Scotland; the adjusted risk associated with intervals of more than 24 months (compared to those of 6-12 months) is slightly lower for Matlab than those Love et al. found for Scotland (whereas the opposite is true for unadjusted risks).

The Love et al. study only considers cases where the miscarriage that began the IPI was the first recorded pregnancy outcome for the woman, whereas we consider all IPIs that began with a miscarriage and control for gravidity in our analyses. This may be one reason why we find greater effects of controlling for other variables than they do. In our data there are only 2,461 first pregnancies that ended with a miscarriage. We conducted our analysis for this sample and found patterns similar to those reported here, but they were not statistically significant.

The decreasing likelihood of having a live birth following a miscarriage as duration of the preceding IPI increases is consistent with what we found in an earlier study of Matlab that considered a much smaller sample of IPIs that began with a miscarriage than that considered here.[15]

Our findings for Bangladesh, like those of Love et al. for Scotland, are consistent with the notion that most women who had a miscarriage wanted to have a live birth, and as a result many of them seek to become pregnant again as soon as possible. Over a fifth (20.5%) of the women in our sample who experienced a miscarriage and became pregnant again did so within three months of the miscarriage, and nearly half (44.0%) were pregnant within six months.

We generally find even stronger pernicious effects of long intervals on the odds of an induced abortion or miscarriage in the focal pregnancy than Love et al. did, and the effects are particularly large when we consider an expanded set of IPI categories (up to >48 months). This suggests not only that women in Matlab do not want to have long intervals, but also those who do may be selective of women in poorer health who take longer to conceive. It has also been hypothesized that one pregnancy prepares the woman's body for the next and that this "protection" decreases as time passes, making pregnancies following long interval similar to first pregnancies,[17] which have been shown to have higher risk of many poor outcomes.[18] A meta-analysis has shown that IPIs longer than 59 months are associated with adverse perinatal outcomes.[19] Other studies of Matlab have shown that women with long intervals (but not distinguishing the type of outcome with which they began) have higher risks of pregnancy complications,[20] maternal mortality,[21] and induced abortion.[15]

A study of Matlab found that short inter-outcome intervals (less than 15 months between one pregnancy outcome and the next outcome) that began with a miscarriage were associated with higher risks of early and late neonatal mortality compared with intervals of 36-59 months that began with the live birth of a child who survived.[22] However, that study did not compare them to longer inter-outcome intervals that began with a miscarriage.

Strengths and weaknesses of the study

We replicate the Love et al. study in a very different setting – poor women in rural Bangladesh. Furthermore, we examine the effects of shorter and longer intervals than considered by Love et al. We consider recent data (up to 2008) -- more recent than those considered in the Love et al. study (which covered the period 1981-2000). The Matlab DSS provides high-quality data, though there

may be some underreporting of voluntary pregnancy terminations and some misreporting of such terminations as miscarriages. The sample for our analysis (n=10,435) is smaller than that considered in the Love et al. study, but is large enough for statistical purposes.

Like Love et al. we consider effects of IPI after a miscarriage on pregnancy outcomes – live birth, stillbirth, miscarriage, and induced abortion – though we are not able to look at ectopic pregnancies as they do. Love et al. also found a positive association of the duration of the IPI with the incidence of ectopic pregnancy, caesarean section, preterm delivery, and low birth weight. As noted above, we do not have these indicators in our data. However, unlike Love et al., for IPIs that end in live births, we look at the mortality of those children during three subperiods of infancy.

Like Love et al. we do not consider some possibly confounding variables that may affect the outcomes of interest, e.g., use and quality of prenatal care and the woman's health and fecundity.

Implications for research

This study is of a setting -- rural Bangladesh -- with relatively high, but rapidly falling, fertility and infant mortality, and one half of the area studied has been exposed to more intense, higher-quality family planning services than are available in most developing countries. The study should be replicated in other settings. Future studies should control for the effects of potentially confounding variables and should assess the effects of the durations of IPIs following miscarriages on the health and survival of the children born at the end of those intervals as well as on those of their mothers.

