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Exploring the effects of birth order on human lifespan in Polish historical populations, 1738–1968

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ABSTRACT: While the relationships between birth order and later outcomes in life, including health and wealth, have been the subject of investigation for several decades, little or no data exist regarding the relationship between birth order and life expectancy in the Polish population. The aim of this study was to explore the link between birth order and lifespan in Polish historical populations. We obtained 8523 records from a historical dataset that was established for parishioners from the borough of Bejsce, including 4463 males and 4060 females. These data pertain to the populations that lived over a long period in a group of localities for which parish registers were well preserved. The Mann-Whitney U test, the Kruskal-Wallis ANOVA and ANCOVA were run. The results strongly suggest that birth order affects male longevity. However, no such association was found for females. On balance, the hypothesis that first-born boys live longer because they are born to relatively younger parents has received some empirical support and deserves further study. We hypothesise that the effects of birth order on human health and lifespan might be overshadowed by other factors, including educational attainment, socioeconomic status and lifestyle.

KEY WORDS: age at death, birth order, health, lifespan, mortality, siblings, survival

Introduction

Human lifespan is a multifactorial trait that is affected by genetic background, epigenetic mechanisms, lifestyle and environmental factors (Govindaraju et al. 2015; Chmielewski et al. 2016; Chmielewski 2020; Costa et al. 2019). While the relationships between birth order and later outcomes in life, includ-

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ing health and wealth, have been the subject of investigation for several decades, little or no data exist regarding the relationship between birth order and longevity in Poland. It has been established that economic resources and social conditions within the family of origin have important consequences for health outcomes in later life (Gluckman et al. 2008). However, few studies have explored the links between birth order and long-term survival in adolescents and adults (O'Leary et al. 1996; Modin 2002; Smith et al. 2009). To our knowledge, no such studies have been reported for the Polish population.

Currently, it is not clear whether and how lifespan is affected by birth order. Several studies have shown that first-born children have a longevity advantage over later-born children, which can be attributed to the fact that they are born to relatively younger parents (Gavrilov et al. 1997; Gavrilov et al. 2000). In particular, it has been demonstrated that individuals who were the first-born in large families were two to three times more likely to reach the age of 100 years than children of higher birth orders (Gavrilova and Gavrilov 2007). Nonetheless, the effects of birth order on lifespan are overshadowed by other factors, including educational attainment, economic resources, socioeconomic status (SES), lifestyle (Gavrilov, personal communication). Furthermore, it has been established that first-born children do better on some aspects and worse on others (Black 2017). Therefore, a binary answer (i.e. 'yes/no' or 'true/false') to the question: 'Do first-born individuals live longer than their later-born counterparts?' cannot be obtained.

Moreover, the idea that a single trait, such as being a first-born child, can confer longevity, is flawed. Like ageing, life is a complex interplay of various elements, including extrinsic (environmental) and intrinsic (genetic and epigenetic) processes and factors (Chmielewski 2017, 2020; Whitwell et al. 2020). Although early life events have some health impacts later in life (Bartke 2015; Chmielewski 2016; Hemati et al. 2021), many other factors, including the genetic background, the environment, exposure to carcinogens and other harmful substances, educational attainment, SES and lifestyle, play a key role in shaping health outcomes (Govindaraju et al. 2015; Chmielewski et al. 2016; Costa et al. 2019). Furthermore, it can be argued that the effects of birth order on health and survival in later life are currently too small to be readily detected, and this relationship is probably tenuous in modern populations.

Nevertheless, it has been demonstrated that first-born individuals are more likely to be overweight and obese in adult life (Rosenberg 1988; Siervo et al. 2010; Derraik et al. 2016). First-born adults have also been shown to be at a higher risk of type 2 diabetes and cardiovascular disease (Lammi et al. 2007). Some other studies have reported that the probability of having high blood pressure declines with birth order, and the largest gap is between first-born and second-born subjects (Black 2017). Since hypertension and obesity are the major risk factors for coronary heart disease (CHD), stroke and premature death (Global BMI Mortality Collaboration et al. 2016; Muller et al. 2016; Mills et al. 2020), it has been hypothesised that first-born individuals experience worse health outcomes in adult life, as they have greater adiposity and cardiovascular risk in comparison to their later-born siblings. However, other authors have reported no association between birth order and cardiovascular risk (Howe et al. 2014).

