Birth spacing and health outcomes:

Differences across the life course and developmental contexts

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In this chapter we discuss research on the effects of long and short birth spacing from the perspective of children. Recent research has placed doubt on previous findings of adverse effects of short birth intervals on birth outcomes as well as short-, medium-, and long-term health, educational, and socioeconomic attainment outcomes. We summarize recent findings with a particular focus on impacts over the life course, and the extent to which findings are applicable at various levels of social and economic development. We also briefly discuss the effects of birth spacing in the broader context of research examining the effects of early life conditions on adult outcomes.

Keywords: birth spacing; infant mortality; health; educational attainment; socioeconomic attainment; life course.

Adverse effects of birth spacing on outcomes of children across the life course

A large literature has examined the relationship between birth spacing, variously operationalized as birth-to-birth intervals and interpregnancy intervals, and the outcomes of children (Conde-Agudelo, Rosas-Bermúdez and Kafury-Goeta 2006). Birth intervals refer to the time interval between the births of adjacent siblings. Birth intervals have been the subject of sustained interest amongst researchers because, as a concept, they have the potential to capture and reflect a number of important dimensions of resource distribution in the household and in family life more generally, as well as important physiological factors around pregnancy and child-rearing. Mothers, particularly in low-income contexts, who have multiple children in the household are likely to be under greater strain if those children are spaced closely together. Raising many small children is physically and emotionally challenging in any setting, and in low-income settings there may not be enough food to fully satisfy everybody in the household. The mother is likely to be breastfeeding the youngest child, whilst also trying to take care of the older siblings. In a low nutrition setting she may not have had time to fully recover from each previous pregnancy before conceiving again, meaning that her breast milk would be of lower quality, and her body would not have been able to fully restore all of the vitamins and nutrients, some essential for foetal development, that the subsequent pregnancy required. In more extreme cases, she may have even been breastfeeding while pregnant with the next child, which would be a drain on the mother, as well as

damaging to both the child breastfeeding and the foetus in the womb. This confluence of factors has led researchers to speculate about how short birth intervals should have a negative effect on foetal development and pregnancy outcomes, as well as educational outcomes and cognitive development, because closely spaced children may not be getting the resources and stimulation that they need to develop to their potential. In the most extreme cases, short birth intervals even increase the risk of death for the mother as well as the children. Thus, short birth intervals have the potential to influence child health and development across the child's life course.

Researchers have most often examined how the length of time since the birth of the preceding older sibling affects the subsequent child, but some work has also examined the interval to the next youngest sibling from the perspective of the older child (Buckles and Munnich, 2012). Interpregnancy intervals are similarly conceptualized but refer to the time from the birth of the older sibling to the conception of the next youngest sibling. The concept of interpregnancy intervals tends to be used more often in epidemiological research and studies examining perinatal health outcomes (Conde-Agudelo *et al.*, 2006).

The specific outcomes that have received attention in relation to birth spacing are varied, ranging from perinatal health outcomes (for example, the risk of low birth weight or preterm birth), to health and mortality during childhood (Conde-Agudelo, Rosas-Bermúdez and Kafury-Goeta 2006), through to longer-term outcomes related to educational and socioeconomic attainment (Barclay and Kolk 2017; Buckles and Munnich 2012; Powell and Steelman 1993), health, and mortality (Barclay and Kolk 2018; Campbell and Lee 2009). Research on birth spacing has also spanned across different developmental contexts. Researchers across disciplines such as demography, epidemiology, anthropology, development studies, as well as others, have examined how birth spacing is related to perinatal health and early childhood mortality in historical as well as low- and middle-income contemporary settings, while the research on medium- and long-term outcomes has tended to be conducted in high-income contemporary settings in North America and Western Europe. In this chapter, we will provide an overview of this research, including the most recent developments, in an effort to synthesize the literature.

Generally speaking, research and theory suggest that short intervals between births are worse for the children, though there is some evidence that especially long birth intervals are also associated with poor outcomes for children. As a consequence, the World Health Organization (WHO) has recommended that mothers should wait at least 24 months before

attempting to conceive again (WHO 2006). Although this advice from the WHO has primarily directed been at mothers in low- and middle-income countries, medical professionals in high-income countries have also tended to recommend avoiding very short birth intervals. For example, the American College of Obstetricians and Gynaecologists recommends women to avoid interpregnancy intervals shorter than 6 months (McKinney et al. 2018). However, recent research suggests that the negative relationship between birth intervals and child outcomes is more complicated than previously believed, to the extent that the US Centers for Disease Control and Prevention (CDC) have recommended that further research is needed in order to understand the relationship between spacing and health outcomes for both the mother and child (Copen, Thoma and Kirmeyer 2015).

