The Long-term Impact of Birth Order on Health and Educational Attainment

Kieron Barclay
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1. INTRODUCTION

This thesis examines the relationship between birth order and health in adulthood, and birth order and educational attainment. Researchers have been interested in the impact of birth order on later life outcomes for over a hundred years (Galton, 1874), and literally thousands of research papers have been published on the topic (Ernst and Angst, 1983). Although interest in this topic has waxed and waned over time, it continues to spark interest, and controversy (Townsend, 2000; Rodgers, 2014). Given the long period of interest in this topic and the many papers published, it is reasonable to ask what new contributions can be made to this field of research. In this introductory chapter I intend to demonstrate that the four research papers included in this thesis do indeed make a novel contribution to this field, through a combination of high quality data and methodological rigour that allows for clear conclusions to be drawn about the relationship between birth order and health in adulthood, as well as through novel study designs that demonstrate and clarify previously unclear dimensions of the relationship between birth order and educational attainment.

The first of these four studies examines the relationship between birth order and mortality in adulthood, and finds that later born children have higher mortality relative to first borns. The second study, using fitness tests from Swedish military conscription data, shows that the disadvantage of later borns is already apparent by early adulthood. The third study attempts to distinguish between physiological and social explanations for the relationship between birth order and later life outcomes by examining whether ‘birth order’ patterns exist in fully adopted sibling groups. When studying educational attainment by age 30, this study finds that later adopted children perform worse than earlier adopted children, just as in fully biologically related sibling groups, indicating that the appropriate theories for why later borns fare worse than first borns are social rather than physiological. Finally, the fourth study points out an important paradox in the birth order literature. While the causal effect of birth order on later
life outcomes is negative, later born children in recent decades have actually performed better than their older siblings. The explanation for this is that educational expansion and other positive secular trends mean that later borns emerge into a more positive social environment, and this outweighs the negative effect of birth order.

This introductory chapter will begin by briefly reviewing how all manner of early life conditions, including in utero conditions, birth weight, family size, and birth order, have been found to be associated with a wide range of later life outcomes. Given that most theories presume that birth order influences later life outcomes through within-family dynamics and the interaction between parents and siblings, and siblings with one another, I also briefly review the literature that has attempted to understand why it is that many siblings are so different from one another, in section 1.2. In section 2 I will then turn to birth order in greater detail and review the dominant theoretical explanations for why birth order should be related to later life outcomes. This will be followed by a review and discussion of empirical research on the relationship between birth order and intelligence, educational attainment, health measures, as well as personality, in section 3. There are literally thousands of studies on the relationship between birth order and later life outcomes, and particularly personality and intellectual development. However, the vast majority of them use between-family comparisons, meaning that the estimates for the relationship between birth order and a given outcome are made by comparing children across different families.

As I will discuss in greater detail in sections 2.3.1 and 9 of this introductory chapter, there is a strong possibility of confounding by unobservables in between-family analyses. Due to this, in the review of previous empirical research, I will, for the most part, focus on studies that have used a within-family comparison design. By this I mean focusing on studies that compare individuals in the same sibling group to one another. I will also discuss how the statistical methods and data used in this thesis means that it has been possible to avoid
many of the problems that have plagued most birth order research, in sections 8 and 9.

Birth order is only one part of the family dynamic, and therefore it is also important to consider how we can study birth order as a phenomenon distinct from family size. I will briefly review literature on this topic in section 4. In section 5 I will discuss in greater detail how it is possible for birth order to exert a negative causal effect on a range of later life outcomes, and yet for later born children to actually do better. The empirical work of this thesis is based on Swedish population register data, and as a result the theory and empirical research that I review in this introduction is primarily drawn from work done in broadly comparable societies. Given this, it is important to consider that the cultural meaning of the family institution, and roles within the family vary from one context to another, and with time. This is turn means that the relevance of birth order as an explanatory variable will also vary according. In section 6 I discuss the particularities of the Swedish context, and how this social environment may be related to the patterns reported in my empirical studies. Given that these findings are particular to the social context that they are studied in, I also discuss how birth order effects may vary in different historical and social contexts. This is addressed in section 7. In section 10 I will discuss some developing research on intergenerational birth order effects, as well as draw some more general discussion points and conclusions from the entire introductory chapter. Finally, before the full studies are presented, I briefly summarise each of the four empirical studies that make up this thesis, in section 11.

1.1. Early Life Conditions. In recent years there has been a growing body of research that examines how early life conditions and exposures can influence long-term outcomes, stretching far into adulthood. The term ‘early life’ is a rather catch-all term that may be said to encompass in utero conditions as well as infant conditions. For example, maternal stress during pregnancy has been shown to affect the likelihood of pre-term birth and birth weight (Lauderdale,
2006; Torche, 2011), while birth weight has been shown to be associated with cognitive development, educational attainment, and health in adulthood (Conley and Bennett, 2000; Black et al., 2007). Early life disadvantage in social conditions also leads to long-term chains of risk, with children born into low socioeconomic status households having lower educational attainment, less successful career trajectories, and higher mortality (Elo and Preston, 1996; Erikson and Goldthorpe, 2002; Hayward and Gorman, 2004). This thesis concerns the relationship between birth order and later life outcomes. Although birth order is a factor that mediates parental attention and investment throughout childhood, as I will discuss in sections 2.1.1 and 2.1.2 it is likely that the way that it mediates resource access and attention in the very earliest years of life has a critical impact upon subsequent development.

There is abundant evidence that cognitive stimulation and the availability of learning opportunities in early life are critical for long-term development (Heckman, 2006; Heckman et al., 2010; Campbell et al., 2014). Randomised control trials show that cognitive and social benefits attributable to early intervention can range from between 0.2 to over 1 standard deviation, which are very substantial effects (Ramey and Ramey, 1998). The body of research on this topic also convincingly demonstrates that intervention in the very first few years of life is more effective than later on, with declining returns as age increases (Heckman, 2006). For example, Campbell and Ramey (1994) found that an intervention designed to enhance cognitive, language, perceptual-motor, and social development from infancy to age five was more effective than the same intervention for children aged five to eight. The experimental group that performed best overall, though, were those who received the intervention from infancy through to age eight (Campbell and Ramey, 1994). Since much of this research has been conducted with social policy implications in mind, many of these experimental interventions have targeted infants who are disadvantaged in some way (Ramey and Ramey, 1998). Nevertheless, the consistency of the
results is demonstrative of the relative sensitivity of early life for individual development (Heckman, 2006).

In this thesis I intend to demonstrate that birth order should also be considered an early life factor with long-term implications. As will be described in section 2, the influence that birth order has on the development of the individual likely stems from within-family dynamics that concern parental investment in the child. Many researchers in the fields of stratification and demography are interested in studying how relative access to resources influences opportunity structures and individual life course trajectories. Birth order is a unique variable in the sense that it allows researchers an opportunity to examine how relative access to resources within the same household, and a shared environment, affects long-term patterns. This provides an opportunity to study relative access to resources net of environmental conditions, as siblings share the same parents and household. In particular the study of birth order provides an opportunity to study how early life parental investment, within family inequality, and a cumulative relative advantage in terms of access to resources over the course of childhood and adolescence, influences long-term outcomes between siblings.

This interpretation of the importance of birth order is bolstered by the fact that birth order effects are commonly observed amongst siblings who originate from both high and low socioeconomic status families (Kristensen and Bjerkedal, 2010; Myrskylä, Silventoinen, Jelenkovic, Tynelius and Rasmussen, 2013), and empirical research shows that parents spend more time with earlier borns than later born children (Price, 2008), and in Sweden also take fewer parental leave days to spend with later born children (Sundström and Duvander, 2002). A skeptic might argue that the presence of birth order effects in high socioeconomic status families, where all children presumably receive more than adequate access to resources in absolute terms, suggests that some other explanation is needed. However, there are good reasons for believing that relative access to resources even after all ‘needs’ are satisfied still matters (Marmot,
A large body of research shows that relative access to resources continues to stratify life course trajectories, even when the absolute level of resources available to individuals is well above those needed for survival (Marmot et al., 1991; Redelmeier and Singh, 2001; Marmot, 2004; Rablen and Oswald, 2008)

1.2. **Why Are Siblings So Different?** Although the debate over the relative importance of nature and nurture has continued in one form or another since antiquity, it is clear that, at least in terms of any measure of interest to social scientists, every individual is a product of both their genetics and their environment. The interaction is so continuous and complex that in most cases it is not possible to distinguish between the two. I have no intention of even briefly trying to summarise the literature on this topic, but allude to it as it is an unavoidable part of trying to understand the extent to which siblings are different from one another. We know that siblings who share the same biological mother and father share, on average, 50% of their genes. For children who grow up in the same household, they also share the home environment. Siblings also share other aspects of their environment, as they live in the same neighbourhood, often attend the same schools, and share the same parents socially, although their precise experience of these environments must differ. While these various factors would suggest that siblings should not differ a great deal, empirical research does not bear that out.

Some psychologists have argued that siblings are virtually no more similar to one another than perfect strangers (Pinker, 2002). Research in multiple countries has shown that a great deal of the variation in long-term outcomes is to be found within the family (Sieben et al., 2001; Conley et al., 2007; Schnitzlein, 2014). Research on early life cognitive performance show that siblings correlate in the range of 0.28 to 0.44 on various measures such as reading comprehension, and math performance (Conley et al., 2007). Income data from Sweden indicates that the correlation in earned income in adulthood is 0.49 amongst brothers born in the 1930s, and 0.34 amongst brothers born in the
1950s (Björklund et al., 2009). This brother correlation in earnings is higher in the United States, at above 0.40, but is also low in the other Nordic countries, ranging from approximately 0.14 to 0.26 (Björklund et al., 2002). Strikingly, even identical twin concordance on the development of cardiovascular disease and and cancer is only 0.30 and 0.10-0.20, respectively (Marian, 1998; Lithienstein et al., 2000). To make an implicit point explicit, these correlations show the average - some siblings are much more, and some much less, similar than others. When we measure outcomes in adulthood such as labour market earnings there is a substantial period of time where siblings usually live not only in different homes and different workplaces, but may even live in different cities or even countries. It is easy to understand how this kind of non-shared environment could produce dissimilarities between siblings, though it is interesting that correlations even on early life measures of cognitive performance can be so low.

These results may initially seem somewhat surprising given that siblings do share a large portion of their genes, and are raised in what is ostensibly the same environment. Given that siblings do turn out so differently, much work has been done to try to understand the reasons why (Plomin and Daniels, 1987). While this question has not been answered in a definitive way (Plomin and Daniels, 2011), there are several reasons to expect that siblings should be different. To begin with, there is the 50% of their genetics that siblings do not share. Furthermore, even the genes that are shared are differently configured, and most gene-dependent traits are non-additive, meaning that there are emergent properties of specific gene combinations (Lykken, 1982, 1987). One researcher has likened the genes that siblings share to two people sharing the same set of digits, but two different telephone numbers (Lykken, 1982). Aside from genes, there is what has been termed non-shared environment (Plomin and Daniels, 1987). The use of the term non-shared environment refers both to experiences that are clearly not shared, say that two siblings are sent to different schools, and those that are ostensibly shared, but where the actual experience is in reality quite
different. For the latter an example would be that although children share the same parents, their parents treat them differently. Parents generally report that they treat their children the same way, with their self-reported treatment correlating at approximately 0.70 (Reiss et al., 2009). However, the correlation based upon the children’s reports falls to 0.25, and it is the latter correlation which is corroborated by independent observers (Reiss et al., 2009).

There are also plenty of other non-shared environmental factors that are likely to contribute towards differences between siblings. These can include anomalous or random events that an individual can experience that their siblings will not. However, I will not treat these any further as they are not systematic by their nature. Considering more systematic non-shared environmental factors, even when attending the same school, siblings are likely to experience this environment differently, particularly as they will usually enter the school in a different cohort, have incomplete overlap in teachers, and even the same teachers may treat them differently. Crucially, even when attending the same schools, siblings will have different classmates. Some researchers have argued that parents have little influence on the way that children develop, particularly in terms of personality, and that it is children’s peers who provide the strongest influence (Harris, 1998; Pinker, 2002). Unsurprisingly, there is indeed evidence that peers influence individuals during their childhood and adolescence, affecting the propensity to smoke (Christakis and Fowler, 2008), to drink alcohol (Rosenquist et al., 2010), to exercise (Barclay et al., 2013), and to engage in delinquent behaviours (Haynie, 2001). Much of this body of research relies on observational data, and the structure of this data means that it is not possible to formally identify the causal effect of peer behaviours on the behaviour of the ego without full information on both the choice of friends and the tendency to engage in a given behaviour, which is rarely available (Lyons, 2011; Shalizi and Thomas, 2011). However, randomised experimental research using the internet has shown that peer influence does have a causal effect on the behaviour of the ego (Salganik et al., 2006; Centola, 2010, 2011; Aral and Walker, 2012).
Although it is clear that peers play an important, and even a key, role in individual development, they do not account for everything. It may be true that parents have relatively little influence on the temperament or the personality of their children, but they certainly influence their socioeconomic outcomes. Intergenerational research on stratification shows that children disproportionately enter the socioeconomic class of their parents (Jonsson et al., 2009), though this effect is partly due to the heritable element of IQ (Björklund et al., 2010). It clearly not always easy to distinguish between the influence of parents and the influence of other factors in the shared environment. After all, children whose parents have a lower socioeconomic status predominantly attend schools where the other children have a similar background. Indeed, research capitalising upon school reforms in Norway finds little evidence for the education level of parents having a causal effect on the educational attainment of children, instead finding that other family characteristics and inherited ability explain the association (Black et al., 2005b). Nevertheless, the educational level of parents and their occupation are clearly a part of that family environment, intertwined with many other aspects of life, from the neighbourhood that the family lives in, to the resources they have at their disposal. It is also likely that educational aspirations are influenced by peers and teachers (Boudon, 1974), and there is also the highly plausible, though consistently nebulous, effect of neighbourhoods more generally (Sharkey and Elwert, 2011).

Although it is difficult to distinguish the influence that parents have on their children net of the influence of these other aspects of the local environment, it is clearly rash to dismiss any notion of their influence whatsoever. While the evidence suggests that parents do have little influence over the personality of their children (Harris, 1995, 1998; Pinker, 2002), by treating their children differently (Reiss et al., 2009), they clearly contribute towards the fact that siblings experience a non-shared environment. Research on the topic of birth order fundamentally assumes that the interaction between siblings and parents in the
household systematically influences the outcomes of the children. If the explanation for differences between siblings by birth order was pre-natal or physiological in origin, then it would still be possible for birth order patterns to emerge even if the influence of parents on siblings was constant and identical. However, research, including Study III in this thesis, shows that the explanation for birth order effects are not physiological, but are due to social, post-natal factors (Kristensen and Bjerkedal, 2007; Barclay, in press). This means that there must be within-family dynamics that partially shape the way that children develop, and crucially, that these family-dynamics must be systematically structured by birth order.