Interestingly, first-born individuals are more likely to consider themselves to be in good health (Black 2017). Moreover, they are two to three times more likely to become centenarians compared with later-born children (Gavrilova and Gavrilov 2007). Furthermore, it has been established that measures of mental health generally decline with birth order (Gates et al. 1988; Easey et al. 2019). Previous studies have shown that first-born individuals tend to be more intelligent and resourceful than their later-born siblings, presumably because they received more parental care and mental stimulation at a relatively younger age (Lehmann et al. 2018). Moreover, it is well known that the eldest child in the family is typically more disciplined. First-born children have no competition, and they are a surrogate parent towards their later-born siblings. Thus, they perform parental roles for their siblings on behalf of their parents, which is a trait that they carry forward in life. On the other hand, several studies have found that later-born children are less likely to have mental health problems and are more likely to have prosocial behaviours and resilience (Fukuya et al. 2021). The current study aims to evaluate the relationship between birth order and lifespan in inhabitants of Bejsce based on a large sample drawn from historical cohorts.

Materials and methods

For the purpose of the study, we collected data from Polish church records. Parishioner data detailing their birth and death dates, birth and death dates of their parents, sex, marital status and family size were used. The data pertain to the populations that existed over a long period, i.e. from 1738 to 1968, in a group of localities for which parish registers were well preserved.

A total of 8523 records, including 4463 males and 4060 females, were included in the analysis. All of these records derive from a historical dataset that was established for parishioners from the borough of Bejsce, which is historically referred to as the 'Bejsce parish'. It covered a relatively large area, and because of its fertile land and moderate climate, it has been inhabited continuously since the Migration period. The Bejsce parish was located in a relatively safe region in Southern Poland, between Kraków and Kielce. Historically, this group of localities has been relatively rich and prosperous. Another advantage of the study sample is the fact that it is homogeneous in terms of nationality and religion of the inhabitants.

In the analysis, two databases from the archives were used: (A) data on individuals and (B) data on marriages. (A) includes: (1) an individual number code for identification purposes, (2) date of birth, (3) sex, (4) a number code of the person's father, (5) a number code of the person's mother, (6) number of marriages, (7) number of offspring and (8) date of death. (B) contains information on the marital history and includes data on: (1) a number code of the person's husband, (2) a number code of the person's wife, (3) a number code of the marriage, (4) date of marriage and (5) number of children. By combining both databases, it was possible to connect children with their mothers and fathers, siblings with each other and spouses with each other in order to group individuals into families of origin and into families in adult life.

Table 1. Study sample showing the four consecutive birth cohorts

Birth cohort		Males *n* (%)	Females *n* (%)	Total *n* (%)
No. 1	1738–1808	652 (14.6)	619 (15.2)	1271 (14.9)
No. 2	1809–1848	1235 (27.7)	1778 (29.1)	2413 (28.3)
No. 3	1849–1888	1610 (36.1)	1455 (35.8)	3065 (36.0)
No. 4	1889–1968	966 (21.6)	808 (19.9)	1774 (20.8)
Total		4463 (52.4)	4060 (47.6)	8523 (100.0)

The study sample was divided into four birth cohorts (Table 1). The number of subjects in these consecutive birth cohorts are presented in Table 2. In all groups, the lifespan significantly deviated from normal distribution assessed by the Kolmogorov-Smirnov test. Therefore, non-parametric tests were employed. The Mann-Whitney U test was used to compare the lifespan between the two studied groups. The Kruskal-Wallis ANOVA was run to compare more groups with each other. After controlling for birth cohort and mother's age at birth, the analysis of covariance (ANCOVA) was performed along with the GLM procedure in order to analyse the effect of birth order on lifespan. The first part of the analysis was performed for the entire study sample, while the second part was conducted for two groups: (1) individuals who died at the age of 15 years or younger and (2) individuals who died at later ages.