The mechanisms by which birth spacing might be associated with child outcomes can be broadly divided into three categories. The first are physiological factors. A child born after a short interval may suffer from maternal nutrient depletion, and particularly maternal folate depletion, if the mother has not been able to recover sufficiently from the previous pregnancy (King 2003; Smits and Essed 2001). This is likely to be a particular problem in low-income settings where maternal nutrition is insufficient to rapidly recover from a previous pregnancy. Furthermore, although breastfeeding is positive for infant development, breastfeeding is likely to impede recovery from maternal depletion (Trussell 2011). Breastfeeding-pregnancy overlap can also negatively affect the child being breastfeed, and breast milk quality may be lower when there are competing demands on the mother's physical resources (Molitoris 2018a). Other potentially important physiological mechanisms include transmission of infections across pregnancies (Goldenberg, Culhane and Johnson 2005), and so-called cervical insufficiency, which refers to how a short period between pregnancies can lead to deficiencies in the ability of the female reproductive organs to retain the pregnancy (Ludmir and Sehdev 2000). Finally, the negative effects of long birth intervals are hypothesized to be explained by maternal physical regression (Zhu et al. 1999). Women go through a number of physical adjustments during pregnancy, and a long interval between births means that the body may return to a state where it is no longer primed for pregnancy (Zhu et al. 1999). Another important factor, and particularly in low-income settings, is that maternal health can be affected by long intervals. Women are more likely to suffer from preeclampsia when pregnant after long birth intervals, and preeclampsia is a leading cause of maternal mortality (Conde-Agudelo, Rosas-Bermúdez and Kafury-Goeta 2007).

A second group of factors that may explain the relationship between the length of birth intervals and child outcomes are social conditions within the household. Such mechanisms may apply across both low- and high-income settings, but the effects are likely to be more pronounced when the absolute level of resources is low, as it is in low-income contexts. One potentially important mechanism is resource dilution within the sibling group (Blake 1981), as short birth intervals would mean that the older sibling has a relatively shorter period of time where they would not be competing with their younger sibling for resources. The notion of resource dilution would also be important from the vantage point of the sibling group as a whole, as shorter average birth intervals in the sibling group should mean that access to parental resources is generally constricted to a greater extent for all siblings. Other important factors related to resource dilution include the stress for parents involved in raising multiple closely spaced children, which may lead to less cognitive stimulation for children (Zajonc and Sulloway 2007), generally lower quality of care, and worse socioeconomic and health outcomes for the parents themselves (Grundy and Kravdal 2014).

The third explanation is unobserved factors that are associated with both birth spacing and child outcomes (Barclay and Kolk 2017; Miller 1989) that may induce a spurious association between birth spacing and child outcomes even if birth spacing actually exerts no genuine causal effect on child outcomes. For example, if a mother who is less healthy than average has trouble conceiving a child, she will have longer birth intervals than average; in turn, her poor health might also translate into poor health outcomes for the child. However, in such a case, one should not hold the length of the birth interval itself responsible for the poor health outcome for the child, because the longer birth interval is largely incidental to the process. Other research shows that in the United States short birth intervals are more likely to be unwanted or mistimed, and are particularly common among teenage mothers, and African Americans (Gemmill and Lindberg 2013). Since these sociodemographic groups experience relatively worse socioeconomic conditions in the United States, this could lead to an association between short birth intervals and worse child outcomes. Related, female labour force participation has a substantial effect on fertility spacing behaviour (Heckman and Walker 1990; Troske and Voicu 2013). In general, it can be said that birth spacing is not randomly distributed across families, and therefore it is important to adjust for systematic variation in the spacing of births across different types of families in order to isolate the net contribution of birth intervals *per se* to child outcomes.

