PARENTAL AGE AT BIRTH AND LONGEVITY OF OFFSPRING IN CENTENARIAN FAMILIES
The role of biology, social interaction and culture

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Introduction

There is an increasing interest in the reasons why we become centenarians. Today, the importance of family in contributing to health and longevity is well-recognized and continues to inspire researchers to identify the conditions and influences that guide the achievement of exceptionnal survival. Many studies have shown that parents and siblings of centenarians have a survival advantage compared with their birth cohort (Perls et al., 1998, 2002; Willcox et al., 2006; Jarry et al., 2012). Genetics as well as familial shared environment early in life have often been put forward to explain familial similarities in life duration. However, of several siblings in a centenarian family, often only one of them will achieve age 100. Therefore, the question to be asked now is what about life span differences between siblings? While the influence of genetics and shared environment on longevity has been extensively studied, the impact of non-shared within families factors on longevity did not reach a consensus.

As far as one century ago, Bell (1918) found that children born to mothers aged 40 and above had almost 11 years shorter life expectancy than those born to mothers younger than 25 years. Javalisto (1959) analyzed 17th to 19th century Finnish and Swedish families and found that maternal age above age 40 was associated with 5 years shorter life expectancy than maternal age below age 25. A retrospective analysis from records of European aristocracy conducted by Leonid Gavrilov and colleagues in 1997, revealed that daughters born to fathers aged >50 years died 4.4 years earlier compared to daughters of younger fathers aged between 20 and 29 years of age(Gavrilov and Gavrilova, 1997). They also found that adult daughters born to mothers aged older than 40 years lived significantly shorter lives. Smith et al. (2009) analyzed Utah cohorts born between 1850 and 1900 and found that, for sons, maternal age above 35 is associated with 8% increased adult mortality compared to maternal age between 20 and 29. Amongst centenarians and their siblings, Gavrilov and Gavrilova's research showed that exceptional longevity was linked to birth order, a relationship that seemed mostly driven by a young maternal age (>25 years) at the child's birth (Gavrilova and Gavrilov, 2010). Even if a few studies found little or no evidence for the link between advanced maternal or paternal age and offspring adult survival (Hubbard et al., 2009; Robine et al., 2003; Westendorp and Kirkwood, 2001), the majority of studies suggest that advanced parental age is associated with negative health outcomes later in life.

Parental age at childbirth implies a range of particular mechanisms, such as social and cultural conditions associated with birth order and family size (for example the *Resource Theory*), as well as physio-biological particularities such as the deterioration process of parental cells (Modin, 2002). In fact, the negative association between advanced maternal and paternal age and offsping longevity is thought to be driven by the physiological aging of both parents. Thus, both biology as well as social and cultural context could explain why siblings, who tend to have a similar lifespan, do not quite have the same chances of becoming a centenarian.

In this study, we investigate the effects of paternal and maternal age at childbirth on survival to age 100 using a sample of 800 centenarians as well as their siblings. We also explore the relationship between seasonality and longevity as the season of birth is another aspect of the non-shared environment. The following research questions were addressed: 1) Is paternal age and maternal age associated with survival to 100?; 2) Are father's and mother's age at childbirth equally important for longevity?; 3) Is the social aspect of birth order more important than parental age in explaining survival? 4) Is the influence of birth order depends on the sex of the child? and 5) How does seasonality affect exceptionnal survival?

Data and methods

Complete data were available for 800 centenarians and their siblings. The 800 validated centenarians were born in the province of Quebec (Canada) between 1890 and 1900 and their family histories were reconstructed using the 1901 and 1911 Canadian censuses as well as birth records. 3000 siblings of centenarians were identified as well as their age at death which were found in the Quebec Consolidated Deaths Index from the genealogical society of Quebec. For deaths occurring beyond 1996, we used a list of registered deaths over 85 years old for the years 1997-2004 provided by l'Institut de la Statistique du Quebec.

We estimated siblings fixed effects models to isolate the causal effect of parental age and to compare children within rather than across families. Fixed effect models were also chosen to capture the underlying family level heterogeneity that could affect the survival of children. The following variables were explored and included in the models: sex, birth order, family size, paternal age at the child's birth, maternal age at the child's birth, and the season of birth. Hypothesis were made concerning social or economic mobility and we assumed that all siblings lived in a similar environment during childhood.

Preliminary results

Since the collection of data on the 800 centenarians and their siblings is still ongoing, preliminary results presented here were derived from the first 130 centenarians (and their siblings) for whom we already have complete information. On the basis of these results, we found that children born to mothers aged between 25 and 29 years of age had more than twice the chances to survive to age 100 compared to their brothers and sisters born to 40-year-old-and-older mothers. Moreover, even when controlling for paternal age, which does not seem to influence offspring survival, and seasonality, it still helps to be born to a 25-29 years of age mother (Table 1). We also found that being born in winter seems to provide a survival advantage compare to being born during summer, an observation that can be explained by possible shortages that sometimes come during spring and can affect the weight of a baby born in the summer. These preliminary results agree with those of Doblhammer (1999) who found that individuals born in winter have a higher life expectancy than those born in summer as a result from factors that affect individuals early in life.

A two-sample t test also allowed us to see that centenarians siblings were born to parents younger than their shorter-lived siblings.

Since the project is ongoing and not completed, there are several analysis we still have to run and we must take into account many other variables, such as the urban-rural residence, the birth interval between two siblings, by sex, etc. Still, we can see a possible link or a relationship between parental age at child's birth and longevity outcomes which gives us insights into the ways a family influences an individual's health. Mechanisms behind this relationship however remain to be elucidated in the next months.

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Table 1: Odds ratios (with p-values) to become a centenarian as predicted by fixed-effect models.

Early-life Variable Conditional on survival to age 50	Model 1	Model 2	Model 3
Maternal Age			
<20	2.02 (0.289)	1.74 (0.562)	1.48 (0.681)
20-24	1.63 (0.253)	2.08 (0.307)	1.68(0.479)
25-29	2.45 (0.015)	3.41 (0.041)	2.77 (0.098)
30-34	1.41 (0.367)	1.68 (0.299)	1.44 (0.475)
35-39	1.19 (0.669)	1.26 (0.586)	1.13 (0.785)
≥40	reference	reference	reference
Female	6.07 (0.000)	5.86(0.000)	5.88 (0.000)
Paternal Age			
<25		1.57 (0.568)	1.71 (0.499)
25-29		0.61 (0.446)	0.70 (0.576)
30-34		0.65 (0.402)	0.70 (0.479)
35-39		0.99 (0.977)	0.98 (0.969)
≥40		reference	reference
Season			
Winter			1.73 (0.080)
Spring			1.37 (0.297)
Fall			1.43 (0.243)
Summer			reference