To avoid confusion on this topic, it is important to be absolutely clear about what outcomes we are talking about when discussing the influence of family dynamics, including birth order, on long-term trajectories. Skeptics of the importance of family dynamics, such as Harris (1998) and Pinker (2002), are unconvinced about the influence of family dynamics on personality and temperament. If, as it should be, birth order is considered to be one aspect of these family dynamics, then empirical evidence would appear to justify their skepticism. Although I will discuss this body of literature in greater detail later on in this introductory chapter, the most careful research on this topic generally shows that there is no systematic variation in personality by birth order (Ernst and Angst, 1983; Freese et al., 1999). At the same time, a large and growing body of literature argues that siblings do systematically differ in educational attainment and health by birth order (Black et al., 2005a; Bjerkedal et al., 2007; Barclay and Kolk, 2013; Barclay and Myrskylä, 2014). It is all too common for discussions about the importance of birth order to expand to very general assertions about the influence of this factor. As I hope to make clear in the rest of this chapter, birth order does play an important role influencing the long-term outcomes of children, but one must be very careful and particular about exactly how this works, and what these outcomes are.
As I stated above, a growing body of literature from Western, developed societies shows that educational attainment, and health in adulthood systematically differ by birth order amongst siblings within the same family. The most influential explanations that have been offered to explain these relationships expound upon the importance of resources within the family (Blake, 1981), and how the degree of intellectual stimulation experienced by children varies by birth order (Zajonc and Markus, 1975; Zajonc, 1976). At the same time we should also consider non-shared environment factors such as the fact that when parents divorce, children of different birth orders experience that event at different ages, which may affect their development (Sigle-Rushton et al., 2014). In the following pages I will discuss in depth both the theoretical mechanisms that have been proposed to explain the relationship between birth order and later life outcomes, as well as what empirical research has documented. However, as stated above, it is important to be precise when discussing the importance of birth order, both in terms of whether it is a within-family or a between-family phenomenon (it is the former), and in terms of what birth order is influencing. This thesis focuses on the influence of birth order on health in adulthood, and birth order and educational attainment. However, since it is central to the larger debate on birth order, I will also discuss the literature addressing the relationship between birth order and intelligence, and birth order and personality, later on in this introduction.

2. Birth Order: Theory

Although birth order research was primarily data driven for many years (Ernst and Angst, 1983), a number of theories have been developed that would account for a relationship between birth order and later life outcomes. Many of these theories are based upon assumptions about access to resources within the family and sibling interaction, though several physiological explanations for why birth order should influence later life outcomes have also been proposed. In this section I will describe the various theories that have been proposed at a conceptual level. The next section will address empirical research on birth order. When
considering the relative importance of these various theories, it is important to remember that it is not a horse race. It is both possible and likely that many of these mechanisms may play a simultaneous role in partially explaining the relationship between birth order and later life outcomes.

2.1. Social Explanations.

2.1.1. Resource Dilution Hypothesis. The resource dilution hypothesis is founded upon the principle that the pool of resources that parents have at their disposal is finite, and that as the number of children within the family increases, the portion of parental resources available to each child decreases (Blake, 1981). These parental resources are defined broadly, and include time, money, as well as more intangible qualities such as attention and patience. The resource dilution hypothesis states that earlier born children have an advantage over later born children as earlier borns have a cumulative advantage in terms of access to parental resources. When there is only one child in the household, he or she has access to 100% of the parents resources. However, when additional children are born, this changes. Given that it is usually not possible to measure exactly how resources are distributed amongst children, it is reasonable to assume that parents follow a heuristic where they distribute resources equally amongst their children at any given size of the sibling group (Hertwig et al., 2002). However, even if following this heuristic, earlier born children will have a cumulative advantage over later born children in terms of the access to parental resources at early ages (Hertwig et al., 2002).

It has also been pointed out that later born children may have increasing access to resources at a later age when older children leave the family home, meaning that the total value of resources received by first borns and last borns, for example, evens out by the time that all the children have left the family home (Hertwig et al., 2002). If we take a two child sibling group, and assume that they both leave home at age 18, and there is a birth interval of 3 years, the first born would have access to 100% of the parents resources for three years, followed
by 50% of the parental resources for the following 15 years. The second born in this example would have access to 50% of the parental resources from birth to age 15, followed by three years of access to 100% of parental resources.

Interpreted this way, the resource dilution hypothesis predicts that middle borns should be disadvantaged relative to first borns and last borns (Hertwig et al., 2002). To give another example similar to the last, let us assume a sibling group with three children, that they all leave home at age 18, and that there is a birth interval of 2 years between each of them. The first born has access to 100% of parental resources for the first two years, followed by two years of access to 50% of the parental resources, and then 14 years of access to 33% of the pool of parental resources. If we say that one year of 100% access to parental resources equals 1 unit, this means that the first born has access to 7.66 units of parental resources by the time they leave the family home. The last born also has had access to 7.66 units of parental resources by the time they leave the family home. The middle born, on the other hand, spends the first two years of his or her life with access to 50% of the pool of parental resources, 14 years with access to 33% of the pool of parental resources, and a final two years again able to access 50% of the parental resources. This leads to a total of 6.66 units of parental resources by the time the middle born has left the family home at age 18, in this case access equal to an entire year of parental resources less than the first and last born.

A dimension of this question rarely addressed in the literature is how there is likely to be variation in how different parental resources will dilute as the pool of siblings increases. Downey (1995) studied the relationship between the size of the sibling group and different parental resources and found that while an increase in the number of sibling diluted some resources linearly, the dilution of other resources followed a 1/x form (where x corresponds to the number of children), and others demonstrated a threshold pattern (Downey, 1995). More specifically, Downey showed that resources such as the frequency of talking between the parents and children showed a linear decline as the number of siblings
increased, while the $1/x$ form best described the dilution of resources such as money saved for college (this study was based upon US data), cultural classes, and cultural activities. The dilution of resources at the household level, such as access to a single home computer, was best fit by using a threshold function. Downey argued that parents are probably able to increase the total level of interpersonal resources available as more children enter the household, which is why measures such as time talking to children would show a linear decline. Resources such as financial savings, however, are more definitely finite, and so the difference between adding an additional child when you already have one, versus when you already have seven, is very different. In the former case the resources available to the established children declines by 50%, while in the latter it declines by less than 2% (Downey, 1995).

While Downey (1995) was studying the relationship between sibling group size and access to parental resources, there are good reasons why birth order effects should dominate over family size effects. Family size is not fixed at birth, unless you are the last born child, and this means that all preceding children will experience a different family size for varying lengths of time, which is determined by a combination of birth order and birth intervals. For example a first born child in a sibling group that will eventually have three children experiences a family size of one child (themselves) for a specific number of years, then a certain number of years in a two-child family, and finally, a three-child family. The question of what happens when the older siblings leave the family home is more vexed. If we assume that children who leave the family home no longer receive any support from the parents, then this would suggest that first borns and later borns should be advantaged at the expense of middle borns, and would predict that patterns of educational attainment or intelligence by birth order would demonstrate an inverse parabola relationship. However, there are several reasons to believe that earlier born children will still be advantaged over later borns, whether that relationship is linear or non-linear.
The first reason is that research indicates that greater access to parental resources at early ages is more critical for success in the educational system (Campbell and Ramey, 1994; Knudsen et al., 2006). Previous research has indicated that as the sibship size grows, children spend more time watching television, and less time reading (Mercy and Steelman, 1982). Children who receive more positive attention at home at early ages have better developed verbal and reading skills, and subsequently enter school better prepared. This early advantage leads to cumulative advantages for the earlier born children over later borns over subsequent grades (Campbell et al., 2001), and would predict that middle borns would outperform last borns for the same reason. The second reason why earlier born children may continue to be advantaged over later born children is that in Sweden parents often provide support to their adult children even after they leave the home (Björnberg and Latta, 2007). If parents support their children, even partially, through university or provide further assistance into adulthood, this would erode the advantages for later borns of being alone at home with the parents after the earlier children have moved away. Again, this would also predict that first borns would outperform middle borns, who would in turn outperform last borns. While the general review of empirical research will be left until section 3, it is worth noting here that Studies III and IV in this thesis show that the relationship between birth order and educational attainment declines linearly in smaller families, and in a non-linear pattern approximating a 1/x relationship in larger families.

2.1.2. Confluence Hypothesis. Like the resource dilution hypothesis, the confluence hypothesis also predicts that earlier born children will outperform later borns. The key idea of the confluence hypothesis concerns the degree of intellectual stimulation that children receive, and thus this theory pertains to the cognitive development of the children. The confluence hypothesis argues that children must be considered as a part of their own dynamically changing environment, and that the entrance into the family of additional children reduces the
aggregate level of cognitive maturity within the household (Zajonc and Markus, 1975; Zajonc, 1976). The first born child interacts exclusively with its parents, which is very cognitively stimulating for a young child. The second born however, interacts not only with its parents, but also with its much less cognitively mature older sibling. In this scenario the average degree of cognitive stimulation within the household falls, and this aggregate level of intellectual stimulation continues to decrease as more children enter the household. While this would seem to principally advantage the earlier born children over later borns, the advantage for earlier born children is gradually eroded as more children enter the household as they also spend more time interacting with siblings who are even less cognitively mature than themselves.

It has been suggested that this means that earlier born children actually do worse than later borns up until a certain point, estimated at approximately age 11 (Zajonc, 1976). Nevertheless, the confluence hypothesis still predicts that earlier born children will be advantaged over later born children later on in life. This recovery of advantage by the earlier born children is due to the opportunity to tutor their younger siblings, which serves to reinforce their own knowledge and skills (Zajonc et al., 1979). The last born never has a chance to tutor any siblings, and so in the long-run they fare the worst. Indeed, the other side of the tutoring advantage for earlier born children is that the later born children have their learning opportunities inhibited by not being able to discover the solutions for themselves (Blake, 1989a). It is worth noting that Zajonc (1976) actually argued that the key element of the confluence hypothesis was not birth order, but birth spacing, but that the measure of birth order could serve as a useful proxy for close spacing in the sibling group.

Some researchers have been critical of this latter addition to the confluence hypothesis, arguing that the additional tutoring dimension was only developed and included so as to explain a discrepancy between the predictions offered by the theory and empirical patterns when data on children below the age of 11
were studied (Rodgers, 2001a). Nevertheless, many found the tutoring dimension of the confluence hypothesis to have face validity. Indeed, the importance of tutoring has been used by some to explain why ‘only children’ often have a lower average IQ and educational attainment than first borns in a multi-child sibling group as it has been argued that only children do not have the opportunity to tutor any younger siblings (Zajonc, 2001). The resource dilution hypothesis would otherwise generally predict that only children would do better do to a lack of competition for parental resources. Nevertheless, it is important to consider that there may be selection processes that explain why parents only have one child which might also explain the mean differences in IQ or educational attainment.

2.1.3. Social Learning Theory. An alternative explanation for why siblings might differ by birth order can be found by considering that siblings interact and learn behaviours from one another. In particular, older siblings may serve as a role model to younger siblings, with the latter more likely to follow their example than vice versa. Research in the fields of social psychology and social networks has consistently shown that alters, including parents and siblings, are influential in shaping a variety of behaviours, with much focus on health behaviours such as smoking, alcohol consumption, eating patterns, and exercise (Christakis and Fowler, 2008; Rosenquist et al., 2010; Leonardi-Bee et al., 2011). The majority of studies in this area use observational data to analyse the influence of peers on the behaviour of the ego. While the results from many of these studies are highly suggestive of induction, meaning that there is a causal relationship between the behaviour of an alter and the behaviour of an ego, the nature of observational social network data usually means that it is difficult to be certain that these effects are not spurious.

Two alternative explanations for why the behaviour of an alter and an ego might be correlated are homophily, meaning that similar individuals are more likely to form a tie with one another (McPherson et al., 2001), and that the two
individuals share a common environment that increases the likelihood that they would both adopt a certain behaviour. For example, if a fast food chain opens a restaurant in a neighbourhood where two friends live, this might increase the probability that these two individuals, who already knew each other, would both start to eat there, and therefore to gain weight. However, although homophily and a shared environment may sometimes explain why behaviours between connected individuals are correlated, experimental research using the internet to examine the influence of alter behaviour on the adoption of health behaviours (Centola, 2010, 2011), and the consumption of popular music (Salganik et al., 2006), has shown that peers can have a causal effect on the probability that the ego will adopt a certain behaviour, providing evidence for a genuine induction effect.

Siblings are also connected individuals. Studies focused on sibling influence indicate that later born siblings are more likely to begin smoking if an older sibling already smokes, but this relationship is not reversed (Harakeha et al., 2007). Research also suggests that because younger siblings may sometimes learn smoking from older siblings, they are likely to begin smoking at younger ages (Bard and Rodgers, 2003). It is highly plausible that older siblings may not only serve as a role model, though in this case not a positive one, but that they would also be able to facilitate access to cigarettes for younger siblings at an age before they would be able to obtain them independently. Smoking initiation at younger ages is associated with a greater daily cigarette consumption, and a stronger tendency towards smoking continuation, particularly when smoking initiation begins before the age of 16 (Chen and Millar, 1998; Khuder et al., 1999). This would suggest that individuals with a higher birth order should be more likely to smoke in the long term, with obvious implications for their future health.

More generally, research shows that younger siblings are more likely to initiate developmentally inappropriate activities at younger ages, and to experience their sexual debut at a younger age (Blane and Barry, 1973; Rodgers and Rowe,
While a shared environment that encourages smoking, such as having parents that smoke, might increase the probability that any child in the sibling group would smoke, it is not clear that this would be an explanation for why younger siblings would begin smoking at a younger age. Indeed, research using a within-family comparison design supports the explanation that older siblings influence smoking uptake by younger siblings (Bard and Rodgers, 2003). An additional factor that may be of influence here is parental social control, which has been shown to diminish as the size of the sibling group grows. One explanation for this may be a shortage of resources, such as time, to keep a close eye on all the children as their number increases.

2.1.4. Sibling Niche Differentiation Model. In Study I of this thesis, my co-author and I refer to the sibling niche differentiation model as the family dynamics model. However, as most of the theoretical explanations for why birth order should influence later life outcomes rely upon presumed family or sibling dynamics, I here refer to the model as the sibling niche differentiation model (SNDM). The SNDM was first proposed by Sulloway (1996) in his book, *Born to Rebel*. The SNDM is based upon several assumptions. The first, similar to the resource dilution model, is that parents have a limited pool of resources. Sulloway also draws inspiration from Darwin, and particularly the idea of evolutionary diversification. He argues that siblings adapt to their family environment just as species develop evolutionary adaptations that allow them to succeed in their ecological environment. The SNDM posits that siblings develop interests and abilities that distinguish them from their siblings, so as to avoid direct competition with these siblings, and to allow them to gain increased parental investment (Sulloway, 1996, page 97-98). This ‘adaptive radiation’ leads to consistent variation between siblings within any given family, with, for example, last borns particularly likely to exhibit greater Openness to experience (one of the Big 5 personality traits) as this allows them to discover an unfilled niche
within the family (Sulloway, 1996, page 86). Broadly speaking, this model predicts that first borns tend to be more conservative and have values that are more closely aligned with those of their parents, and that later borns tend to be more rebellious and liberal (Sulloway, 1996; Zweigenhaft and Von Ammon, 2000; Sulloway and Zweigenhaft, 2010).

2.1.5. *Optimal Stopping Theory.* Optimal stopping theory is based upon the idea that one aspect of the decision made by parents to continue childbearing is the experience that they have had with their current children (Newman, 2008; Read et al., 2012). Indeed, many parents report that the experience of raising a child is much more challenging than they had previously expected (Presser, 2001; Read et al., 2012). Furthermore, research findings suggest that parental happiness levels after the birth of a child influence the likelihood of having an additional child (Cartwright, 1976; Callan, 1985; Newman, 2008; Myrskylä and Margolis, 2014). It is certainly plausible that if a child has specific health or behavioural problems then this will make the experience of childrearing even more challenging than it already is. If this in turn influenced parental decisions about whether to have any further children, then this would have the potential to generate a pattern where the last born in sibling groups of any size has lower levels of attainment, or worse health. While research using cross-sectional data has sometimes shown that last borns perform substantially worse than their older siblings (Belmont and Marolla, 1973, for example), studies using a sibling comparison approach do not typically exhibit this pattern of results.