Research on the relationship between birth spacing and child outcomes often alludes to other factors within the sibling group, such as parity, family size, and maternal age at the time of birth. It is worth briefly reviewing how these factors are related to birth spacing, and how they are themselves associated with child outcomes, because they are often important confounders for the relationship between birth spacing and the child outcomes that we are most interested in identifying. For example, first-born children do not experience a birth interval in the same sense as later-born children do; children in large families tend to experience shorter than average birth intervals; and older mothers in high-income settings tend to have shorter birth intervals, particularly if they started childbearing later and are trying to achieve their fertility goals. Later-born siblings tend to have better perinatal health outcomes than first-borns (Kramer 1987), but worse long-term socioeconomic, educational, and health outcomes than first- and earlier-born siblings (Black, Devereux and Salvanes 2005), and therefore it is important to adjust for parity when studying birth spacing. Likewise, there is a large literature that shows that family size can be related to outcomes for children (Steelman et al. 2002), and other studies show that parental age at the time of birth can be important for perinatal outcomes as well as long-term health trajectories (Jacobsson, Ladfors and Milsom 2004; Myrskylä and Fenelon 2012). As a result it is important to adjust for parity, family size, and maternal age in models examining how birth spacing is associated with child outcomes.

Previous research on birth spacing

Research in low-income countries has tended to show that children born after especially short and long intervals have worse peri-natal health outcomes, including an increased risk of low birth weight, pre-term birth, being born small for gestational age, as well as an increased risk of foetal death, neonatal death, and infant mortality. The definition of short birth intervals varies across the literature, but tends to average around 24 months, while the definition of long intervals tends to average around 60 months. A meta-analysis of studies examining the relationship between interpregnancy intervals and perinatal and child health outcomes suggested that the relationship follows a pronounced J-shape, highlighting the poor outcomes of children born after short and long intervals (Conde-Agudelo, Rosas-Bermúdez and Kafury-Goeta 2006). Although less pronounced, previous research had also found that short birth intervals were associated with poor perinatal health outcomes such as low birth weight, preterm birth, and being born small for gestational age in high-income countries such as the

contemporary United States. Research by historical demographers has also supported this general pattern of findings, where short birth intervals were associated with higher risks of infant mortality in Western Europe and North America prior to industrialization and modernization (Bean, Mineau and Anderton 1992; Lynch and Greenhouse 1994).

Research on long-term outcomes in relation to birth spacing has received relatively much less attention in the literature than research examining the relationship between birth spacing and perinatal and child health outcomes; while there have been dozens, if not hundreds of studies, of the latter, until the 2010s there were only a handful of studies of the former. In general this research showed that short birth intervals and high sibling density were poor for long-term outcomes. In a pair of studies using data from the United States, Powell and Steelman (1990) found that having multiple siblings closely spaced lead to worse educational outcomes, including lower grades in high school. Powell and Steelman (1993) further reported that close spacing had a detrimental effect on the transition to post-secondary school training, and also had a negative association with time spent talking to mothers and fathers, as well as a negative impact on access to educational materials. Regarding long-term health outcomes, the only studies that we were aware of until the most recent tranche of research were a handful of studies examining the risk of schizophrenia (Gunawardana et al. 2011; Smits et al. 2004), autism (Cheslack-Postava, Liu and Bearman 2011; Cheslack-Postava et al. 2014; Gunnes et al. 2013), the risk of self-harm (Riordan et al. 2012), and examining the association between spacing and adult mortality in 18th and 19th century China (Campbell and Lee 2009). Each of these studies found that short intervals were associated with an increased risk of the respective outcomes studied.

Despite the large number of studies examining the relationship between birth intervals and child outcomes, this body of research was not caught up in the wave of enthusiasm for re-examining long established empirical findings with careful causal identification strategies until 2012, with the publication of a study by Buckles and Munnich (2012)). Buckles and Munnich (2012)) used an instrumental variable strategy where they parlayed variation in birth spacing attributable to miscarriages into estimates of how birth spacing affected school outcomes in the contemporary United States for both the older and younger sibling of any given birth interval. Buckles and Munnich (2012)) found that longer birth intervals, that is, a longer period of time until the birth of the younger sibling, were associated with better outcomes for the older sibling; specifically, they found that a one-year increase in the birth interval increased test scores for the older sibling by 0.17 standard deviations, which is

substantial in magnitude, though there was no observed effect on the younger sibling. Although this study was an important contribution to the literature, the validity of miscarriage as an instrument, given response bias, misreporting, and the almost certain violation of the exclusion restriction (Angrist and Pischke 2008), can be seriously questioned.