Implications for clinical practice

Our results from Matlab, Bangladesh, are very similar to those of Love et al. for Scotland in finding no adverse pregnancy outcomes if women become pregnant soon after a miscarriage. However, we find that very short intervals following a miscarriage are associated with higher mortality risks for infants, which suggests that, for the sake of child survival, in less developed settings it may be best for women to wait to become pregnant again following as miscarriage. Steer noted a similar concern in a recent editorial in BJOG.[23]

In developed settings, such as that considered in the Love et al. study, there is concern that postponing pregnancies after a miscarriages may lead to difficulties in conceiving and greater probabilities of miscarriage because of older women's age. This is less of a concern in poor countries such a Bangladesh, where women begin (and often end) childbearing at earlier ages than in more developed countries.

Conclusion

Women who conceive within three months of a miscarriage are more likely to have the subsequent pregnancy result in a live birth. However, the children born after IPIs that began with a miscarriage are more likely to die in infancy if the IPI was short.

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Contributors: JD conceived the study, oversaw the data analysis, and wrote the paper. LH conducted the data analysis. MR designed the data file construction and assisted with the writing of the paper. AR oversaw the construction of the initial data file.

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Ethical approval: Formal ethical review was not necessary for this study because only anonymised data were analyzed. The data file was created based on records of the Matlab Demographic Surveillance System (DSS) of ICDDR,B. DSS data collection and management procedures are approved by the ICDDR,B Ethical Review Committee.
Data sharing: No additional data are available. Permission of ICDDR,B may be sought to use Matlab DSS data for specific research questions.

Table 1. Demographic characteristics of the sample, by IPI

IPI duration	Mother's age at miscarriage at beginning of IPI (s.d.)	Mother's age at outcome at end of IPI (s.d.)	MCH-FP Area (%)	Woman has no education (%)*	Gravida =2 (%)	*Year* 1977-1990 (%)	1991-2000 (%)	2001-2008 (%)	n
≤3 mos.	24.9 (5.8)	25.6 (5.8)	44.3	51.0	27.7	46.3	25.1	28.6	2,138
3-6 mos.	25.5 (6.1)	26.5 (6.0)	45.1	54.0	23.8	50.2	25.3	24.6	2,458
≤6 mos.	25.2 (6.0)	26.1 (6.0)	44.7	52.6	25.6	48.3	25.1	26.5	4,596
6-12 mos.	25.9 (6.4)	27.2 (6.4)	43.4	53.8	24.4	48.0	27.8	24.1	2,920
12-18 mos.	26.7 (6.7)	28.5 (6.7)	45.9	51.1	21.3	44.5	27.3	28.1	988
18-24 mos.	26.9 (6.8)	29.2 (6.7)	46.8	50.3	21.0	37.9	30.5	31.7	676
>24 mos.	27.0 (6.5)	31.5 (6.5)	46.7	50.0	17.4	29.9	34.3	35.8	1,255
24-36 mos.	27.4 (6.8)	30.5 (6.7)	46.6	50.3	17.4	33.2	32.3	34.5	579
36-48 mos.	27.0 (6.5)	31.1 (6.4)	48.6	45.9	18.8	33.2	29.8	37.0	292
>48 mos.	26.5 (6.0)	33.4 (6.0)	45.3	52.6	16.2	22.4	40.9	36.7	384
Total	25.9 (6.3)	27.5 (6.5)	44.8	52.4	23.5	45.0	27.6	27.4	10,435
Significance of differences across expanded IPI categories	P<0.001	P<0.001	ns	P=0.064	P<0.001	P<0.001	P<0.001	P<0.001	

ns = Not significant

* Among those with non-missing values. Education is not reported for 347 cases.