Results

The baseline characteristics of the study sample are shown in Tables 1 and 2. Considering deaths up to the age of 15 years, girls lived longer than boys. However, no differences were found for individuals who lived longer than 15 years (Table 3). Table 4 shows the results of the Kruskal-Wallis test. Table 5 reports on the differences in lifespan, which were assessed with ANOVA, in individuals who died

Table 2. Number of individuals in the four consecutive birth cohorts, depending on their birth order

Birth order	Birth cohort	Males	Females	Total	%
First	1738–1808	302	278	580	15.0
	1809–1848	492	474	966	25.1
	1849–1888	699	642	1341	34.8
	1889–1968	540	428	968	25.1
	Total	2033	1822	3855	100.0
Second	1738–1808	199	214	413	15.4
	1809–1848	400	389	789	29.4
	1849–1888	521	452	973	36.2
	1889–1968	276	236	512	19.1
	Total	1396	1291	2687	100.0
Third	1738–1808	151	127	278	14.1
	1809–1848	343	315	658	33.2
	1849–1888	390	361	751	37.9
	1889–1968	150	144	294	14.8
	Total	1034	947	1981	100.0

after the age of 15 years. In females, no differences were observed for those who died at the age of ≤ 15 years and after age 15.

After controlling for birth cohort and mother's age at birth, the effects of birth order on lifespan remained significant in males but not in females (Table 6). However, a statistically significant second-order interaction between birth order and birth cohort was observed.

Table 3. Sex differences in lifespan in the two studied groups

Age at death	Mean (SD)	Median	*U*	*p*
≤ 15 years				
Boys	2.5 (3.4)	1.1	3.3	<0.001
Girls	2.8 (3.4)	1.3		
Cohort				
No. 1	2.6 (3.3)	1.4		
No. 2	2.9 (3.5)	1.5		
No. 3	2.8 (3.3)	1.6		
No. 4	2.3 (3.5)	0.7	*H*=131.5	<0.001
≥ 15 years				
Males	50.2 (19.0)	52.4	1.9	0.068
Females	49.0 (20.4)	49.5		
Cohort				
No. 1	50.5 (15.2)	52.4		
No. 2	50.0 (19.2)	50.4		
No. 3	53.4 (21.1)	57.3		
No. 4	32.5 (14.0)	28.2	*H*=306.5	<0.001

Table 4. Differences in lifespan in males and females who died at the age of 15 years or earlier, depending on their birth cohort and birth order

	Males			Females		
	H	*df*	*p*	*F*	*df*	*p*
			Whole lifespan			
BC	327.48	3	<0.001	381.59	3	<0.001
BO	14.36	2	<0.001	18.87	2	<0.001
			Earlier or at age of 15 years			
BC	64.78	3	<0.001	67.94	3	<0.001
BO	20.86	2	<0.001	7.48	2	<0.05

BC, birth cohort; BO, birth order; df, degrees of freedom. Differences were assessed with the Kruskal-Wallis test.

Table 5. Differences in lifespan in individuals who died after the age of 15 years, depending on their birth cohort and birth order

	Males			Females		
	F	*df*	*p*	*F*	*df*	*p*
BC	72.56	3	<0.001	43.16	3	<0.001
BO	2.47	2	0.099	3.13	2	<0.05

BC, birth cohort; BO, birth order; df, degrees of freedom. Differences were assessed using ANOVA.

Table 6. Results of analysis of covariance (ANCOVA)

	Males			Females		
	Wald's χ^2	*df*	*p*	Wald's χ^2	*df*	*p*
BC	1166.3	3	<0.001	1490.8	3	<0.001
BO	48.2	2	<0.001	94.6	2	<0.001
BC × BO	320.0	6	<0.001	259.5	6	<0.001
Mother's age	698.3	1	<0.001	314.7	1	<0.001

BC, birth cohort; BO, birth order; df, degrees of freedom. Dependent variable is lifetime and independent variables are sex, BC and BO. Mother's age is a covariable.

In the first birth cohort (1738–1808), third-born males had the lowest age at death as opposed to their siblings. These differences in lifespan were 6 years in relation to the middle siblings ($p = 0.003$) and 7 years in relation to the first-born ($p < 0.001$). In the second birth cohort (1809–1848), first-born males lived significantly longer (by about 5 years) than boys of higher birth orders. In the third birth cohort, however, second-born males had the highest age at death (26.9 years) and lived significantly longer than their siblings ($p = 0.005$). In the fourth birth cohort, third-born males had the highest age at death and these differences in lifespan were statistically significant ($p = 0.046$).