Sibling comparisons and adjustments for parental background in research on birth spacing

An alternative strategy for reducing unobserved confounding from differences across families that has been employed in recent research is to compare siblings who share the same biological parents. By means of parental level fixed effects, where models are estimated using within-group deviations-from-means, these models hold the influence of parental background constant across siblings. By only comparing the outcomes of siblings to each other, all factors that are shared by siblings, such as their parents' education, the number of siblings in the family, their primary school (if shared), and parental health, are implicitly controlled for. As it has been shown repeatedly in the social sciences that family background is important for virtually all later life outcomes, adequately adjusting for such factors is a very powerful research design. If, for example, parents more likely to misuse contraceptives have very short birth intervals, comparing siblings that share parents who are more likely to make such errors, but have different birth intervals, allows a better estimation of the effect of birth intervals on an outcome. Other aspects of severe disadvantage such as substance abuse are also hard to measure with the kind of variables that are available in standard social science sources, but would be accounted for in a sibling comparison design.

Recent research using a sibling fixed effects approach on full population data from contemporary Sweden has suggested that when comparing children who share the same biological parents, neither the interval preceding nor following the index person is significantly or substantially associated with grades in high school, intelligence quotient (IQ) scores, completed educational attainment, labour market earnings, the probability of unemployment, or the probability of receiving government welfare support (Barclay and Kolk 2017). Further research has shown that after comparing siblings within the same family, there are similarly no clear associations with health outcomes for contemporary Swedish men in early adulthood in terms of body mass index (BMI), physical fitness, or height, and neither

any consequences for adult mortality for men and women (Barclay and Kolk 2018). Research using a similar statistical approach with survey data from the United States also supports the conclusion that there are no consequences associated with interval length for outcomes in adulthood (Nguyen 2014).

Although the evidence for long-term outcomes clearly leans towards a null effect of birth interval length in high-income settings, the pattern is less clear in research examining the relationship between birth spacing and perinatal health outcomes for children in high-income settings. A study by Ball et al. (2014) found that when comparing siblings who shared the same mother using contemporary data from Australia, short birth intervals were no longer significantly associated with the risk of low birth weight, preterm birth, or being born small for gestational age. Further recent research has generally replicated these findings in different contexts such as Canada (Hanley et al. 2017), and Sweden (Barclay et al. 2020; Class et al. 2017). Research using Swedish data has also found that the associations do not vary significantly according to salient social factors such as maternal educational level or maternal country of origin (Barclay et al. 2020). However, studies using the same statistical approach but data from the United States (Mayo et al. 2017; Shachar et al. 2016), and the Netherlands (Koullali et al. 2017), have continued to find that short birth spacing is associated with an increased risk of poor perinatal outcomes. It may be the case that specific contextual factors related to the health care system or socioeconomic stratification may be part of the explanation for variation in the relationship across these different settings.

It should be noted that, despite the strengths of sibling comparison models, there are inevitably some drawbacks. For example, not *all* family background factors are controlled for in such models. For example, siblings share some, but not all genes. Family circumstances may also change during childhood. For example, if parents divorce, siblings will experience that event at different ages; likewise, if a parent experiences a sudden deterioration in health. Such time-varying factors are not controlled for in a sibling comparison model unless the researcher adjusts for them explicitly. Factors such as breastfeeding that affect both birth spacing and potentially also health outcomes are also not necessarily adjusted for in a sibling comparison design. A further issue to consider is that sibling comparison models exclude small families. As siblings are compared, singletons ('only children') are not included in sibling comparison models. However, there is simply no conceptual relevance in discussing birth intervals among singletons. When study birth intervals, at least two intervals in the