Table 2. Outcomes of subsequent pregnancy after miscarriage in previous pregnancy, by Interpregnancy Interval (IPI) (n=10,435)

	Outcome of Subsequent Pregnancy						
IPI duration	**Abortion**	**Miscarriage**	**Stillbirth**	**Live Birth**	**Total**	**Col. %**	
≤3 mos.	16	160	87	1,875	2,138	20.5	
(%)	(0.8)	(7.5)	(4.1)	(87.7)	(100.0)		
3-6 mos.	33	262	89	2,074	2,458	23.5	
(%)	(1.3)	(10.7)	(3.6)	(84.4)	(100.0)		
							Love et al. Col. %
≤6 mos.	49	422	176	3,949	4,596	44.0	41.2
(%)	(1.1)	(9.2)	(3.8)	(85.9)	(100.0)		
6-12 mos.	52	302	114	2,452	2,920	28.0	25.2
(%)	(1.8)	(10.3)	(3.9)	(84.0)	(100.0)		
12-18 mos.	25	125	45	793	988	9.5	9.6
(%)	(2.5)	(12.7)	(4.6)	(80.3)	(100.0)		
18-24 mos.	32	81	20	543	676	6.5	6.4
(%)	(4.7)	(12.0)	(3.0)	(80.3)	(100.0)		
>24 mos.	63	173	51	968	1,255	12.0	17.6
(%)	(5.0)	(13.8)	(4.1)	(77.1)	(100.0)		
Total	221	1,103	406	8,705	10,435	100.0	100.0
(%)	(2.1)	(10.6)	(3.9)	(83.4)	(100.0)		
% in Love et al.	(4.9)	(11.7)	(0.6)	(80.3)	(97.5)*		
24-36 mos.	15	66	29	469	578	5.5	
(%)	(2.6)	(11.4)	(5.0)	(81.1)	(100.0)		
36-48 mos.	19	38	9	226	290	2.8	
(%)	(6.5)	(13.1)	(3.1)	(77.9)	(100.0)		
>48	29	69	13	273	384	3.7	
(%)	(7.6)	(18.0)	(3.4)	(71.1)	100.0		

* The Love et al. numbers do not add to 100% because their data also included ectopic pregnancies (0.8% of all outcomes) and "other" outcomes (1.7% of all outcomes).

Table 3. Mortality outcomes after miscarriage in previous pregnancy, by Interpregnancy Interval (IPI) among all live births (n=8,705) (Mortality rates are calculated using denominator for infants alive and in Matlab at the beginning of the interval. [A total of 284 migrated out before age 1.])

	Child's age at death						
IPI duration	**First week**	**Week 2-4**	**Week 5-52**	**Known alive at 1 Year**	**Migrated out before Year 1**	**Total births**	**Col. %**
≤3 mos.	67	37	49	1,647	75	1,875	21.5
(%)	(3.6)	(2.0)	(2.6)	(87.8)	(4.0)	(100.0)	
3-6 mos.	64	26	54	1,868	62	2,074	23.8
(%)	(3.1)	(1.3)	(2.6)	(90.1)	(2.9)	(100.0)	
6-12 mos.	81	28	75	2,196	72	2,452	28.2
(%)	(3.3)	(1.1)	(3.1)	(89.6)	(2.9)	(100.0)	
12-18 mos.	31	8	13	714	27	793	9.1
(%)	(3.9)	(1.0)	(1.6)	(90.0)	(3.4)	(100.0)	
18-24 mos.	18	5	12	496	12	543	6.2
(%)	(3.3)	(0.9)	(2.2)	(91.3)	(2.2)	(100.0)	
24-36 mos.	16	2	7	438	16	469	5.4
(%)	(3.4)	(0.4)	(1.5)	(93.4)	(3.4)	(100.0)	
36-48 mos.	6	2	6	207	5	226	2.6
(%)	(2.7)	(0.8)	(2.7)	(91.5)	(2.2)	(100.0)	
>48	9	2	4	243	15	273	3.1
(%)	(3.3)	(0.7)	(1.5)	(89.0)	(5.5)	(100.0)	
Total	292	110	220	7,799	284	8,705	
(%)	(3.4)	(1.3)	(2.5)	(89.5)	(3.6)	100.0	
Rate per 1,000 at risk	33.5	13.1	26.6				