Discussion

This study uses a large and representative sample of children and adults, derived from historical data, to test the hypothesis that birth order affects lifespan. The results suggest that birth order affects male longevity, while no such association was found for females. In general, the lower-birth-order males had a survival advantage over males of higher birth orders. Nevertheless, the youngest males had the highest age at death in the fourth birth cohort. The second order interaction between birth cohort and birth order is significant, which means that the strength of the effects of birth order on lifespan varied in different historical periods. In boys, the effects climaxed in the 18th century and waned afterwards. In those who were born in the 20th century, there were no differences in lifespan due to birth order. However, in the 18th century firstborns tended to live longer than their later-born siblings.

To date, several studies have demonstrated that first-born children have an advantage in educational attainment, health status and later outcomes in life over their later-born counterparts (Behrman and Taubman 1986; Hanushek 1992; Price 2008; Keller et al. 2015). Interestingly, when birth order is controlled for, family size has either a small effect or no effect on the first-born child (Black et al. 2005; Conley and Glauber 2006). Observations that offspring from older parents, but especially from older mothers, have shorter life expectancies, suggest that the accumulation of genetic damage in eggs (and sperm, as similar effects have been observed for the paternal line) occurring over time can negatively affect the healthspan and lifespan of offspring (Crow 1997; Gavrilov et al. 1997; Gavrilov et al. 2000). Epigenetic alterations in germ cells also play a critical role in development and growth throughout ontogeny (Chamani and Keefe 2019).

Alternatively, this might be an artefact of genetic heterogeneity in mortality rates within populations, as short-lived women do not contribute offspring to 'old female' cohorts, resulting in a population-level shift in the genetic composition of offspring with increasing female age (Vaupel and Yashin 1985). However, several studies have controlled for this confound. For example, Priest and associates (2002) reported that maternal age still had an effect on offspring survival. Furthermore, individuals who were the first-born in large families were two to three times more likely to reach the age of 100 years in comparison to later-born children (Gavrilova and Gavrilov 2007). In general, these findings have been interpreted as indicating possible interactions between age of parents and the health status of their offspring. It has been hypothesised that sperm and eggs become damaged with increasing age. Therefore, children born of relatively older parents are more likely to have health problems in later life.

On the other hand, observations that first-born children are smaller at birth but are more likely to be overweight and obese in later life in comparison to their later-born siblings, challenge the view that first-born individuals tend to have better health outcomes in terms of life expectancy (Siervo et al. 2010; Derraik et al. 2016). These links have been historically studied and have not significantly changed since their first description in the 19th century. Moreover, it has been established that modern first-born children have a higher risk of type 2 diabetes in adult life (Lammi et al. 2007). Nevertheless, this may not have been the case for the historic samples. Over the last decades, life expectancy has increased dramatically. In general, modern people are taller, heavier and live longer compared to previous generations. Modern diets tend to be rich in sugar, saturated fats and processed food. Since ageing, obesity, energy dense diets and physical inactivity constitute the main risk factors for the development of type 2 diabetes (Thibault et al. 2016), the general picture might have looked quite different in the historic populations. Even if firstborns are more susceptible to type 2 diabetes, it is conceivable that they did not live long enough in the past to develop this condition. In the past, life conditions were different. It is also possible that the advantageous first-born effect on life expectancy in the historic samples was outcompeted by the negative first-born effect on health in the recent samples.

A growing body of evidence suggests that early-life events can affect the long-term health and survival of offspring via several different mechanisms (Stöger 2008; Taylor 2010; Wells 2011; Martin-Gronert and Ozanne 2012). Biological factors acting during early development, such as nutritional and hormonal signals, can alter the onset of various chronic diseases in adulthood and during ageing (Bartke 2015). The concept of developmental 'programming' of adult health and longevity is supported by results from both animal models and anthropological investigations (Aiken and Ozanne 2014). In general, males are more vulnerable than females. Therefore, the observed relationships are more pronounced in men. Likewise, the month of birth effects on lifespan are stronger in men (Doblhammer and Vaupel 2001; Lerchl 2004; Chmielewski and Borysławski 2016).

It has been suggested that the bio-social factors and the social context of the family are involved in the relationship between birth order and lifespan.