sibling group are needed in order to exploit variance within the sibling group, and that means that sibling comparison models can only be estimated on families with at least three siblings. It has been argued that this decreases the generalizability of the findings, which is true, but we find such critiques overstated. It is true that many parents and children are not included in sibling comparisons on birth intervals. From the parents perspective, a quite large share have zero, one or two children. In Sweden for example, a society with low to moderate fertility, 68 percent of parents have zero, one or two children. However, from the child's perspective the distribution is very different (Preston 1976); only seven percent of children have no siblings and 66 percent have two or more siblings in contemporary Sweden. In high fertility populations, virtually all children grow up with a large number of siblings. In many senses this question about the effect of birth intervals is really a research question about children growing up in relatively large families. No doubt this is one reason why most research on this topic has focused on low-income societies that tend to have high levels of fertility. It is true that families of exactly two children are missing from sibling comparison models, and in Sweden and other high-income countries they represent a reasonably large share of all birth intervals (34 percent). It is possible that the effects of birth intervals in families of exactly two children are worse than in larger families, but theoretically this seems implausible because all of the mechanisms that have been suggested to link short birth intervals to poor child outcomes would be more exaggerated in larger families, and negative effects are not observed in larger families in high-income contexts (Barclay and Kolk 2018). Research on high-fertility populations also supports the conclusion that the effects should be worse in larger families (Molitoris 2018b; Molitoris, Barclay and Kolk 2019).

When does birth spacing matter? Comparisons across the lifecourse and across developmental context

The research findings from the last five years applying sibling comparisons find that previously documented strong negative effects of short birth intervals in high-income countries are often greatly attenuated or disappear completely once characteristics of the mother are held constant across birth intervals. Most of this research has been focused on outcomes early in life, often directly connected to the birth. These findings stand in contrast to the large body of literature that documents the strong negative effects of short birth intervals in low-income countries with high fertility.

Below we will briefly discuss how very recent research has provided a fuller picture of how the effects of birth intervals may vary across the life course, and whether and how the effects of birth intervals seem to be moderated by the level of economic development, the fertility context, and public health conditions. Most previous literature has been focused on childhood health and perinatal outcomes in less developed countries, while research on high-income countries has focused both on perinatal health, childhood health, and adult outcomes such as education, income and health. These studies have consistently found adverse impacts of short intervals, and to a lesser extent, also very long intervals. As described earlier, recent research has questioned the negative causal impact of short birth intervals in high-income societies after applying research designs that can control for maternal and family characteristics (Ball et al. 2014; Barclay et al. 2020; Barclay and Kolk 2017; Class et al. 2017). Here we aim to give an interpretation of how these findings can be reconciled with the documented negative effects of birth intervals in poor countries. A first thought is that perhaps the negative impacts of short birth intervals are also spurious low-income settings, in the sense that they are correlated with poor outcomes, but not after controlling for maternal traits. The vast majority, if not all, of the studies that are the basis for the WHO recommendations in low- and middle-income countries are also based on between family comparisons (Conde-Agudelo, Rosas-Bermúdez and Kafury-Goeta 2006). However, a null effect of short birth intervals in low-income settings would be an even more surprising finding than the absence of adverse effects in high-income societies.

Some recent studies that apply the sibling comparison methods to studies of low-income and high fertility societies have, however, found that the negative effects of birth spacing on infant mortality remain high in substantive terms, even after adjusting for maternal characteristics (Molitoris 2017; Molitoris 2018b; Molitoris, Barclay and Kolk 2018). Molitoris (2018b) documents this in contemporary Bangladesh, and Molitoris, Barclay and Kolk (2018) examine millions of children born across 77 low- and middle-income countries between the 1960s and 2010s. Both studies find that short intervals (but not always long intervals) are associated with much higher infant mortality. Molitoris, Barclay and Kolk (2018) and Molitoris (2017) both provide insights into when we can expect to find an adverse effect of short birth intervals. Molitoris (2017) studied the relationship between birth intervals and mortality in Stockholm between the 1870s and the 1920s. During this period, health care expanded greatly, fertility fell dramatically, and the economy grew rapidly. Molitoris finds an adverse effect in the beginning of the period that gradually disappears by the 1920s, where birth intervals are

independent of child mortality. Molitoris, Barclay and Kolk (2018) examine the relationship between infant mortality and birth spacing in 77 countries, for 4.5 million births, over 50 years. The period and country context varies from least developed societies, to low middle-income countries. They find that the negative impacts of birth spacing are greatly attenuated by increasing development, and that at high levels of HDI, low fertility, low infant mortality rates, and high life expectancy, there is no clear association between short birth intervals and infant mortality. The relationship is also much weaker within smaller families. These studies help to reconcile the widely accepted finding of a negative impact of very short intervals in low-income settings with the increasing evidence that these effects are likely quite small in contemporary high-income settings. The exact point at which short intervals seem to stop being a very powerful determinants of perinatal outcomes is hard to pin-point, but there is increasing evidence that in most low-income societies we find an adverse effect, and that effect is much less strong in substantive terms in high-income societies. Further research may want to examine if the context dependency of the relationship between birth intervals and poor perinatal outcomes is primarily attributable to overall development in a society, changes in fertility, or availability of health care, prenatal care, and adequate medical facilities.