2.1.6. *Selfish Parents.* Although this is not a theory that is widely encountered in the literature on birth order, some have speculated that birth order patterns might be the consequence of self-interested conscious decisions made by the parents (Silles, 2010). If parents choose to value their own welfare over those of their children as a collective group, and particularly over the welfare of later born children, then they may choose to invest most heavily in the first born child. Silles (2010) has argued that first borns are the most likely to be able
to provide their parents with various types of support as they age, as they will be the oldest and most capable of providing that support. Furthermore, the parents are more likely to be alive to benefit from that support from the oldest child. Silles (2010) also argues that parents may not only perceive that they have diminishing marginal utility from parental investment after the first born, but also that parents may believe that they have become more efficient and capable parents due to having gained some experience, which may cause them to reduce the time they spend raising later born children.

2.2. **Physiological Explanations.**

2.2.1. *Immunoreactive Theory (IMRT).* One biological theory that has been proposed to explain the relationship between birth order and a variety of outcomes is the immunoreactive theory (IMRT) (Gualtieri and Hicks, 1985). The IMRT explanation for the relationship between parity and a variety of outcomes is based on several principles that rest upon male antigenicity. Male antigenicity describes how histocompatibility-Y antigens, exclusive to males as they are located on the Y-chromosome and thus alien to the mother, induce an immune system response from the mother when she carries a male foetus (Gualtieri and Hicks, 1985). This antibody response from the mother is hypothesised to have a permanent negative effect on the uterine environment (Gualtieri and Hicks, 1985; Puts et al., 2006), and would grow more severe with bearing additional sons due to the memory inherent in human immune system response (Bogaert and Skorska, 2011). The IMRT predicts a negative effect of increasing parity, but more particularly a negative effect of the number of sons, on a range of different outcomes. The IMRT has been most consistently applied to research on sexual orientation, with research suggesting that the prevalence of homosexuality amongst males is higher amongst later born boys who have a higher proportion of older brothers, which has become known as the fraternal birth order effect (Blanchard, 1997, 2001; Bogaert and Skorska, 2011). Evidence
for the prenatal physiological mechanism rather than a potential alternative hypothesis regarding socialisation comes from research which shows that fraternal set order in blended and adoptive families does not have any association with homosexuality in males, while it does in fully biologically related sibling sets (Bogaert, 2006), though not all studies support the hypothesis (Bearman and Brückner, 2002; Frisch and Hviid, 2006).

2.2.2. Maternal Age. An additional physiological factor to consider is that later born children in a sibling group are necessarily always born to an older mother. The increase in the risk of birth defects of children born to older mothers actually rises very slowly until the mother reaches the age of 40, but children born to mothers above the age of 40 do have a risk of suffering from certain birth defects (Gill et al., 2012). Advanced maternal age is also associated with accumulation of DNA damage to germ cells (Kaytor et al., 1997), decreasing oocyte quality (Armstrong, 2001), as well as an increased risk of pregnancy complications (Heffner, 2004). Children born to very young mothers are also at increased risk of some problems. Teenage mothers are more likely to give birth to a low-birthweight child. Some potential explanations for this relationship are biological underdevelopment, the fact that teenage mothers are more likely to have a lower socioeconomic status and be in poverty, and that teenage mothers may be more likely to engage in detrimental health behaviours (Strobino et al., 1995; Roth et al., 1998). Although maternal age at the time of birth is rather straightforward to take into account when analysing the effect of birth order, by including the variable in a multivariate regression model, it is an important factor to bear in mind.

2.2.3. Birth Weight. Birth weight increases with parity (Crump et al., 1957; Kramer, 1987), and first borns are more likely to suffer from abnormally low birth weight (Douglas, 1950; Fedrick and Adelstein, 1978; Kramer, 1987). A heavier weight at birth is also related to physical development in childhood and adolescence, as a heavier weight at birth is associated with greater height and
weight at later ages (Babson et al., 1964; Binkin et al., 1988). This impact of birth weight exists across the distribution, and not just in a comparison between normal weight and low birth weight infants (Binkin et al., 1988). Some research has found that onset of puberty varies by birth order, with later born children experiencing earlier onset (Rodgers et al., 1992). This is important to bear in mind when considering the importance of sibling influence as a factor shaping individual behaviour, at least so far as initiation of sexual behaviour is concerned; researchers who first attributed the earlier onset of sexual behaviour to sibling influence (Rodgers and Rowe, 1988), later argued that this was due to earlier physical maturation instead (Rodgers et al., 1992).

Birth weight is not only related to physical growth and development in childhood and adolescence, but also to outcomes much later in life (Conley and Bennett, 2000; Hack et al., 2002; Black et al., 2007). A study using Norwegian register data comparing twins who vary in birth weight has found that a heavier weight at birth is associated with an advantage in physical height in adulthood, a higher IQ, greater educational attainment, and greater earnings in adulthood (Black et al., 2007). Studies using within-family sibling comparisons and comparisons of monozygotic twins in the United States have also found that birth weight is positively associated with IQ, educational attainment, height, and labour market success (Conley and Bennett, 2000; Behrman and Rosenzweig, 2004). Clearly the fact that later born children have, on average, greater birth weight, means that birth weight is a relevant factor when considering the relationship between birth order and later life outcomes. Unlike many of the other theoretical explanations reviewed in this section, viewed through the lens of birth weight later birth order children would be expected to outperform first borns in terms of later life outcomes.

2.2.4. Birth Intervals. Birth intervals can play an important role in development, and particularly for the second born in any pair of births. Empirical research shows that peri-natal outcomes are often negative when the conception
interval since the birth of the previous child is less than six months (Zhu et al., 1999). A short birth interval has been found to be associated with a range of negative outcomes, such as low birth weight, pre-term birth (Douglas, 1950; Conde-Agudelo et al., 2006), and infant mortality (Bhalotra and Soest, 2008), while studies suggest that a conception interval of 18 to 23 months is associated with positive outcomes for the next born child (Zhu et al., 1999). The main explanation proposed for this relationship is maternal nutritional depletion (King, 2003). Child bearing places a substantial degree of strain on the physical resources of the mother, and the in-utero environment benefits when the woman has a chance to fully recover. An important factor in this is the way that the foetus and mother interact as they consume nutritional resources. It was previously believed that the foetus was similar to a parasite, and took what it needed regardless of the physical status of the mother, while it is now understood that the mother and the foetus in fact compete for resources. This means that if nutritional resources are scarce, the foetus may not receive all the resources that they require (King, 2003).

Research has also indicated that there may be long-term impacts, as the children born after a short interval have higher rates of schizophrenia (Gunawardana et al., 2011), and lower test scores (Powell and Steelman, 1990, 1993). However, the relationship between conception interval and various outcomes is endogenous, and amongst other factors is linked to parental socioeconomic resources, and parental health and fecundity (Buckles and Munnich, 2012). Given that the time between conceptions is endogenous, some researchers have attempted to identify the causal impact of birth intervals by using policy reforms as an instrument for shortening birth intervals (Petterson-Lidbom and Skogman Thoursie, 2009), and by examining the outcomes of children whose mothers have suffered miscarriages (Buckles and Munnich, 2012). These studies show that a longer birth interval increases test scores for the older sibling of the sibling pair (Petterson-Lidbom and Skogman Thoursie, 2009; Buckles and Munnich, 2012). Surprisingly, given that previous research shows that a short
preceding interval is associated with poor peri-natal outcomes, there is no discernable impact of the birth interval on the test scores of the younger sibling (Buckles and Munnich, 2012). Although using miscarriage as an instrument has been criticised due to the fact that it has other impacts, such as reducing completed family size, that also influence child development (Strøm, 2012), the policy reform examined by Petterson-Lidbom and Skogman Thoursie (2009) did not have the same problem.

Overall, these studies suggest that a negative relationship between birth order and later life outcomes might be related to birth intervals, particularly as an 18-month birth interval is not uncommon in Sweden. Figure 1 shows the distribution of the preceding and subsequent birth interval for births between 1950 and 2010 in Sweden. However, the first of the two studies to examine long-term impacts of birth intervals using a causal research design did not focus on the younger sibling in a given pair (Petterson-Lidbom and Skogman Thoursie, 2009), and the second study found no discernable impact on the younger sibling of the pair (Buckles and Munnich, 2012). If short birth intervals were the main explanation for the relationship between birth order and later life outcomes, it would be expected that this would primarily operate through the younger sibling of the pair being disadvantaged by that short interval. As it is, the relative

![Figure 1. Distribution of Preceding and Subsequent Birth Interval for Index Person for All Births in Sweden between 1950-2010.](image)
importance of birth intervals on long-term outcomes can be said to be primarily unexplored, particularly as it is only test scores and years of educational attainment that have been examined using causal research designs up to now.

2.2.5. **Hygiene Hypothesis.** The hygiene hypothesis (Strachan, 1989) has two potential interpretations. The first, by the original author, argues that having more children in the household increases exposure to disease, and this leads to a more developed immune system. One would expect that this would benefit later born children, as well as children in households with a larger number of siblings more generally; that is, there should be independent effects of birth order and family size (Strachan, 1989; Holman et al., 2003). Later born children and children in large families are less likely to suffer from allergic diseases such as eczma, though these findings are not always consistent for other atopic diseases (Matricardi et al., 1998; Bernsen et al., 2003).

The second interpretation of the hygiene hypothesis argues that a larger sibship increases the likelihood of communicable diseases being introduced into the family, and younger siblings may be more susceptible to these diseases (Myrskylä, Silventoinen, Jelenkovic, Tynelius and Rasmussen, 2013). While it would seem that this explanation would be more appropriate in historical or developing societies where the communicable diseases are often more severe, there are examples of this mechanism operating in modern developed societies, with household crowding found to be associated with the risk of tuberculosis and acute rheumatic fever (Baker et al., 2008; Jaine et al., 2011). Furthermore, post-neonatal mortality is also higher amongst later born children, and it has been suggested that this is related to environmental pathogens (Heady et al., 1955).

2.3. **Alternative Explanations.**

2.3.1. **The Admixture Hypothesis.** The admixture hypothesis provides a completely different perspective on birth order research (Velandia et al., 1978; Page and Grandon, 1979; Rodgers, 2001a). The admixture hypothesis is not really
a hypothesis in the sense of the other hypotheses described above, but instead posits that birth order effects do not exist at all. The key argument of the admixture hypothesis when it was first proposed was that almost all the empirical research that had sought to test the relationship between birth order and a range of later life outcomes was based upon cross-sectional data (Rodgers et al., 2000). This cross-sectional data meant that the statistical methods that were used to analyse the data were between-family comparisons. By between-family comparisons I mean comparing individuals of different birth orders across different families. The reason that this is problematic is that all the theories that have been proposed to explain the relationship between birth order and later life outcomes describe within-family processes that would produce differences by birth order. The admixture hypothesis argues that the only way to detect a within-family pattern is to conduct a within-family comparison, which means comparing siblings of different birth order to one another.

Tolstoy once wrote that “All happy families are alike; each unhappy family is unhappy in its own way”. Supporters of the admixture hypothesis and many other birth order researchers would say that this was only half true. All happy families are different from one another as well, and comparing children from different families in the attempt to identify a within-family phenomenon does not allow one to draw clear conclusions. One alternative explanation that has been proposed for birth order effects based upon cross-sectional data is that parents with higher IQ might be more likely to have smaller families, and low IQ parents larger families, and this would produce a negative birth order pattern in the data (Rodgers et al., 2000). Furthermore, even if it is possible to adjust for the size of the sibling group, the educational level of the parents, and the age of the parents, there are myriad other differences between families, many of which would be difficult to measure even if they could be identified (Rodgers et al., 2000). Based upon some studies that showed no relationship between birth order and intelligence (Olneck and Bills, 1979; Galbraith, 1982; Retherford and Sewell, 1991, for example), some have argued that if there is no within-family
empirical pattern, then there is actually nothing for any birth order theories to explain (Rodgers, 2001a).

The researchers who described the admixture hypothesis were completely correct in their critique of the methodological approach of the between-family comparison. Nevertheless, research on the relationship between birth order and intelligence is not as conclusive as some would claim. Furthermore, there is clear and consistent evidence for the relationship between birth order and educational attainment. This suggests that birth order theories do indeed have something to account for. Literally thousands of studies of birth order have been conducted over the past two hundred years (Ernst and Angst, 1983; Rodgers, 2001a), but only a small number have actually conducted a within-family comparison. In the following section I will review research on the relationship between birth order and a range of outcomes, including educational attainment, intelligence, health, and personality. The results presented in studies that have conducted a between-family comparison are confounded to an unknown degree, but there is a possibility of serious bias. As a result I will largely ignore the body of research that has used between-family comparisons, as these studies do not allow for valid inference. Thus, the review of the literature below principally focuses upon studies that have used a within-family comparison.


Research on birth order has largely focused on its association with intelligence, educational attainment, and personality. A relatively new area of interest is the relationship between birth order and later life health outcomes. Although this thesis focuses upon the relationship between birth order and educational attainment, and birth order and health, there has been so much research on the relationship between birth order and intelligence, and personality that it is worthwhile reviewing the literature on those topics so as to situate my own work within the field as a whole.
3.1. **Intelligence.** There have been hundreds of studies on the relationship between birth order and intelligence (Ernst and Angst, 1983), and so rather than describing the intellectual debate as it has progressed over time, it makes more sense to point out some key milestones, summarise the key points of contention, and to move to the current state of knowledge on the topic. Interest in the relationship between birth order and intelligence had an early beginning. Although the claim was not always made explicitly, early studies that showed that first borns were over-represented amongst scientists, college students, and Rhodes scholars, at the very least presumed that this demonstrated the preeminence of earlier born children (Galton, 1874; Gini, 1915; Apperly, 1939; Schachter, 1963). Research addressing the relationship between birth order and the construct IQ (devised in 1912) has existed for almost as long, with examples in the literature emerging at least as early as the 1920s (Thurstone and Jenkins, 1929). However, much of the early research on this topic was criticised on the grounds of flawed study designs, such as the prevalence fallacy, where selection bias precludes the ability to draw clear inferences about the importance of birth order (Price and Hare, 1969; Schooler, 1972).

Despite this, a new wave of research on the relationship between birth order and IQ was stimulated by a study based upon a large cross-sectional dataset of almost 400,000 Dutch adolescents, appearing in *Science*, showing that later born children had a lower IQ (Belmont and Marolla, 1973). The study by Belmont and Marolla (1973) encouraged the publication of many new empirical studies of the relationship between birth order and IQ. It was also this study that inspired the development of the confluence hypothesis (Zajonc and Markus, 1975), and the resource dilution hypothesis (Blake, 1981), described in detail in sections 2.1.2 and 2.1.1. Many of these new studies addressing the relationship between birth order and intelligence sought to test this new theory. However, despite this renewed interest, many researchers continued to be skeptical about both the relationship between birth order and intelligence, and the newly developed confluence hypothesis (Page and Grandon, 1979). More specifically, the
admixture hypothesis (see section 2.3.1), was developed as a criticism of this cross-sectional-data-based approach to birth order research (Page and Grandon, 1979).

In addition to this general criticism of birth order research based upon cross-sectional data, there were additional concerns about the data used for the study by Belmont and Marolla (1973). In this case, the selection of a cohort of adolescents, born 1944-1947, meant that the first and lower birth order individuals in the sample came from families that were predominantly started after World War II, whereas the high birth order individuals came from families that were started during the Great Depression. Even though they were all born in roughly the same year, they were drawn from families which had vastly different access to resources and experiences during this particularly traumatic period of the 20th century (Blake, 1989). A more recent criticism of research on the relationship between birth order and intelligence concerns the Flynn effect. The Flynn effect describes the tendency of the population averaged IQ to increase over time, with this increase usually around 3 IQ points per decade (Flynn, 1984, 1987). Rodgers (2014) has argued that the Flynn effect entirely accounts for the birth pattern shown in the study by Belmont and Marolla (1973).