Figure 1. Relative risk ratios of induced abortion, miscarriage, and stillbirth following a miscarriage by IPI duration: unadjusted and adjusted results from Matlab and Love et al. (2010) (Note: Solid symbols indicate p <0.05)

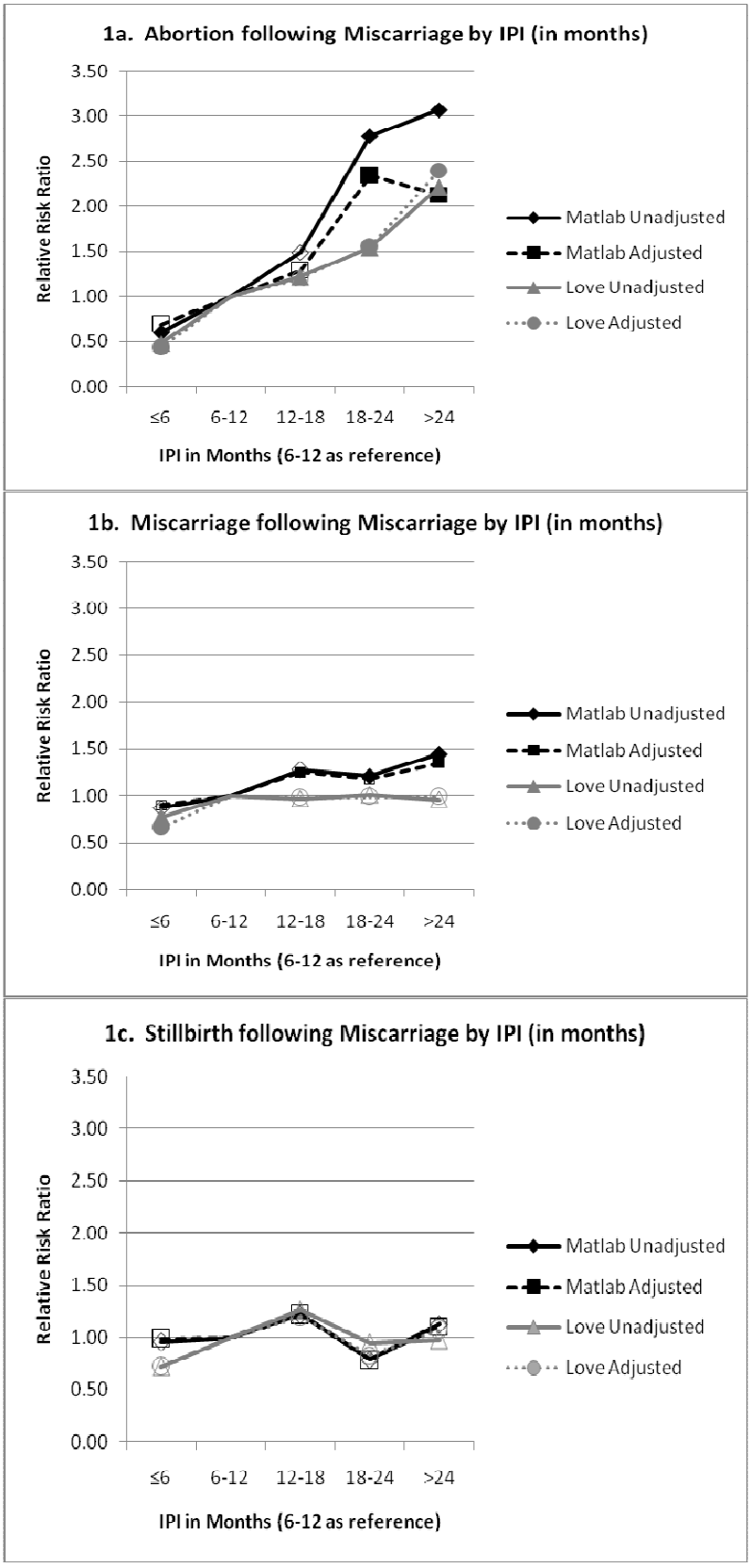


Figure 2. Relative risk ratios of induced abortion, miscarriage, and stillbirth following a miscarriage by expanded IPI categories: unadjusted and adjusted results for Matlab (Note: Solid symbols indicate $p < 0.05$)