While above, it seems to be the case that effect of birth spacing on infant mortality is highly contingent on the developmental context. Other recent research has focused on outcomes of birth spacing across the life course at other life course stages beyond the time just after birth. It is possible that the adverse outcomes of short birth intervals are primarily evident for outcomes later in life rather than for early-life physiological outcomes. This might be the case if social conditions during childhood, such as the potential effect of short intervals in diluting parental time investment in each child, were the animating mechanism for the relationship. Much less research has focused on this aspect, and we are only aware of one study that has examined if birth spacing affects adult health and mortality in a low-income context (Campbell and Lee 2009). Three recent articles have examined these issues for childhood health, and a range of health and socioeconomic outcomes in adulthood, including mortality, for contemporary Sweden (Barclay et al. 2020; Barclay and Kolk 2017; Barclay and Kolk 2018). In all cases there is no direct negative impact of birth spacing on any outcome.

To sum up recent findings on birth spacing and health outcomes, it is universally the case that children born before or after short or long intervals do worse in terms of child health, adult health, and long-term socioeconomic attainment. However, in high-income societies, this pattern seems to be due to family characteristics, not birth spacing *per se*. We therefore argue that there is no evidence of an effect of birth spacing on any outcomes, including on perinatal outcomes, in contemporary Sweden. This finding applies to all stages of the life course. The evidence suggests that the developmental context is very important, and while birth intervals do matter in low-income settings, the negative effects are neutralized by increasing development.

A general challenge when researchers examine early life effects is that the factors that researchers suspect may have adverse causal effects are also concentrated in disadvantaged subpopulations. We conclude by putting our research in the context of other research on family background characteristics and childhood and adult outcomes. When researchers have examined hypothetical effects of circumstances such as family size, birth order, and birth spacing, they have often found negative effects. There is, however, an increasing understanding that such effects are often mediated by other parental background factors, and that these mediating factors could explain the relationship. In other words, it is true that factors such as a large family size, short birth spacing, and late birth order are associated with poor outcomes, but in many cases, this seems to be driven by a confounding factor that is associated both with the demographic factor under suspicion as well as the outcomes of children.

The most recent research suggests that the concentration of a variety of negative factors in disadvantaged families is the explanation for the negative association between short birth intervals and poor child outcomes in high-income, but not low-income, societies, and that in the latter case it makes sense to talk about the causal negative health impacts of short birth intervals on child outcomes. In studies of family size researchers long found negative effects of a large number of siblings. Similar to recent birth intervals research however, research designs that incorporated variation in sibling numbers that was exogenous to parental background (typically using twin births), found that negative effects of siblings dissipates in advantaged populations, and to some extent also less advantaged populations (Baranowska-Rataj, Barclay and Kolk 2017; Baranowska-Rataj, De Luna and Ivarsson 2016; Fitzsimons

and Malde 2014; Kolk 2015; Åslund and Grönqvist 2010). On the other hand, the negative effects of late birth order on adult health appears to exist both in high-income and low-income countries, even after controlling for parental background traits (Barclay and Kolk 2015; Barclay and Myrskylä 2014). The example of the effect of birth spacing shows that controlling for parental background factors is critical when examining the impact of early life factors on child outcomes, and the results may differ substantially across different contexts. For birth spacing, we see few reasons for policy-makers in high-income societies to worry about short birth-spacing in relation to, for example, parental-leave policies, but we do find that the WHO recommendations for low- and middle-income countries are consistent with the most reliable empirical findings, and would improve population health if adhered to. We also conclude that birth intervals do not seem to matter at any point in the life course for children in high-income societies, but that they do matter for children in low-income societies.

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