Although critics argued that there was nothing to even be tested, as they believed that the confluence hypothesis was invented to explain a pattern that did not actually exist (Rodgers, 2001), this did not stop empirical testing of the theory. Although the vast majority of these studies were based upon between-family comparisons, a small number did use siblings data. This kind of data made it possible to perform a within-family comparison. As I described in greater detail in section 2.3.1, birth order theories are based upon within-family dynamics, and therefore valid inferences about birth order effects can only be drawn from within-family data. Some of these studies found support for the relationship between birth order and intelligence (Berbaum and Moreland, 1980; Pfouts, 1980; McCall, 1984), but others found none at all (Olneck and Bills, 1979; Mascie-Taylor, 1980; Galbraith, 1982; Retherford and Sewell, 1991).
However, even interpretation of the results from these studies differs between those who argue for and against the existence of the relationship between birth order and IQ. For example, some of the studies that are counted as showing no support have relatively low statistical power, but show coefficients that point in the direction of the pattern predicted by theories like the resource dilution and confluence hypothesis (Olneck and Bills, 1979; Retherford and Sewell, 1991). Others, supporting the existence of a negative relationship between birth order and IQ have later been reinterpreted as showing no support (Berbaum and Moreland, 1980) (see Rodgers (2001a)).

Somehow, this debate continued through the 1990s, the 2000s, and to the present day (Retherford and Sewell, 1991; Rodgers et al., 2000; Bjerkedal et al., 2007; Rodgers, 2014). The reason for this continuing debate is that divergent results appear in the literature. A simple distinction that can be found is that research based upon data from the United States using a within-family comparison has shown that there is no relationship between birth order and intelligence (Rodgers et al., 2000; Wichman et al., 2006), while studies from the Nordic region, and more specifically Norway, show that there is a relationship between birth order and IQ, with later born brothers performing worse than earlier born brothers (Bjerkedal et al., 2007; Black et al., 2011). It is possible that there are differences in birth order effects across differences countries. I can report from my own analyses (Barclay, 2014), that the same pattern exists in the Swedish military conscription data, with later-born children performing worse on the item used to measure cognitive ability. A second noticeable distinction between the studies from the US and the UK, and from the Nordic region is the different types of data used. The Nordic studies are based upon administrative register data, while the US and UK studies are based upon survey data. However, the US studies do not generally even show a negative relationship between birth order and IQ, so the explanation is not simply one of statistical power. As will be clear in the next section, and from Study III in this thesis, birth order patterns in
educational attainment are also apparent when the population used for analysis numbers in the hundreds, so it is not necessary to have millions of data points.

3.2. **Educational Attainment.** Intelligence and educational attainment are related, with studies typically showing a correlation ranging from approximately 0.4 to 0.6 (Neiss et al., 2002; Rodgers et al., 2008). Nevertheless, educational attainment and intelligence are completely distinct measures. As section 3.1 indicated, there remains a lack of consensus on the relationship between birth order and intelligence. In the case of the relationship between birth order and educational attainment there is much more agreement. Part of the reason for this is that critics of the literature addressing the relationship between birth order and intelligence, who are particularly critical of the confluence model (Rodgers, 2001a) are much more receptive to the idea that resource dilution within the family could influence educational outcomes.

When considering the full body of research concerning the relationship between birth order and educational attainment, the evidence is mixed, with some studies showing that later birth order children have lower educational attainment, and other studies finding no statistically significant patterns of association. As with research on the relationship between birth order and intelligence, the majority of previous research was conducted using data comparing individuals with different birth orders across different families. As described above, this between-family comparison approach has been heavily criticized due to the possibility of confounding by unobservables (Rodgers et al., 2000; Rodgers, 2001b). However, recent studies with data on multiple members of the sibling group have been able to apply a within-family comparison approach. These studies that have applied a within-family comparison approach used fixed effects have consistently shown that later birth order causes lower educational attainment (Black et al., 2005a; Kalmijn and Kraaykamp, 2005; Kantarevic and Mechoulan, 2006; Kristensen and Bjerkedal, 2010; Härkönens, 2014). These studies have also found that this pattern is consistent when separate sibship size
specific models are conducted (Black et al., 2005a, and Studies III and IV in this thesis).

Research on the relationship between birth order and educational attainment using a within-family comparison design has been conducted using data from Norway (Black et al., 2005a), the Netherlands (Kalmijn and Kraaykamp, 2005), the United States (Kantarevic and Mechoulan, 2006), Germany (Härkönen, 2014), and Sweden (Barclay, in press). With the exception of the study by Kantarevic and Mechoulan (2006), most research on the relationship between birth order and educational attainment has been based upon data from Western Europe or the Nordic region. All of these countries (Norway, Sweden, the Netherlands, and Germany) have educational systems that are free, or heavily subsidised (Willemse and De Beer, 2012). Average tuition fees as a percentage of GDP per capita in 2006/07 were 2.7% in Norway, 0.0% in Sweden, 3.1% in the Netherlands, and 1.3% in Germany (Willemse and De Beer, 2012). This can be compared to average tuition fees as 25.5% of GDP per capita in the United States (Willemse and De Beer, 2012). At least in the United States these numbers will be higher today (2014) due to economic stagnation and tuition fees that have increased inexorably for many years.

The fact that birth order patterns in educational attainment are found across countries with a great deal of variation in the cost of higher education is intriguing. If the resource dilution hypothesis explains the relationship between birth order and educational attainment, it might be expected that later borns would do particularly badly in countries with very high tuition fees for tertiary education such as the United States, and more recently, the United Kingdom. The fact that birth order patterns are also present before individuals enter higher education (e.g. in high school) (Kantarevic and Mechoulan, 2006; Härkönen, 2014), indicates that, assuming the resource dilution hypothesis is correct, the value of resources for educational development are salient far before any significant education costs have to be borne by the family. Although at first sight this pattern would seem incongruent with the resource dilution hypothesis, it is consistent
with other research examining how early life access to resources, measured by socioeconomic status, for example, influences educational achievement prior to university (Sirin, 2005).

3.3. **Birth Order and Health.** In contrast to studies in the relationship between birth order and intelligence and personality, far fewer studies have addressed the relationship between birth order and health. There have been several studies that have examined the relationship between birth order and health. There have been several studies that have examined the relationship between birth order and infant mortality in both historical and contemporary societies. As described above, in section 2.2.3, studies have also shown that birth order is associated with birth weight (Crump et al., 1957; Kramer, 1987), and the onset of puberty (Rodgers et al., 1992). A small number of studies have also examined the relationship between birth order and height (Grant, 1964; Alter and Oris, 2008; Myrskylä, Silventoinen, Jelenkovic, Tynelius and Rasmussen, 2013). If the scope was restricted to those studies that have performed a within-family comparison examining later life health, broadly defined, the number of studies falls to a mere handful (Barclay and Kolk, 2013; Bjørngaard et al., 2013; Jelenkovic et al., 2013; Myrskylä, Silventoinen, Jelenkovic, Tynelius and Rasmussen, 2013; Barclay and Myrskylä, 2014; Rostila et al., 2014).

Generally speaking, empirical research on the relationship between birth order and health has found a pattern consistent with that shown in research on birth order and educational attainment, which is that later born children fare worse. For example, studies examining the association between birth order and height have shown that later born children are shorter than their earlier born siblings. Adult height is often considered to be useful measure of the quality of early life conditions. Using data on siblings collected in London in 1960, Grant (1964) found that later borns were shorter by 0.8cm. A recent study using military conscription data from Sweden and performing a within-family comparison found that compared to first borns, second borns were 0.4cm, third borns 0.7cm, and fourth borns 0.8cm shorter, respectively (Myrskylä, Silventoinen,
Jelenkovic, Tynelius and Rasmussen, 2013). One study using historical data actually found that later born brothers were taller than earlier born siblings, but this was explained by substantial improvements to environmental conditions in the intervening period (Alter and Oris, 2008). This is discussed in greater detail later in section 5, and in Study IV in this thesis.

A number of studies have been made of the relationship between birth order and infant mortality. This research has mainly been conducted using data from developing societies, and using historical demographic data. The pattern that emerges from this field of research is decidedly mixed. In developing countries, some studies have shown that birth order is negatively associated with infant mortality (Bolstad and Manda, 2001; Gemperli et al., 2004), others show a positive relationship (Brittain, 1992; Mulder, 1998; Sear et al., 2002), and some show a U-shaped relationship (Breiman et al., 2004). Studies using data from developed countries, such as the UK, have also shown that there are birth order patterns in infant health, with early born children faring better (Kaplan et al., 1992). However, with few exceptions (Bolstad and Manda, 2001; Sear et al., 2002, for example), most of these studies have used between-family comparisons and cross-sectional data, which means that it is difficult to draw firm conclusions.

There are relatively few studies investigating the relationship between birth order and measures of health in adulthood. Jelenkovic et al. (2013), using Swedish military conscription data and a within-family comparison, found mixed patterns in the relationship between birth order and muscle strength in early adulthood; later borns had greater hand grip and elbow flexion strength, while earlier born children performed better in knee extension tests. The same study also found that later born children had a lower BMI, but there was no statistically significant pattern in terms of blood pressure (Jelenkovic et al., 2013). A number of epidemiological studies have also investigated the relationship between birth order and the development of cancer, including lung cancer (Hemminki and Mutanen, 2001; Richiardi et al., 2004; Altieri and Hemminki, 2007;
Amirian et al., 2010; Bevier et al., 2011). The findings from these studies have also been mixed, and the association found with birth order varies according to the specific site of cancer development.

Several studies have also investigated the relationship between birth order and mortality (O’Leary et al., 1996; Modin, 2002; Smith et al., 2009). Using the Utah Population Database, Smith et al. (2009) investigated how a range of early life factors were associated with mortality risk in adulthood. The impact of birth order on adult mortality risk was not the main focus of the study. Operationalizing birth order as a binary variable indicating whether the individual was first born or not, this study found no statistically significant associations between birth order and adult mortality risk for either males or females. The study by O’Leary et al. (1996) found little relationship between birth order and mortality risk, but used a small (n=1,162), and non-representative sample. Finally, a study using Swedish data (n=14,192) from the Uppsala Birth Cohort Study found that birth order was associated with an increased risk of all-cause mortality for both males and females aged 20-54, and for males aged 55-80 (Modin, 2002). No statistically significant patterns were found after adjusting for the socioeconomic status of the ego in adulthood. However, sibling size was not adjusted for in the models, which leaves open the potential for confounding.

More recently, two studies have been published examining the relationship between birth order and suicide (Bjørngaard et al., 2013; Rostila et al., 2014). Both studies used Nordic register data, with Bjørngaard et al. (2013) using Norwegian data, and Rostila et al. (2014) using Swedish data, and both studies stratified their analyses by sibling group membership. Both studies found a positive, monotonic, relationship between birth order and the hazard of suicide. Rostila et al. (2014) also conducted additional analyses where they examined the relationship between birth order and other causes of death. The results differed according to which cohorts were being studied, with a positive (though not statistically significant) relationship between birth order and all-cause mortality for those born 1967 to 1980, but only a weak, positive relationship for those
born 1932 to 1980, for example. Separate results for men and women were only presented for the analyses on the relationship between birth order and suicide, which showed that a similar pattern pertained across both groups.

The first study in this thesis also investigates the relationship between birth order and mortality. The key contributions of Study I are that it uses a within-family comparison approach, in contrast to most previous research on the relationship between birth order and mortality, and examines how this relationship differs by gender. Although further details are available in section 11 of this introductory chapter and in Study I, to summarise briefly: later borns suffer from higher all-cause mortality relative to first borns, and this is true in separate analyses by the size of the sibling group for sibling groups with two to six siblings. The pattern is stronger for women than for men, and we also find that the pattern varies by the particular cause of death. The birth order pattern is strongest for mortality attributable to cancers of the respiratory system, and neoplasms generally for women, and for both men and women later borns have elevated mortality attributable to external causes, such as suicides and accidents.

3.4. **Birth Order and Personality.** While research on the influence of birth order on health and socioeconomic outcomes in adulthood in Western developed societies clearly points in one direction, the research on personality differences by birth order remains far less conclusive (Ernst and Angst, 1983; Freese et al., 1999). In a thorough review of research published on the relationship between birth order and personality conducted between 1946 and 1980, Ernst and Angst (1983) concluded that birth order does not systematically affect personality. Indeed, they went further than that, stating in the preface that “this kind of research is a sheer waste of time and money” (Ernst and Angst, 1983, page: XI). This is not to say that siblings do not differ significantly in their personality - that much is clear to anybody - but that this variation in personality is not consistently patterned by birth order. That is to say that there is no adequate evidence to demonstrate that first borns are more conscientious or responsible, while later
born are more rebellious, or care-free, despite the popularity of these urban myths. That is not to say there isn’t a very large volume of literature purporting to support these assertions. One of the most prominent of these is Frank J. Sulloway’s (1996) *Born to Rebel*. Given that this book reignited interest in birth order effects both inside and outside of academia, it is necessary to consider the arguments of the book before dismissing its claims with sound reason.

Sulloway’s *Born to Rebel: Birth Order, Family Dynamics, and Creative Lives*, published in 1996, became a bestseller, and also reignited interest in birth order as a topic of research. The book was based upon years of historical research as Sulloway compiled information upon the birth order of individuals who were participants in 28 historical ‘revolutions’. These revolution events were defined as highly divisive scientific controversies over key conceptual points, with examples including the Copernican revolution, the Newtonian revolution, and the Darwinian revolution. Furthermore, Sulloway included in his study the Terror following the French Revolution, and the Protestant Reformation. Sulloway further classified these revolutions into two types, which were ‘radical ideological revolutions’, and ‘technical revolutions’. Sulloway’s argument was based upon the theory that birth order caused competition amongst siblings for parental resources and attention. In this work Sulloway conceptualized birth order as a dichotomy between first borns, which included only children, and later borns.

Sulloway argued that competition for parental investment within the family caused siblings to adapt their behaviour so as to occupy particular niches within the family. First borns and only children were the most likely to be aligned with their parents as they experienced a period of time where they were the only child within the home, and where they were the sole focus of parental care. This led them, on average, to identify with power and authority, and thereby to become more conservative and socially dominant than their later born siblings. Later born children, finding that they were disadvantaged from the very beginning in terms of size and strength, were naturally more inclined to develop a personality.
that was questioning of authority. Furthermore, in the scramble for parental investment, later borns were forced to become more creative, original and follow risks so as to achieve that goal. Broadly speaking, Sulloway reported that of the various 28 revolutions that he studied as he developed *Born to Rebel*, later borns were far more likely to support the challenge to the status quo than were first borns.

Although Sulloway’s work drew widespread admiration both for its originality and the depth and breadth of the original research, it also sparked controversy. As with any piece of work claiming to explain the answer to a fundamental question, in this case sibling differences and the tendency to rebel, there were skeptics. Part of the success of Sulloway’s work was undoubtedly its ability to appeal to the personal experience of the reader. As anybody who conducts research on birth order knows, everybody has an opinion on this topic, and many people are quick to offer their support, or skepticism, towards any theory on this topic based upon their own personal experience. As engaging as it is, Sulloway’s thesis suffers from several flaws that undermine its propositions.

The first of these weaknesses is what is known as the prevalence fallacy (Blake, 1989a). This is the approach of counting how many individuals take a certain ideological position, or hold a certain occupation, or what have you, and then counting how many of them are of a certain birth order. The problem is that there is no way of knowing what underlying selection biases are responsible for the number of individuals in whatever particular category is of interest, meaning that it is not possible to draw conclusions about what the relative prevalence of individuals of a given birth order in that category actually signifies. A hypothetical best practice approach to addressing this question would be instead to have an entire population, particularly where it is known who are siblings to one another, as this would avoid these selection biases.