The scientific literature is replete with examples which indicate that children in larger families tend to have lower levels of educational attainment and worse outcomes in adult life in terms of risky behaviours and delinquency (Becker and Lewis 1973; Blake 1989; Steelman et. 2002; Black et al. 2005). Furthermore, it has been established that parental resources available to each child decrease as the number of siblings increases. In particular, the Resource Dilution Hypothesis states that siblings are competitors for parents' time, energy, money, support and other resources (Blake 1989; Downey 2001; Li et al. 2008; Tanskanen et al. 2016). Accordingly, the first-born child has the exclusive attention and resources of the parents. As the number of children in the family increases, the resources accrued by any one child necessarily decline. Even one sibling dilutes the resources that are available to the other sibling (Downey 2001). Furthermore, an increased number of siblings of the opposite sex can be harmful to educational achievement as sex minority children might find their gender-specific needs unmet (Powell and Steelman 1995; Conley 2000).

It is important to note that methodological issues can affect the interpretation of these findings. As Price (2008) points out, parents who have a 'good' child are more likely to have more children, such that reversion to the mean increases the likelihood of the second birth being a 'worse' child. Although, early studies reported small and insignificant effects of birth order on child outcomes (Kessler 1991), later investigations revealed that higher-birth-order children have worse outcomes. Hanushek (1992) found a U-shaped relationship where the first-born and last-born have the best outcomes. In general, the empirical data reveal that the first-born child receives about 20 more minutes of quality father-time and 25 more minutes of quality mother-time each day at each age as opposed to the second-born child (Price 2008). These observations indicate that there are birth-order differences in the amount of quality time that children spend with their parents.

Other studies have found that both first-born children and last-born children are at a greater risk of dying compared with those in the middle (Mishra et al. 2017). Children of higher birth orders might be in a more favourable position than their older siblings due to the greater amount of material resources that have been accumulated by their parents. Furthermore, later-born children experience a household environment in which the parents are more experienced at parenting and have more income (Behrman and Taubman 1986; Powell and Steelman 1995). Nonetheless, children of higher birth orders have worse outcomes in terms of risky behaviours and delinquency, which suggests that they are more likely to die earlier due to accidents, violence and suicides (Becker and Lewis 1973; Blake 1989; Steelman et. 2002; Barclay and Kolk 2015). Interestingly, firstborns score higher (by 2 points) in IQ tests and are more likely to be in a higher social class (Lehmann et al. 2018), which may translate into higher income and SES.

Firstborns have higher educational attainment than second-born children, and the difference in educational attainment between the first child and the fifth child in a five-child family is comparable with that between the educational attainment of whites and blacks calculated from the 2000 Census (Black et al.

2005). Moreover, other studies have revealed an inverse link between education attainment and mortality. Adults with higher education are healthier and tend to live longer than those with primary or vocational education (Baker et al. 2011; Hummer and Hernandez 2013; Krueger et al. 2015; Sasson and Hayward 2019; Johnston 2020).

Several investigations have indicated a significant role of parents and older siblings in shaping proper pro-health behaviours in younger siblings. It has been demonstrated that younger siblings are more likely to use stimulants, e.g. alcohol, if their older siblings also use these substances (Elliott 1992; Modin 2002). Given that first-born children are more likely to achieve higher levels of education and higher positions on the social scale, they tend to live longer compared with their younger siblings. This statement is consistent with several studies on child survival. It is also possible that the long-term effect of birth order position on mortality is mediated by personality traits, adult social class, education, income and SES.

It is, however, important to note that this study is not without its limitations. One major issue is that the observed lifespan was rather short, which suggests that life expectancy was reduced due to unknown factors such as natural disasters, epidemics and conflicts. Futhermore, Catholic priests often excluded atheists, agnostics, non-believers and those who professed other faiths from their parish registers. Thus, it is possible that the collected data represent only Catholics. However, the overwhelming majority of Poles identified themselves as Catholic, which means that the collected data are still representative for the Polish population.

Conclusions

These findings are consistent with the idea that birth order can affect lifespan. Nevertheless, the observed effects are rarely straightforward as firstborns do not always live longer than their younger siblings. Males are more vulnerable than females and these effects are typically more pronounced in males.

Authors' contribution

PPC did a literature review, interpreted the results and wrote the manuscript. AŻ prepared the data for analysis, advised on interpretation of the results and wrote an early version of the paper. SK conceived the idea for the article, analysed the data and proofread the manuscript.

Conflict of interest

The authors declare no conflict of interests.

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