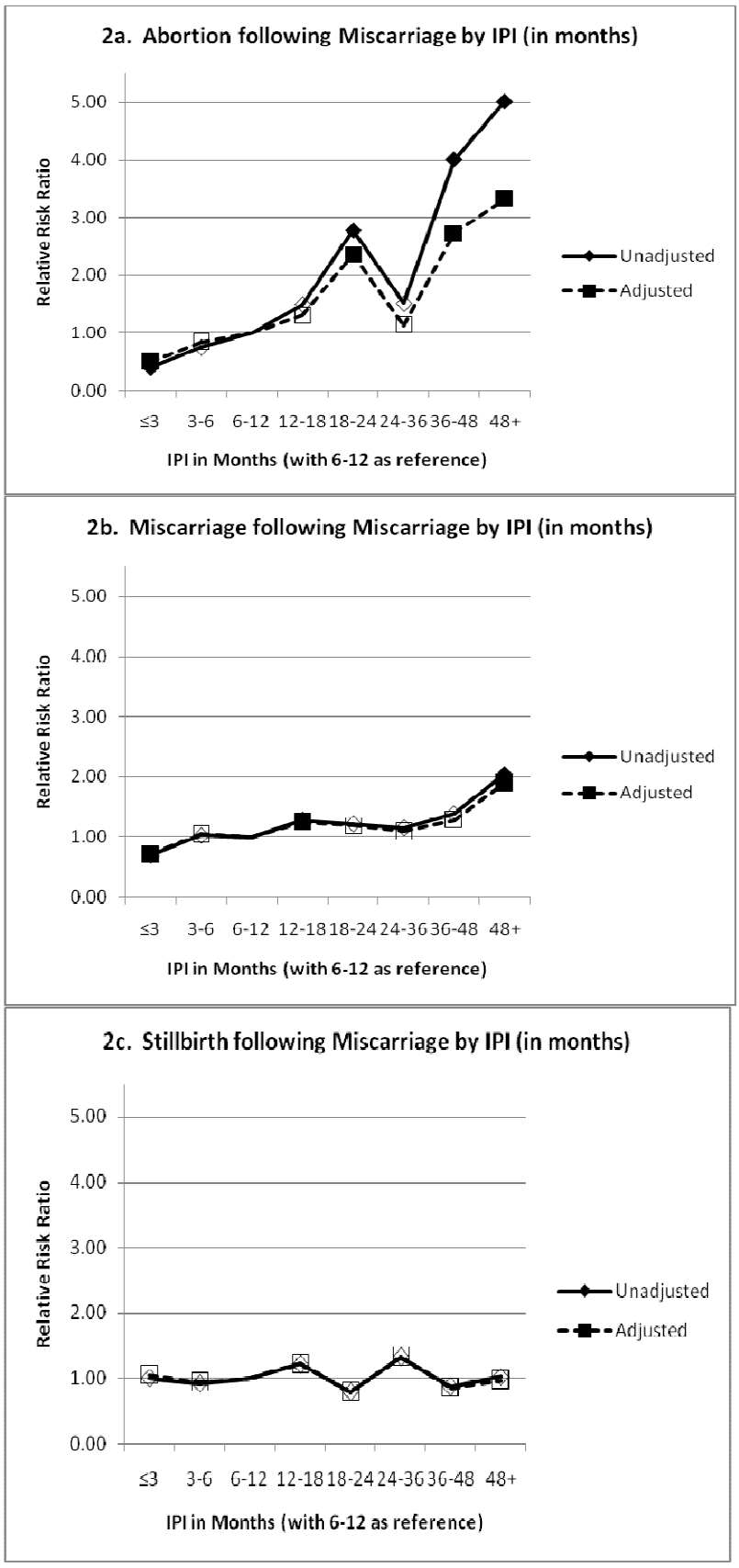
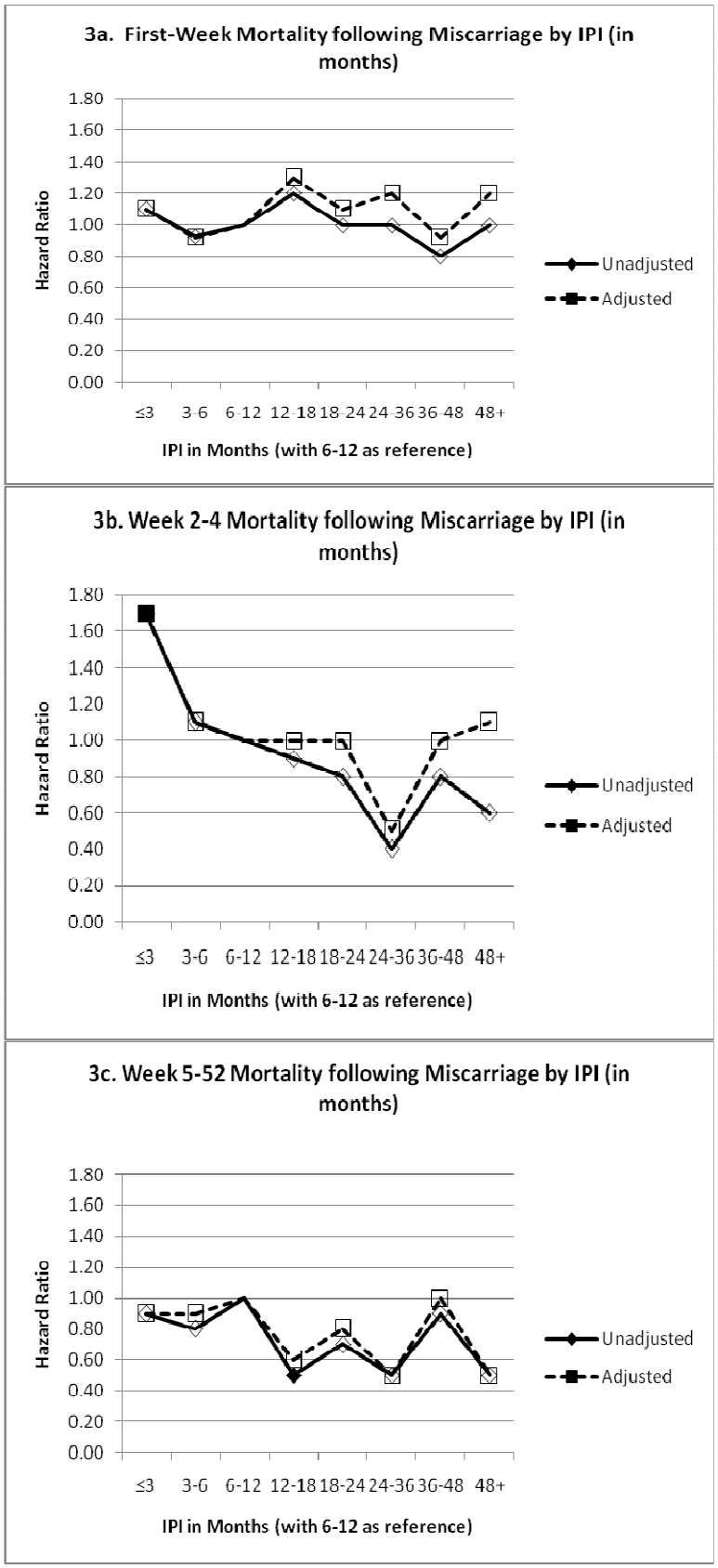


Figure 3. Hazard ratios of mortality during subperiods of infancy, by IPI duration, unadjusted and adjusted results from Matlab (Note: Solid symbols indicate p <0.05)



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