A second problem, related to the first, with this approach to identifying personality differences by birth order is methodological. The finding that first borns tend to support the status quo while later borns contest it in this case relies upon
a comparison of siblings from different families. Although this point is discussed in greater detail in sections 2.3.1 and 9, it can be said here that if one is keen to identify the influence of birth order, it is important to compare siblings from the same sibling group. Hypothetically, if parents who are conservative tend to have only children, or tend to have small families, and more free-spirited parents tend to have large families, then this could produce a similar pattern to that observed by Sulloway. A small number of siblings do appear in Sulloway’s study: 105 out of the total study population of 2,013. While the comparison of the siblings in his data does support his theory, they are a small number, and their highly select nature precludes the possibility of drawing strong conclusions from those analyses.

A third point is that plenty of other research that has addressed the ‘cause’ of personality differences, and as was mentioned in section 1.2, no current empirical research shows that the origin of personality differences comes from social dynamics within the family (Harris, 1995, 1998; Pinker, 2002). Previous research suggests that parents have little influence on personality outside of the genes that they contribute to their children (Harris, 1998). Individuals are born with a personality and a temperament. Furthermore, it appears that personality and temperament is largely stable throughout the life course (Caspi, 2000). Finally, several attempts have been made to replicate part of the findings of Born to Rebel, without success (Modell, 1997; Harris, 1998; Johnson, 2000). More concerningly, there is public record of Sulloway threatening legal action to prevent scholarly criticism of the hypotheses proposed in Born to Rebel (Johnson, 2000). A special issue of Politics and the Life Sciences published in 2000 (Volume 19, Issue 2) is a fascinating mixture of birth order research and commentary, and academic real politik for anybody who is interested to read further.

Crucially though, beyond Born to Rebel, is that a large body of literature has investigated the relationship between birth order and personality, but the vast majority are based upon poor methodological design, and mainly elicit noise (Ernst and Angst, 1983). The vast majority of research in this field compares
individuals of different birth orders across different families, which is flawed for the reasons outlined directly above, and in section 9. Other research in this area has been based upon survey data where an individual has been asked questions about his or her birth order, a battery of questions to assess dimensions of his or her personality, and then asked questions about his or her siblings. However, the ‘sibling comparison’ that this kind of data allows is problematic as it is heavily subjective. Careful studies that have used appropriate data, comparing siblings to one another who have responded to the survey independently, find weak or no consistent or systematic evidence for the relationship between birth order and personality (Ernst and Angst, 1983; Freese et al., 1999; Beer and Horn, 2000).

3.5. Social and Physiological Explanations for Birth Order Effects. As the above sections describe, birth order has a consistent and substantial effect on long-term socioeconomic and health outcomes, though there is little evidence for the influence of birth order on personality. In section 2 of this introductory part of the thesis, I outlined various theories that purported to explain the relationship between birth order and later-life outcomes. Some of these theories described social mechanisms within the family for the emergence of birth order effects, while others described physiological mechanisms for the patterns that have been observed. To date only two empirical studies have been conducted that explicitly attempt to distinguish between these social and physiological explanations. The first was a paper by Kristensen and Bjerkedal, published in Science in 2007. Using Norwegian register data, Kristensen and Bjerkedal devised an imaginative study design to distinguish between social and physiological explanations for birth order effects on IQ. They compared three types of sibling groups, each with three births. The first type, where no children had died, a second type, where the first child had died in infancy, and a third type, where the first two children born had died in infancy.

Their intention was to be able to examine biological birth order, or parity, distinct from what they called social birth order. In the families where none
of the children had died, biological birth order was equal to social birth order. However, in the families where the first child had died, the second born child was socially the first born, while the third born biologically became the second born socially. In the families where the first two children born had died, the third born inherited the role of the first born socially. They found remarkably clear support for the importance of social birth order over biological birth order. The biological second born in a sibling group where the first child had died, and the biological third born in a sibling group where the first two children had died, had the same IQ as a first born in a sibling group where none of the children had died. This strongly suggested that it was the social position within the family rather than any pre-natal physiological process that explained the decrease in IQ by birth order.

Although the results from the study by Kristensen and Bjerkedal (2007) point towards the importance of social dynamics rather than any physiological explanation, the type of study design that they use is inherently dependent upon a between-family comparison. Although I will talk about the difference between a within-family comparison design and a between-family comparison design in greater detail in section 9, this point can also be summarised briefly. A between-family comparison means comparing siblings of different birth orders across different families. While this is not a problem statistically, it is problematic conceptually. Families can differ in countless different ways, and it is all but impossible to adjust for these myriad differences explicitly in a statistical model. This means that there is the potential for confounding in the association that is estimated, meaning that it is biased. While estimated coefficients are always biased to one extent or another due to residual confounding, the use of a between-family comparison for studying birth order effects leaves much more bias than we should be comfortable with. Furthermore, the types of families that were included in the analysis by Kristensen and Bjerkedal (2007) are likely to be even more different from one another than even two families chosen at random due to the deaths of multiple infants. Norway has a very low rate
of infant mortality (WHO, 2012), and so the types of families where multiple children are dying are likely to be substantially different from families where infants have not died.

The second empirical study that has attempted to distinguish between physiological and social explanations is the third study included in this thesis. Study III uses a different study design to try and distinguish between the importance of biological and social birth order, by studying fully adopted sibling groups. The objective of this study design was to be able to conduct a within-family sibling comparison, meaning that it would be possible to adjust for many factors that the adopted siblings would share, while still being able to distinguish between social and physiological explanations for the birth order pattern given that the siblings are not biologically related to one another. Rather than looking at IQ, Study III examines educational attainment as the outcome, by looking at both years of education achieved by age 30, and whether individuals had made the transition to tertiary education by age 30. The latter served as a robustness check as it is not uncommon in Sweden that individuals have not completed their educational attainment by age 30 (Högskoleverket, 2012). The results from this study showed that in fully adopted sibling groups the same pattern is observed as in fully biologically related sibling groups, with later adopted children having lower educational attainment.

In devising study designs to test whether birth order effects are physiological or social in origin, it has been necessary to seek out unusual sibling groups, and it is true that both sibling groups where multiple children have died in infancy and fully adopted sibling groups are very different from the average sibling group. In turn, this raises questions about the generalizability of these findings. Nevertheless, in spite of that particular limitation, the fact that both study designs lead to results that point in the same direction suggests that birth order effects can be explained by post-natal, within-family dynamics.
4. How Can We Separate Birth Order from Family Size?

A large body of previous research has also examined the relationship between family size and later life outcomes such as cognitive development and educational attainment (Blake, 1989a; Guo and VanWey, 1999; Steelman et al., 2002; Conley et al., 2007). Many researchers have argued that it is family size and not birth order that is the crucial within-family factor that influences individual achievement (Blake, 1989a; Conley, 2004). There is indeed evidence that family size matters, though separating birth order from family size requires that researchers utilise careful and sophisticated study designs. Birth order is directly tied to family size, and the number of children that parents choose to have, either biological or adopted, is endogenous. The relationship between the size of the sibling group and educational outcomes is highly consistent, and uniformly shows that educational outcomes are worse the larger the sibling group grows (Steelman et al., 2002).

Because family size is endogenous with a number of other factors that are also likely to influence the educational attainment of children, such as the educational level of the parents, recent research that has attempted to identify the effect of the size of the sibling group on educational attainment has turned to instrumental variables. Very briefly, an instrumental variable is a variable that influences the outcome variable, but only through the explanatory variable of interest. In the case of family size and educational attainment, a common instrument that has been using is a twin birth (Rosenzweig and Wolpin, 1980; Black et al., 2005a; Glick et al., 2007; Lee, 2008; Li et al., 2008, for example). At least before the days of in-vitro fertilisation a twin birth could be considered random for most intents and purposes, meaning that it would lead to an increase in the family size over and above that of the standard one-child pregnancy. Other researchers, understanding that many parents wish to have a sibling group with a mixed gender composition, have used the current gender composition of the sibling group as an instrument for the likelihood of having an additional child
(Cáceres-Delpiano, 2006), while another strategy has been to use maternal fecundity as an instrument (Jaeger, 2008). Those who wish to read about the formal mathematical details of instrumental variables may turn to Chapter 4 in Angrist and Pischke (2008) for a careful treatment.

The evidence that is most likely to be relevant to Sweden comes from Norway (Black et al., 2005). This research indicates that the negative relationship between family size and educational attainment is causal, but that the size of the relationship is relatively small (Black et al., 2005). Indeed, this same study found that the variation in educational attainment by birth order dominated over the importance of family size. In on-going research examining the relationship between the size of the sibling group and one’s own mortality, my colleagues and I find that birth order dominates over completed family size, and that there is no clear evidence for a causal effect of the size of the sibling group on own’s own mortality in adulthood in Sweden (Baranowska-Rataj, Barclay and Kolk, 2014). It makes sense that birth order effects should dominate over family size effects. If we consider the resource dilution hypothesis (see section 2.1.1) as a valid explanation for within-family differences, it seems impossible to apply this theory without recourse to the importance of birth order (Rodgers, 2001b). After all, family size is not fixed at birth, unless you happen to be the last born child. A first born child in what will eventually become a sibling group with four children is likely to spend at least the first seven or eight years of his or her life in a sibling group that has fewer than four children, and this has clear implications for the degree of access to parental resources that that child will have. Therefore, the actual experience of the size of the sibling group one is raised in is more accurately measured using information on birth order and birth intervals, rather than completed family size.

Furthermore, studies using within-family comparisons have shown that birth order patterns exist in families with two or three children, as well as families with many more than three children (Black et al., 2005a, also see Studies I, III, and IV in this thesis). One way of showing this pattern is by separating sibling
groups of different sizes and running quantitative analyses on the individuals in these different sibling groups separately. These results show that the negative birth order pattern for educational attainment persists not only in sibling groups with two or three children, which are the most common sizes of sibling groups today in Sweden and Norway, but also in sibling groups with up to eight children (Black et al., 2005a, and Study III in this thesis). That said, the degree of difference amongst the last born children is less clear in these very large sibling groups, but the degree of differentiation from first, second, and third born children is almost without exception extremely clear (Black et al., 2005a, and Study III in this thesis).

5. **Who Does Better? Earlier Borns, or Later Borns?**

The focus of Study IV in this thesis is an interesting and intriguing research question, which is, how do secular improvements in social conditions affect the raw association between birth order and later life outcomes. Attempts to identify the causal effect of birth order on later life outcomes take care to adjust for confounding variables. While I describe my overall approach to study design and statistical estimation in section 9, it is also possible to give an example here. If we want to know how birth order influences educational attainment later in life, it is important to acknowledge and adjust in our analyses for the fact that, within the same sibling group, later birth order children are by definition born later in time. Subsequently there may also have been changes to environmental conditions during the intervening years.

While identifying the causal effect of birth order on a later life outcome such as educational attainment is of great interest, it is also valid to consider the fact that, if educational enrolment is increasing, later birth order children may in reality be more likely to attend university despite the fact that being of a later birth order actually has a negative causal effect on later life outcomes in the abstract. To be clear, in an environment of rapidly increasing educational enrolment, or indeed rapidly improving public health, or whichever secular aggregate level
change is relevant, later born children actually do better, not worse, than earlier born children.

To my knowledge, this has also been addressed in the literature in two other related papers. The first, by Alter and Oris (2008), using historical military conscription data from 19th century Belgium, found that the further apart brothers were born, the weaker was the correlation in their height. Furthermore, the weakening of the correlation could be explained by the younger brother being taller than the older brother, which was attributable to improvements to social conditions in the intervening period. Secondly, using Swedish military conscription data, Myrskylä, Silventoinen, Tynelius and Rasmussen (2013) showed that even though being born to an older mother has a mild negative causal effect on IQ, in reality, because of secular improvements to public health, and perhaps also due to the Flynn effect (Flynn, 1984, 1987), children born to older mothers actually have a higher IQ than those born to younger mothers.

It is important to note here that the causal effect of birth order on later life outcomes remains ‘constant’, while the raw association is heavily contingent upon whether any given secular pattern, say in educational enrolment, continues its upwards trajectory, stagnates, or decreases. If educational enrolment were to stagnate, the raw association between birth order and educational attainment would more closely mirror the causal effect of birth order on educational attainment. If educational enrolment were to decrease, later born children would do even worse than earlier born siblings than the causal effect would suggest. However, at least since the beginning of the 20th century, later borns have actually been advantaged over earlier born siblings in this respect (Breen et al., 2009), and perhaps for even longer in terms of long-term health outcomes (SCB, 2010).

In Study IV I also suggest that some of the confusion about the effects of birth order more generally might be attributed to this paradox between the abstract causal effect of birth order and what the actual raw association has been for many outcomes for at least the last half century. In The Pecking Order, for example, Conley (2004) found that later born children often did better than
earlier borns. Similarly, Blake (1989b) found that later born children in large families actually performed better than earlier borns. It has been suggested that the explanation for this in some cases is that older siblings may be in a situation to provide financial support to their younger siblings (Conley, 2004; Blake, 1989a). While this is certainly plausible, improving environmental conditions over time would provide a more parsimonious explanation for why later born children may have better outcomes than their older siblings.

6. THE CONTEMPORARY SWEDISH CONTEXT

Several times in this chapter I have mentioned that the relationship between birth order and socioeconomic outcomes in adulthood has been consistently observed in Western, developed societies. Studies that have used a within-family comparison to identify the effect of birth order on educational attainment in adulthood have used data from Norway (Black et al., 2005a), Sweden (Barclay, in press), Germany (Häkönen, 2014), the Netherlands (Kalmijn and Kraaykamp, 2005), and the United States (Kantarevic and Mechoulan, 2006). It is worth expanding briefly on this point, as the modern, Western society is one that is relatively new, and rather unique, in terms of human history. This point has been explicitly made by Henrich et al. (2010b), who point out the dangers of extrapolating the findings from what they term WEIRD societies. This acronym stands for Western, Education, Industrialised, Rich, and Democratic societies. Although this is particularly a weakness of much research in the field of psychology, which aims to understand human nature, and whose empirical foundation largely rests upon the performance of undergraduate psychology students in the United States (Henrich et al., 2010a), it is still of value to be explicit about this assumption when talking about empirical research in demography and sociology. As mentioned above, birth order effects on educational attainment have been found in Norway, Sweden, the Netherlands, Germany, and the United States. To date, the only studies that have used a within-family comparison to study the relationship between birth order and health in adulthood have used
Nordic data, two of which are part of this thesis (see Studies I and II). While I would be confident that the findings presented in this thesis would be replicated if conducted on data from other WEIRD societies, such as Norway, the UK, or the United States, I would be very hesitant to generalise without careful consideration to other historical settings, and to non-WEIRD societies.

Aside from its status as a WEIRD society, it is relevant to consider what particular aspects of Swedish society might be important in terms of mediating the influence of birth order on socioeconomic and health outcomes in adulthood. Although a key factor to consider is the educational system and public health regime, which I will do shortly, it would be remiss not to evaluate whether Swedish kinship norms and culture influence the way that birth order might influence later life outcomes, particularly given that birth order effects are predicated upon within-family dynamics. To the outside observer of the Swedish welfare state, it would be easy to draw the simple conclusion that Swedish society is dominated by a communitarian ethos which lays the foundation for the socialistic state system, or at least a compromise between capitalism and socialism. However, in drawing such a conclusion one would be sorely mistaken. There is a strong case for arguing that Swedish society is in fact built upon strong principles of individualism. Government social policies, including family policy, are designed so that individual adults are able to take responsibility for themselves, and not have to rely upon family members for financial or other types of support (Lundqvist and Roman, 2008).

Lars Trägårdh and Henrik Berggren have argued that the foundation of the Nordic version of capitalism is a combination of radical individualism and a strong state, which has been described as ‘statist individualism’ (Berggren and Trägårdh, 2006; Eklund et al., 2011) [for an illustrative discussion, see also The Economist, January 31st 2013 - Special Report: The Nordic Countries]. The theory of statist individualism relies on several central characteristics. One is that there is strong trust in the State, by which I refer to the government and civil service. This means that individuals believe that levels of corruption are low,
and that they can rely upon the State to fulfil its duties and obligations. Levels of trust in the Nordic countries, in other individuals as well as in government, are substantially higher than in most of the rest of the EU and the United States. One explanation that has been proposed for this is a unique set of historical conditions which include geography, climate, and religion. Although such a theory is impossible to prove, or more importantly to falsify, surveys do routinely show that high levels of trust exist in Sweden. Unlike in the United States, the State in Sweden is not viewed as a threat to individual liberty.

A second central characteristic of statist individualism is a tradition of strong individualism, and a desire to exercise that preference. The combination of these two conditions has over time led to the development of social policies that liberate the individual from a reliance on his or her family to pursue whatever ambitions that individual holds in life (Berggren and Trägårdh, 2006; Eklund et al., 2011). This can be seen in a wide range of social policies which include the free provision of education throughout the educational system [including at the graduate level], separate taxation policies for spouses, the provision of heavily subsidised child day care, and other family policies. This liberation from obligations within the family can also be seen in the way that elderly care is provided. Unlike several countries in Southern Europe, there is very little tradition of multigenerational households in Sweden, and elderly care is also provided by the State, removing obligations to care for parents in their old age. Other evidence of this emphasis on individualism and self-sufficiency might be read in the fact that Sweden has the highest proportion of single-person households in the world, at 34% in 2012 (SCB, 2014), as well as in the gamut of behaviours that have collectively been dubbed the second demographic transition (Van de Kaa, 1987; Lesthaeghe, 2010).

6.1. Caregiving and Transfers in Sweden: The Role of the Family and the State. Given this social and political context, what are the implications for birth order research based upon Swedish data? One interpretation could be that the
influence of birth order should be strong in Sweden due to the way that the welfare system liberates individuals from dependency on, and responsibility for, the family. This means that after leaving the family home, individuals may be less likely to be expected to provide support for their younger siblings, if that kind of support is necessary. Accordingly, the advantage gained by earlier born children from the early life advantage in terms of access to parental resources is not lost through subsidising a younger sibling. However, an alternative view is that it is possible that birth order effects could be stronger if there were stronger social norms for providing financial support to kin. As I outlined in section 2.1.6, Silles (2010) argued that birth order effects might be the result of parents investing to a greater extent in earlier born children as they would be the ones most likely to be able to support them as they aged.

These questions can be approached by examining the caring function of the family, both for children and for the elderly, in a comparative perspective (Leitner, 2003; Albertini et al., 2007). The extent to which individuals take on the role of caregiver for their parents, and the extent to which they would provide support for their siblings, would seem to matter for how birth order may influence long-term outcomes in Sweden relative to other contexts. There is also a pertinent gender dimension to these questions, as women assume the lion’s share of family caregiving (Leitner, 2003). A useful typology when considering these questions is the distinction between familialistic and de-familializing welfare regimes, as proposed by Esping-Andersen (1999). This typology concerns the extent to which families must assume responsibility for the care and welfare of the group members, and the extent to which that responsibility is assumed by the state, though it should be stressed that even in the most de-familialized of contexts the family still has a role to play (Leitner, 2003).

Esping-Andersen (1999) has argued that these familialistic and de-familializing welfare regime differences can be measured by examining indicators such as overall subsidies for families with children, the cost and availability of public day care, and the supply of care to the elderly. Based upon these criteria,
Esping-Andersen (1999, Chapter 4) argues that the Nordic welfare regimes are de-familialized to a much greater extent that other welfare regimes, and particularly stand out in contrast to the nations of Southern Europe, and Japan. Several nations, including Austria, Germany, Italy, and Spain, have legal obligations for intergenerational support, meaning that social assistance is withheld even from adults if they have parents with the potential means to support them (Albertini et al., 2007). That is a far cry from the Nordic model. It is useful to note that the de-familialization of care and welfare responsibilities in Sweden and the other social democratic welfare regimes is through state welfare provision, and not through market provision. This means that the practice of de-familialization is less stratified by socioeconomic class than it is in liberal welfare regimes (Leitner, 2003), though those in the lower quintiles of the income distribution in Sweden are still relatively more likely to receive financial transfers from family members (Björnberg and Latta, 2007).

Overall, these de-familializing policies have meant that individuals in Sweden are relatively liberated from the potential constraints attributable to families. After all, even with the best intentions, financial and social support transfers communicate an implicit understanding about power, dependence, and independence in that relationship (Björnberg and Latta, 2007, page 418). As Trägårdh (1990, page 578) puts it, these de-familializing policies have allowed ‘the freedom of women from the tyranny of men, children from the tyranny of parents, and all individuals from the tyranny of the family’. It is important to note that the de-familialization policies of the Swedish welfare state, and individualistic Swedish policies are not the product of a plan to free the individual from the family (Trägårdh, 1990). Instead, the development and implementation of these policies were made possible by the existing presence of cultural norms emphasizing the value of independence and self-sufficiency that meant the electorate was comfortable with the implementation of these policies (Trägårdh, 1990; Daun, 1996).
Another way of approaching the question of perceived responsibilities is to examine attitudinal data. Survey data shows that when asked the question ‘who do you consider as mainly responsible for financial support in cases of unforeseen expenses’, 67% of Swedes respond that the individual concerned is responsible for unforeseen expenses, 9% say that the state should be responsible, and 13% say the family (Björnberg and Latta, 2007). When asked the same question, but for long-term economic difficulties, 37% of Swedes respond that the individual is responsible, 44% say the state, and just 4% say that the family should be responsible for helping them (Björnberg and Latta, 2007). The percentage of Swedes who report having given a loan to their children is 18%, while 4% report having given a loan to their mother or father, and 8% report having given a loan to a sibling (Björnberg and Latta, 2007). Overall, the general pattern of transfers tends to flow down generations, rather than up, though horizontal transfers, in this case referring to transfers between siblings, appear to be less examined.

Overall, these patterns are consistent with the theory that Sweden is characterised by a high degree of individualism, and that they are more free from obligations to the family than individuals in Central and Southern Europe. All things being equal, this situation likely works to the advantage of first and earlier born children, who might otherwise experience a greater expectation to postpone further education so as to find work directly and support the family. Likewise, the strong welfare state means that the probability of a family falling into dire straits is lower in Sweden than in countries without that welfare safety net. Assessing the second possibility, that parents might favour first borns due to the possibility that they could support them as they aged, is difficult. Parents are generally loathe to admit to favoritism of one child over another. However, the relatively low frequency of financial transfers to parents (Björnberg and Latta, 2007), as described above, suggests that this factor probably plays a fairly limited role in explaining birth order patterns in Sweden.
6.2. **Family Complexity in Sweden.** Another important dimension of the Swedish context to consider when studying how family conditions can influence long-term outcomes is the experience of family complexity. Complex families can take many forms, but examples include families with step-parents, or half-siblings. Like elsewhere in Western Europe and North America, the prevalence of complex families has been increasing in Sweden from the 1950s to the present (Thomson, 2014). In this thesis the study population that I use varies from one study to another, but the entire cohort range includes individuals born between as early as 1938, to as late as 1982. Given that family complexity has grown more common over the course of the 20th century, it is important to consider whether this introduces error into the measurement of the birth order variable. Using register data to accurately capture the experience of social as distinct from biological birth order is potentially difficult, and this is particularly true in blended families. If birth order is calculated based upon the simple criteria of sharing a biological mother and father, then the social order that is actually experienced may deviate from that biological birth order due to the presence of half- or step-siblings. Importantly, previous studies, including Study III in this thesis, have indicated that it is social order within the sibling group rather than biological birth order that explains birth order patterns (Kristensen and Bjerkedal, 2007, 2010).

Amongst those borns in the 1960s, 23% of individuals have at least one half-sibling, and for those born in the 1970s and 1980s the corresponding figure is 25% and 30%, respectively (Thomson, 2014). Furthermore, these figures do not include the experience of step-siblings. Research using Swedish register data indicates that individuals who grow up in complex families have lower test scores in school than those in non-complex families (Turunen, 2014), though the causal nature of the relationship is not firmly established (Björklund et al., 2007). It should also be noted that later born siblings are more likely to experience family disruption (Thomson, 2014), as many unions grow less stable over time. Given this, it might be the experience of family complexity that produces
a pattern where later born children have lower educational attainment. One way of approaching this issue is to examine the relationship between birth order and educational attainment only amongst sibling groups where neither of the the parents have any children with a third person. In these cases, the experience of social birth order is likely to conform more closely to the measure of biological birth order. In Studies II and IV in this thesis I check the robustness of the results when looking at sibling groups without half-siblings, and find that these results are extremely similar to the results when not taking into account the existence of half-siblings.

6.3. **Gender.** Although gender is not the central focus of this thesis, in two of the three papers I have examined gender differences in birth order patterns (Studies I and IV). Gender differences were not addressed in Study II in this thesis as the outcome measure was drawn from the military conscription registers, and women in Sweden have not been required to conscript, so no data was available for them. I also did not address gender differences explicitly in Study III in this thesis, as the focus was upon fully adopted sibling groups. The nature of this data means that the sample group is relatively small by administrative register data standards, and so I tried to avoid reducing it any further by analysing men and women separately. Although it is often not the central dimension of studies on the relationship between birth order and later life outcomes, many studies have examined whether there are gender differences in birth order patterns. For those fields of study where birth order patterns have been consistently found, such as educational attainment and health, it has been shown that the negative effect of birth order exists for both men and women (Black et al., 2005a, and Study IV in this thesis, for example).

Study I in this thesis shows that the relative effect of birth order on mortality is stronger between sisters than between brothers. In that paper we suggest that part of the reason for that pattern is that previous research suggests that women
are often more heavily involved in maintaining kinship ties (Young and Willmott, 1957; Hagestad, 1986; Rossi and Rossi, 1990). As a result it might be the case that they are more influenced by within-family dynamics than men. On the other hand, it is not really clear that the mechanisms posited by the resource dilution hypothesis or the confluence hypothesis would have a stronger impact on individuals who are more heavily invested in the family system. Perhaps a more plausible explanation is that, even in Sweden, women are disadvantaged relative to men in numerous spheres of life. Sweden is often referred to as a model for gender equality, and according to the United Nations Development Program’s 2013 Gender Inequality Index (GII), Sweden was ranked 4th in the world (UNDP, 2014). The GII is a composite measure based upon labour market participation, empowerment, and reproductive health indicators (UNDP, 2014).

Swedish female labour force participation rates are amongst the highest in the OECD, at 78.8% in 2013. The level of gender equality in Sweden can largely be attributed to the fact that achieving greater equality has been an explicit goal of successive governments (Hoem, 1995). An important aspect of that goal has been towards achieving a dual earner-carer system, where women are able to have a career as well as have a family (Ferrarini and Duvander, 2010). This goal has led to the development of social policies that have aimed to minimise the negative impact of childbearing on womens careers. There are, perhaps, two main ways of achieving this: the first is to reduce the amount of time that women are forced out of the labour market by having children. This can be achieved by, among other things, low cost daycare for children, which means that parents do not have to drop out of the labour force to raise their offspring (Andersson et al., 2004). Today approximately 85% of children attend public daycare (Ferrarini and Duvander, 2010). Another approach that has been adopted for reducing gender inequality in the labour market is to increase the amount of time that men spend away from work. This has been partially achieved through extending generous parental leave policies to men as well as women (Hoem, 1995).
However, despite these efforts, Sweden has one of the most horizontally segregated labour markets in the developed world (Nermo, 1999), and the success of women in the labour market continues to lag behind that of men. Despite the pro-gender equality policies that the Swedish government has enacted, women still tend to play a larger role in child rearing and the domestic sphere than men, which has meant that gender inequality in the labour market, and more generally, has persisted, albeit in reduced form. Research indicates that couples tend to share domestic and labour market responsibilities remarkably equitably before they have children (Ahrne and Roman, 1997), but then fall back into traditional gender roles, and thereby reproduce gender inequality, after having children (Sanchez and Thomson, 1997). Despite the relative level of gender equality in Sweden, it may be that the continued degree of inequality means that when women are relatively disadvantaged in some respect early in life, such as birth order, there are greater cumulative disadvantages for them due to institutionalised structures that disadvantage women relative to men (Read and Gorman, 2010). This is turn might then manifest itself as a measurable difference in health or educational attainment many years later. Although it is difficult to test explicitly, empirical research supports this idea. For example, recent studies have shown that early life relative socioeconomic disadvantage leads to bigger differences amongst women than it does amongst men for outcomes such as cardiac disease, diabetes, and obesity. (Hamil-Luker and O’Rand, 2007; Maty et al., 2008; Khlat et al., 2009). Nevertheless, it will be necessary to investigate the difference in the relationship between birth order and health for men and women in different contexts before drawing firmer conclusions.

6.4. **Education.** Given that this thesis focuses upon educational attainment and mortality as outcomes measures, I will briefly describe the contemporary education system in Sweden. This section is only intended as a brief treatment, to address aspects of the educational system that are relevant to this thesis. If the reader is interested in further details and about how the Swedish education
system has developed over time I would suggest turning to Halldén (2008). The Swedish education system is divided into three sections, the first of which is 9 years of compulsory schooling (grundskolan), the second of which is three additional years of secondary school (gymnasium), and finally, the tertiary section (Halldén, 2008). Tertiary education in Sweden today consists of two parts. The first is a traditional university education, with degrees at the Bachelors (kandidatexamen), Magister (magisterexamen), Masters, Licentiate, and Doctoral levels. The second part is a vocational tertiary education (Högre yrkesutbildning / Högskolor) (Halldén, 2008).

Education in Sweden is state funded at all levels, and tertiary education is free for Swedish and European Union citizens (Halldén, 2008; Högskoleverket, 2012). This has meant that family resources are not crucial for the transition to tertiary education in the same way that they are in other contexts, such as the United States. To give an idea of the relative burden that university tuition fees place on students in different countries, average tuition fees as a percentage of GDP per capita in 2006/07 were 2.7% in Norway, 0.0% in Sweden, 3.1% in the Netherlands, 1.3% in Germany, and 25.5% in the United States (Willemse and De Beer, 2012). Approximately 33% of the Swedish population has undergone post-secondary education, which is higher than the OECD average (Högskoleverket, 2012), and the period of time that individuals spend in education has increased steadily since the beginning of the 20th century (Erikson and Jonsson, 1996; Breen et al., 2009). This is true for both men and women, though the increase in the rate of entrance into tertiary education has been greater amongst women (OECD, 2013). The median age at which students enter the tertiary education system in Sweden was 22.1 in 2009 (Högskoleverket, 2012). Students in tertiary education are eligible for financial support from the Swedish state for living costs in the form of study grants and student loans with low interest rates (Högskoleverket, 2012), minimising the need for reliance on family resources for maintenance.
As can be seen in Studies III and IV, there is clear support for the relationship between birth order and educational attainment in Sweden. This is extremely interesting given that the education system is state funded at all levels. In the absence of direct costs for continuing with education, it might be expected that the gradient for educational attainment by birth order would be flat or shallow after adjusting for birth year. Since birth order patterns are attributable to within family social dynamics (Kristensen and Bjerkedal, 2007, and Study III in this thesis), it seems likely that resource dilution within the family makes its impact within the very first few years of life (Sénéchal et al., 1998; Sénéchal and LeFevre, 2002; Heckman et al., 2010), and that in turn leads to a cumulative advantage for earlier born children over the long-term. While welfare policies more generally might be expected to have a leveling effect that should minimise the long-term impact of relative inequality, previous research does show that interventions later in adolescence and adulthood are less efficient in their impact than experiences during the first few years of life (Heckman, 2006).

6.5. **Public Health.** Sweden has a national health system which is all but fully funded through taxation, and is free at the point of access aside from a small nominal charge for primary health care services. Sweden has one of the highest life expectancies at birth in the world, at 79.7 for men, and 83.8 for women (UN, 2013), and this has been rising year on year almost without exception for over a century (SCB, 2010). Study I in this thesis analyses mortality amongst men and women born 1938 to 1960. One particular dimension of mortality that we study is the cause-specific pattern. It is worth discussing this as cause-specific mortality patterns vary not only by age, but may also vary by cohort. One reason why age-specific patterns of mortality could vary by cohort is due to improvements in medical technology, and in general public health, meaning that young adults should have lower rates of mortality than previous cohorts. Later born cohorts are more likely to suffer from neoplasms than earlier born cohorts, partly due to increased longevity. The rates of mortality attributable to
heart and cerebrovascular diseases across ages 15 to 74 have been decreasing in Sweden for both men and women over the past twenty five years (Socialstyrelsen, 2010, see page 42). Cancers and diseases of the circulatory system are responsible for the majority of deaths in Sweden (Socialstyrelsen, 2010, page 9). Data from the Swedish National Board of Health and Welfare shows that rates of mortality attributable to all cancers across ages 15 to 74 have been largely stable over the last twenty five years for women, and falling slightly for men (Socialstyrelsen, 2010, page 44), and that rates of lung cancer across ages 15 to 74 have been increasing for women, and falling for men (Socialstyrelsen, 2010, page 45). Indeed lung cancer is the most common cause of death amongst the larger category of neoplasms for women in Sweden (Socialstyrelsen, 2010, page 9). In Sweden the majority of deaths at old ages are attributable to cancer and diseases of the circulatory system (Janssen and Kunst, 2004).

7. BIRTH ORDER IN NON-WEIRD SOCIETIES

The theories that have been reviewed in this introductory chapter describe the way in birth order should affect later life socioeconomic or health outcomes have been developed to explain birth order patterns in modern, developed societies. This means that there are specific assumptions inherent in these models about the culture, society, and typical kinship structure that the average individual and family will experience. In historical or non-WEIRD societies, the systematic influence that birth order may exert over later life outcomes may be the same, but attributable to different mechanisms. Alternatively, it is entirely possible for birth order effects to be completely different, or to be absent altogether. When considering historical societies, for example, one must take into account factors such as primogeniture, and the existence of stem families. Primogeniture is a mode of family succession where the first born, and typically the first born son, inherits the family estate at a certain age, or upon the death of his father. It has been suggested that primogeniture may emerge as a system of
succession in societies where wealth is a strong predictor of reproductive success, where this wealth has a stable source, and where infant mortality is high and the probability of any given child surviving is unpredictable (Boone, 1986).

Theoretically and empirically, the practice of primogeniture is associated with greater reproductive success for first borns, and typically first born sons, as wealth and status in stratified societies ensure reliable access to potential partners of the opposite sex (Boone, 1986; Low, 1991). For example, in Portugal between 1380-1580, birth order amongst aristocrats was strongly predictive of reproductive success, with first born sons and daughters having many more children than later born siblings (Boone, 1986). Fertility in this aristocratic population was above replacement level, and this meant that over the decades and centuries, the number of descendants far outgrew the number of titles and estates available, the latter of which remained fairly constant. This growing supply of later born young men constituted a problem for political and societal stability; they had been raised with wealth and status, but upon entering adulthood no longer had meaningful titles, land, or any substantial source of income. This downward mobility naturally created frustration and friction. Multiple historians have argued that military excursions such as the Crusades and European colonial expansion were attempts by the ruling church and state elite at the time to divert and export this source of domestic political instability (Wallerstein, 1974; Duby, 1980; Boone, 1983). After all, military success could bring status, reputation, and in colonial conquests, land and wealth, and thereby an opportunity for these landless elite to restore their positions.

As a result, those from the aristocracy who went away on these military and colonial excursions were primarily later born sons. As can be imagined, this also meant that these later borns had higher mortality. Later born daughters amongst the aristocracy struggled to find a partner of suitable wealth and standing due to the relatively constant status of titles and estates, and this meant that they were far more likely to be sent to convents, whose population grew over the
centuries (Boone, 1986). While it is clear that it was the institution of primogeniture and not birth order that was responsible for these developments, birth order is an inextricable part of the practice of primogeniture. Although birth order was an important predictor of reproductive success for both men and women in historical Portugal, research using Swedish data from the 19th century shows that birth order was predictive of reproductive success for men, but not for women (Low, 1990, 1991). Other studies have shown that when there are few or no resources to distribute amongst children in a highly stratified historical society, birth order plays very little part in predicting reproductive success (Dickemann, 1979).

Birth order may also play a different role in contemporary but non-WEIRD societies. Take, for example, the !Kung San, previously known as the Kalahari bushmen. The !Kung San today have largely moved to permanent settlements due to continuous encroachment into their traditional territories, but until as recently as the 1960s some still followed a traditional hunter-gatherer lifestyle that had been practiced for hundreds, if not thousands, of years (Draper and Hames, 2000). The traditional nomadic existence of the !Kung meant that there was no possibility to collect material possessions, and children were usually raised collectively within the band. Modern !Kung San society is characterized by a general lack of stratification, without meaningful ownership of property (Lee, 1979). Because of the harsh environment of the Kalahari desert in which they traditionally lived, the key resource an individual could have was kin, and particularly kin networks in other bands. These networks could make the difference between life and death in times of severe drought or hardship (Marshall, 1961).

After moving to permanent settlements, the !Kung San practice of collective childrearing has largely continued, meaning that the theories described earlier in this chapter (section 2) to explain birth order differences in later life success, based upon within-family dynamics, can barely apply. Indeed, Draper and Hames (2000) found that later borns outperform earlier born children in terms of reproductive success later in life. The reason for this is because later born
siblings have, by definition, a greater number of older siblings, and the assistance of kin continues to play a key role in the life of the !Kung San. Those with more older siblings are therefore more successful at attracting reproductive partners, which explains their reproductive success. Later born siblings are advantaged over first and other earlier born children because even though they have the same total number of siblings, having older siblings is a greater advantage as they are typically older, have greater resources, and more influence (Draper and Hames, 2000).

This section is clearly far from an exhaustive review of birth order-related patterns in different societies. Any attempt to address that topic in a comprehensive fashion might fill several volumes. Although I have not provided any examples here, it is also easy to imagine that birth order patterns in other different contexts, for example in societies that practiced polygyny (e.g. frontier societies in 19th century Utah), or have a restrictive fertility policy (e.g. modern China), could be completely different again. By using a couple of illustrative examples I simply hope to make clear that the birth order patterns that I describe in this thesis are highly contingent upon the social and cultural context in which they are studied.

8. Data and Study Design

8.1. Data.

8.1.1. Personal Identification Number, Multigenerational Register, and Dwelling Information. The data used in this thesis is Swedish administrative population register data. This means that we have access to data on all individuals residing in Sweden. In Sweden each individual has a unique personal identity number, and this ID is used to link information across a wide range of administrative registers, including registers of births, deaths, migrations, income, and education. The ID number that researchers using this data see is anonymised, but still allows us to link an individual’s records across the registers that are available to
us. One of the key administrative registers for this thesis is the Swedish multigenerational register. This register provides information on the ID of the mother and father of each individual. For Swedish children who are adopted in Sweden, the multigenerational register includes information on the ID variables of the biological mother and father as well as the adoptive mother and adoptive father, while for transnational adoptees the register only includes information on the ID numbers of the adoptive parents. The multigenerational register makes it possible to identify kin relationships in Sweden, including grandparents, aunts, uncles, and cousins. However, the kin group of key interest to this thesis is siblings.

In each of the four studies in this thesis I have constructed the sibling group based upon the children sharing a biological mother and father (except for the adopted sibling groups in Study III, who share an adoptive mother and father). In nuclear families where children live with their biological mother and father, and the parents have no children from other relationships, this is not a problem. In these families the biological birth order corresponds to the functional birth order within the family. However, for children living in blended families, their biological birth order may not correspond to their social birth order, which previous research by Kristensen and Bjerkedal (2007), and Study III in this thesis, indicate is the critical experience. For example, a first born may effectively become a third born if two families merge, and the two children from the step-parent are older. This introduces measurement error into the measure of the birth order variable that I have used in my studies. If this measurement error is random, then the effect of birth order on the various outcome measures studied in this thesis will be attenuated. Alternatively, if the measurement error is not random, the size of the effect could be either inflated, or attenuated.

As discussed in section 6.2, blended families are common in Sweden, just as they are across Western Europe and the United States (Andersson, 2002). It is possible to infer cohabitation to a high degree of accuracy using the Swedish register data, at least when a couple has a child (Thomson and Eriksson, 2013),
which could allow for inferences to be made about the social birth order within the household. However, I chose to base the calculation of birth order on sharing a biological mother and father, without taking into account step-siblings, as trying to deduce the actual social order experienced as distinct from the biological birth order in blended families would require some guesswork, resting upon assumptions about how gender and age would influence experienced social rank in blended sibling groups. Such an approach would also have to make ungrounded assumptions about the contribution of non-cohabiting siblings towards the experience of social rank, and how much these other siblings would draw upon parental resources.

In Study I of this thesis, the degree of measurement error for the birth order variable should be less than in Studies II, III, and IV, because in Study I we study cohorts born 1938 to 1960, when families were on average less complex (Thomson, 2014). Study II is based upon cohorts born 1965 to 1977, and Studies III and IV are based upon cohorts born 1960 to 1982. Blended families were a much more common experience for individuals born in these more recent cohorts. One way of testing the robustness of the main results presented in this thesis is to examine the relationship between birth order and the outcome variable of interest only amongst the population that has not experienced family complexity. By that I mean examining birth order in sibling groups where neither parent has any children with any third person. Although this conditions on union stability, which may introduce a different bias, and cannot account for step-siblings, it means that the social experience of birth order will conform to the biological birth order within the sibling group with a higher degree of accuracy. In Studies II and IV, I present appendices which take this approach, and the results are extremely similar to the results when not stripping out sibling groups with half-siblings.
8.1.2. Availability of Information for Specific Variables. While the Swedish data is very well suited for conducting research on siblings, there are some variables that I have not had access to for the studies included in this thesis. One of these variables is the birth weight of individuals. Birth weight is measured and recorded in the live births register in Sweden, but I have not had access to that particular register. As discussed in section 2.2.3, birth weight is commonly lower for first borns than for later born children, and a heavier weight at birth has been consistently found to be associated with a range of favourable outcomes in adulthood. However, the results presented in this thesis consistently show that the effect of birth order on educational attainment and health in adulthood is negative, with later borns performing worse than earlier borns. Because I have not been able to adjust for birth weight, it is likely that the results presented underestimate the ‘causal effect’ of birth order on educational attainment and health in adulthood. In this case the results are biased, but they are biased upwards in favour of later borns. If I was able to adjust for this factor it would likely show that later borns have even worse outcomes relative to earlier born siblings.

8.2. Study Design. In this thesis my co-authors and I claim on numerous occasions that we have identified the causal effect of birth order on, variously, mortality, physical fitness in early adulthood, and educational attainment by age 30. From one perspective, these claims are rather bold. The gold standard for identifying the causal effect of an exposure, X, on an outcome, Y, is to conduct a randomised control trial (RCT). However, in the social sciences this is rarely possible, or even remotely plausible. As I have outlined above, in section 8, the data used in this thesis is observational data. Although the data is of unusually high quality and covers the entire population, the integrity of the data does not make it anything less than observational. In this thesis I have largely relied on the use of fixed effects, to be described later, in section 9, and on the modern approach for identifying causality in the social scientific and epidemiological
literature (Morgan and Winship, 2007; Pearl, 2009). Essentially this relies upon adjusting for variables that are theoretically and empirically understood to confound the relationship between our exposure, X, and the outcome, Y.

There are two types of error in demographic studies, and these are systematic and random error. True random error is variation in the data that cannot be explained by the statistical model, but that is not systematically related to the relationship between the exposure and explanatory variables. True random error will affect the precision of the estimates that are generated from a statistical model, but will not bias the estimated coefficients (Rothman, 2012). Systematic error, on the other hand, does introduce systematic bias into the estimates. A variable that confounds the relationship between X and Y is known as a confounder variable. A confounder variable is correlated with both the independent variable that we are interested in, as well as the outcome variable (Rothman, 2012). To illustrate the role that a confounder variable plays in distorting the relationship between the exposure and explanatory variables, I would like to briefly make use of directed acyclic graphs (DAGs) (Morgan and Winship, 2007; Pearl, 2009).

A DAG is a way of showing the relationship between variables that approximates in a remarkably close way the actual relationship that would otherwise take lengthy and complicated matrix algebra to demonstrate. DAG 1 shows what we want to estimate, which is the nature of the relationship between the explanatory variable and the outcome variable. In this case the explanatory variable, X, is birth order and the outcome variable, Y, is educational attainment at age 30.
X - Birth Order.
Y - Educational Attainment.
S - Parental Socioeconomic Status
T - Year
M - Maternal Age at the Time of Birth
U - Birth weight.

(1)

\[ X \longrightarrow Y \]

In a between-family comparison, where children of different birth orders are compared across different families, there is the risk of confounding from factors that are related both to family size (and therefore birth order) as well as educational attainment. One example of this could be the socioeconomic status of the parents. If parents with a low socioeconomic status have larger families, they will overwhelmingly be the parents of high birth order children. Since the children of low socioeconomic status parents are also more likely to have lower educational attainment than average, this series of relationships would produce a pattern in the data that would suggest a negative relationship between birth order and educational attainment. An illustration of this series of relationships is shown in DAG 2. As with DAG 1, X indicates birth order, and Y indicates educational attainment, and S is added to show the socioeconomic status of the parents. One way of dealing with this confounding is to adjust the analysis, using a tool such as a multivariate regression, for the socioeconomic status of the parents.
As DAG 3 shows, isolating the relationship between the explanatory variable of interest and the outcome variable is rarely so simple. In many studies it is crucial to consider the potential role of numerous confounding variables. Some confounders can be observed, such as the socioeconomic status of the parents, while others are very difficult to measure even if the financial resources were available to collect the data, such as parenting style. It is also easy to think of many other potential confounding factors that could vary across families; perhaps the mother or father is always away on business, or suffers from alcoholism, for example. In this thesis I have relied upon the use of fixed effects (see section 9) to try and minimise residual confounding to the greatest extent possible. This approach to statistical modelling differences out the environmental factors that siblings share, to the extent that they remain constant over the time period that the siblings were raised. If we take DAG 2, this means that S, the parental socioeconomic status, is no longer considered a serious problem.
However, this does not mean that no problems remain. Even after applying the fixed effects approach to estimation, it is important to consider factors that could confound the relationship between birth order and educational attainment (or health, in another example) that still vary amongst siblings. In DAG 3 these are shown as T, year of birth, and M, the maternal age at the time of birth. When trying to isolate the impact that birth order has on educational attainment it is important to adjust for these variables, as they are correlated with both birth order and the outcome. Within the family both year of birth and the maternal age at the time of birth are mechanically associated with birth order, as later born siblings will by definition be born in a later year, and to an older mother. Likewise, increasing educational enrolment over time means that those who are born later in time are more likely to spend longer in the educational system, while the age of the mother at the time of birth has a non-linear influence on later life outcomes.

In truth, however, DAG 4 represents a more honest articulation of the study designs implemented in this thesis. While adjusting for maternal age at the time of birth and birth year does reduce the degree of confounding, it is still possible that there are factors that remain unobserved that are correlated with birth order and educational attainment. As I discussed earlier, an example of this could be
birth weight. A more complete DAG would also show that this is associated with M, maternal age, for example, as birth weight has a non-linear relationship with maternal age at the time of birth (Strobino et al., 1995; Roth et al., 1998). As I discussed earlier, the inability to control for birth weight probably means that the results reported in this thesis, and other research on this topic, underestimates the negative impact that birth order has on educational attainment and health. On the other hand, however, it is also possible to think of variables that could take the role of U that would counteract that underestimation. For example, the likelihood of parental death increases with time and the age of the parents, and younger siblings are more likely to still be at home when a parent dies (Conley, 2004), though parental death is not extremely common in modern day Sweden. A more common example is that parents might divorce, or if cohabiting, separate, and this might have a more serious impact on younger siblings who are less likely to have left the home (Conley, 2004; Sigle-Rushton et al., 2014). In truth then, the point estimates that have been presented in this thesis for the relationship between birth order and both educational attainment and health are likely to be slightly biased, but I have made every effort possible to minimise that bias with the data available.

9. Statistical Methods

In this study I have employed a variety of statistical methods to analyse the relationship between birth order and later-life outcomes, including ordinary least squares, logistic regression, and event-history analysis. In each case the choice of statistical method was based upon the most suitable approach to modelling the data, taking into account both the structure of the data, as well as the nature of the outcome variable. One of the key features of the statistical analyses used in this thesis is the application of fixed effects. Since this is such a cornerstone of the analyses presented in this paper, it is worthwhile describing it in more detail in this section. The use of fixed effects in this thesis was primarily motivated by the need to avoid the problems pointed out by those who have argued
that the admixture hypothesis (see section 2.3.1) explains many of the findings that have previously been reported in studies on the relationship between birth order and a range of later life outcomes. By using fixed-effects, specified at the level of the sibling group, it is possible to perform a within-family comparison. This means comparing siblings in the same group to one another. This approach makes it possible to analyse factors that vary within the sibling group, such as birth order, net of factors that remain constant, such as the size of the sibling group, or the personality of the parents.

The reason why this fixed effects approach is valuable is because when trying to develop precise estimates of the relationship between a given explanatory variable \( x \) and a given outcome variable \( y \), we are concerned about confounding (described above in section 8.2). It is likely that parents who have more children are different from those who have few children. This means that large families will contribute the majority of high birth order children to a population, and comparing children of different birth orders across different families may confuse the ‘effect’ of birth order with the ‘effect’ of something else, such as the socioeconomic class of the parents. Another reason that the fixed effects approach is crucial for conducting birth order research is that all the theories, even the physiological ones, proposed to explain why birth order should have any influence whatsoever, are based upon within-family dynamics. This means that it is critical that siblings are compared to one another for the influence of birth order itself to be estimated.

In practice what this means is that these unobserved factors (e.g. parenting style) are treated as nuisance parameters. Rather than being interested in the degree to which these unobserved factors may influence the outcome variable, the goal is to measure the effect of the relevant variable of interest, in this case birth order, net of these unobserved factors. So how does the fixed effects model work? For the sake of an example, let us focus upon a linear regression, or ordinary least squares (OLS), model. If we take the following model:
\( y_{ij} = \alpha + x_{ij}\beta + v_j + \epsilon_j \)

Where \( y_{ij} \) refers to the outcome variable, say years of education achieved by age 30, and \( \alpha \) is the intercept. What we are interested in estimating is \( \beta \) for a vector of covariates \( x \), and in particular birth order, for individual \( i \) in sibling group \( j \). The term \( v_j \) refers to the unit-specific error term, meaning the unobserved heterogeneity within a given sibling group. The term \( \epsilon_{ij} \) refers to the standard error term for individual \( i \) in sibling group \( j \), meaning the unobserved heterogeneity that is not accounted for by our vector of covariates \( x_{ij} \) or unobserved factors that remain constant within the sibling group, \( v_j \). Whatever the properties of \( v_j \) and \( \epsilon_{ij} \) in equation 5, if that is true, then so must:

\[ \bar{y}_i = \alpha + \bar{x}_i\beta + v_j + \bar{\epsilon}_i \]

Subtracting 6 from 5 leads to:

\[ (y_{ij} - \bar{y}_i) = (x_{ij} - \bar{x}_i)\beta + (\epsilon_{ij} - \bar{\epsilon}_i) \]

To gain the fixed effects estimates, OLS is used to estimate equation 7. In this transformation observed and unobserved factors within a sibling group \( j \) are removed (Baltagi, 2013; Wooldridge, 2013). As with any statistical estimator, there are underlying assumptions. For example, it is assumed that that the \( v_j \) should not be correlated with \( x_{ij} \), otherwise the model will continue to generate biased estimates. Although fixed effects make it possible to minimise residual confounding by adjusting for unobserved heterogeneity at the group level, it also has its limitations. One disadvantage of the fixed effects approach is that it cannot generate estimates for factors that remain constant within the group. In this thesis a clear example of that is the size of the sibling group. However, this is not a major issue for the studies included in this thesis, as the main
explanatory variable of interest is birth order, which does vary within the sibling group. Notably, it is possible to estimate the importance of birth order within different categories of a variable that remains constant, such as the size of the sibling group, by restricting the analysis to specific categories of that variable (Rothman, 2012). Examples of this approach are shown in all of the four studies included in this thesis. Although OLS, logistic regression, and event-history analysis are different statistical tools, the key idea for fixed effects underlying the example above applies to all three.

10. Discussion

This chapter has sought to review a wide range of literature relevant to those who are interested in the relationship between birth order and later life outcomes in Western, developed societies. This thesis contributes to the field of research on birth order in several ways. The first is by extending the relatively small body of previous research on the relationship between birth order and health in adulthood. The number of studies that have previously addressed this topic using a within-family comparison was previously very small (Bjørngaard et al., 2013; Jelenkovic et al., 2013; Myrskylä, Silventoinen, Jelenkovic, Tynelius and Rasmussen, 2013; Rostila et al., 2014). As this introductory chapter has emphasized, a within-family comparison is critical for drawing valid inferences about the effect that birth order has. Study I examines the relationship between birth order and mortality in adulthood, and finds that later borns have higher mortality. Furthermore, Study II shows that differences in health by birth order already exist in early adulthood. This is consistent with previous research showing that birth order has a negative effect on height (Myrskylä, Silventoinen, Jelenkovic, Tynelius and Rasmussen, 2013), as it suggests that the explanation for birth order patterns is to be found very early in life.

As was discussed in section 2, a number of different theories have been proposed to explain why birth order should influence later life outcomes. A number of these theories posit physiological, pre-natal explanations for this relationship.
By examining ‘birth order’ in fully adopted sibling groups, Study III in this thesis demonstrates that it is highly unlikely that pre-natal mechanisms can account for the negative relationship between birth order and educational attainment. This had previously been hinted at by a previous study examining the effect of ‘social birth order’ over ‘biological birth order’ examining families where children had died in infancy (Kristensen and Bjerkedal, 2007), but Study III is the first to show this by examining siblings within the same family. Finally, Study IV rounds out the four empirical papers in this thesis by showing that, despite all of the evidence for later born children doing worse, when we take into account improvements to environmental conditions it is actually completely possible for later borns to do better than their older siblings. To demonstrate this I have used the example of educational attainment, but the potential extensions are clear to any sphere of life where conditions have been improving over time, such as cognitive ability or longevity.

While thousands of studies have been published on the relationship between birth order and later life outcomes, there is still room for novel research on this topic. For one it would be interesting to examine whether the influence of birth order on educational transitions exists at all levels of the educational system. While there is evidence that birth order already matters in high school (Kantarевич and Mechoulan, 2006), and for the transitions to gymnasium (Härkönen, 2014), and tertiary education (Studies III and IV in this thesis), it would be interesting to know if this persists further up the educational system. Furthermore, it would be interesting to know whether there is not only vertical segregation by birth order, but also horizontal segregation. If first borns are more likely to study subjects at university that lead to advantageous career trajectories, this would serve to widen the gap between first and later borns, whereas the reverse would close the gap. Research showing that first borns have higher earnings than later borns suggests the former (Björklund, Eriksson, Jäntti, Rauum and Österbacka, 2004), but since this might be due to having greater educational attainment it remains an empirical question.
Another new area of birth order research concerns the multigenerational aspect of birth order effects. What I mean by the the multigenerational aspect of birth order effects is that if the socioeconomic and health outcomes in adulthood of parents are influenced by their own birth order, it may be that there is cumulative effect through the birth order of their own children.

Consider the simple family tree above. As has been detailed earlier in this introduction to the thesis, there is a consistent pattern that, when adjusting for confounding variable to the greatest extent possible, first borns have a greater level of educational attainment and health than do later borns. Birth order patterns in socioeconomic and health outcomes have been found over a wide range of cohorts in the 20th century, and so it is reasonable to expect that birth order would be important not only for the parents generation, but also for the subsequent generation of their children. Given this assumption, we might expect some kind of cumulative effect, where the first born of a first born should perform better not only than the second born in his or her own sibling group, but also better than the first born of the third born, and particularly better than the third born of the third born, for example. Colleagues in Norway are currently working on a first study addressing this research question, and it may be that the idea bears fruit.

Birth order generally accounts for a small percentage of the variance in educational and health outcomes between siblings. However, it may well be that when considered across multiple generations the average degree of influence of
birth order is much more substantial. Studying the intergenerational or multi-generational influence of birth order may be complicated by changing rates of educational enrolment, or the Flynn effect (Flynn, 1984), for example, but it may be possible to overcome this by using multilevel statistical models. Of course this kind of research is immensely demanding in terms of data, and even the current population registers in Sweden and Norway would be stretched to the limit in trying to address this research question. Nevertheless, we may be able to find preliminary answers to these questions in the short term, although firmer conclusions may have to wait.

Interest in the relationship between birth order and all manner of outcomes is not in short supply, as is evidenced by the fact that literally thousands of papers have been published on this topic (Ernst and Angst, 1983; Rodgers, 2014), spanning a period of over a hundred years (Galton, 1874). Nevertheless, the policy implications of birth order research are not clear. After all, birth order effects appear even in sibling groups with two children, and first borns in a multi-child sibship tend to perform better than only children. Thus, it is not completely clear what advice this should lead to for parents. However, this does not mean that there is no policy relevance. Towards the beginning of this chapter I argued that stratification researchers should take notice of birth order research even if they are not primarily interested in birth order itself as a variable. The justification that I gave for this is that empirical research indicates that birth order can serve as a marker of access to resources within the family, and particularly during the first few years of life.

As research on early life interventions has shown, the first few years of life are very sensitive, and the degree to which stimulation and opportunities to learn are available have a long-term impact (Campbell and Ramey, 1994; Heckman, 2006). Although birth order cannot tell us exactly what degree of resources individuals had access to in their childhood, it can serve as a proxy for that measure. Most research on the importance of early life resource access has had to study children across different families, and this body of the literature often focuses
on infants who are specifically disadvantaged in some way or another. Typical examples of this disadvantage are living in poverty, or having been born with low or very low birthweight (Ramey and Ramey, 1998). However, birth order as a variable provides researchers with an opportunity to study how relative access to resources can lead to divergent outcomes in all types of families, including those that have high levels of financial and social resources. The current state of knowledge in birth order research is consistent with that in the early intervention literature, meaning that this body of research may have greater policy relevance than appears at first sight.

11. SUMMARY OF EMPirical STUDIES

11.1. Study I

Birth Order and Mortality: A Population-based Cohort Study. This study uses Swedish population register data to investigate the relationship between birth order and mortality in adulthood over the ages 30 to 69 for Swedish cohorts born between 1938 and 1960, using a within-family comparison. The main analyses are conducted with discrete-time survival analysis using a within-family comparison, and the estimates are adjusted for age, mother’s age at the time of birth, and cohort. Focusing on sibships ranging in size from two to six, we find that mortality risk in adulthood increases with later birth order. The results show that the relative effect of birth order is greater amongst women than amongst men. This pattern is consistent for all the major causes of death, but is particularly pronounced for mortality attributable to cancers of the respiratory system, and external causes. Further analyses where we adjust for adult socioeconomic status and adult educational attainment suggest that social pathways only mediate the relationship between birth order and mortality risk in adulthood to a limited degree.
11.2. **Study II**  
**Birth Order and Health in Early Adulthood: Evidence from Swedish Military Conscription Data.** Physical fitness at young adult ages is an important determinant of physical health, cognitive ability, and mortality. However, few studies have addressed the relationship between early life conditions and physical fitness in adulthood. An important potential factor influencing physical fitness is birth order, which prior studies associate with several early- and later-life outcomes such as height and mortality. This is the first study to analyse the association between birth order and physical fitness in late adolescence. We use military conscription data on 218,873 Swedish males born between 1965 and 1977. Physical fitness is measured by a test of maximal working capacity, a measure of cardiovascular fitness closely related to VO2max. We use linear regression with sibling fixed effects, meaning a within-family comparison, to eliminate the confounding influence of unobserved factors that vary between siblings. To understand the mechanism we further analyse whether the association between birth order and physical fitness varies by sibship size, parental socioeconomic status, birth cohort or length of the birth interval. We find a strong, negative and monotonic relationship between birth order and physical fitness. For example, third-born children have a maximal working capacity approximately 0.1 (p<0.000) standard deviations lower than first-born children. The association exists both in small (3 or less children) and large families (4 or more children), in high and low socioeconomic status families, and amongst cohorts born in the 1960s and the 1970s. While in the whole population the birth order effect does not depend on the length of the birth intervals, in two-child families a longer birth interval strengthens the advantage of the first-born. Our results illustrate the importance of birth order on physical fitness, and suggest that the first-born advantage already arises in late adolescence.

11.3. **Study III**  
**Sibling Set Order and Educational Attainment: Evidence from Fully Adopted**
Sibling Groups. This study uses data on fully adopted sibling groups to test whether the explanation for the consistently observed negative effects of birth order are physiological or social in origin. Swedish administrative register data is used to construct full sibling data for cohorts born 1960 to 1982. Using a within-family comparison approach, I compare adopted siblings of different adopted birth order to one another to see whether birth order amongst adopted children (N=6,968) is associated with educational attainment by age 30, and the likelihood of having entered tertiary education by age 30. These same within-family comparison analyses are also performed on siblings in fully biologically related sibling groups (N=1,588,401). I find that there is a negative relationship between adopted birth order and both educational attainment and the likelihood of entering tertiary education in fully adopted sibling sets. These findings strongly suggest that differences in educational attainment by birth order are driven by intrafamily social dynamics. I also conduct additional analyses in fully adopted sibling groups where age order and adoption order are reversed to test whether there is evidence for tutoring by siblings. These results do not indicate clear support for any tutoring effect.

11.4. Study IV
The Birth Order Paradox: Sibling Differences in Educational Attainment. This study examines the relationship between birth order and educational attainment, and demonstrates that while the causal effect of birth order on educational attainment is negative, later born children perform better. The explanation for this finding is due to the secular trend of increasing education enrolment, which outweighs the negative causal effect of birth order. This is particularly true for women due to the fact that the rate of increasing educational enrolment has been greater for women than for men. These results also show that later borns in large families particularly benefit from the secular trend in increasing educational enrolment due to the higher average birth interval between the first and last child in large families. This study uses Swedish register data on cohorts
born between 1960 and 1982. Educational attainment is measured using both years of education by age 30, as well as whether individuals have made the transition to tertiary education by age 30. These results shed new light on the disputes over birth order effects in the literature, as they show that those who argue that birth order has a negative causal effect on educational attainment, and those who argue that later borns actually do better, are both correct, but are arguing at cross-purposes.
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