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Descriptive Finding

Birth month and adult lifespan: A within-family, cohort, and spatial examination using FamiLinx data in the United States (1700–1899)

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Abstract

BACKGROUND
Research has shown that the circumstances surrounding birth may influence the timing of death. In the northern hemisphere, children born in spring and summer have a shorter lifespan than those born in fall and winter.

OBJECTIVE
We describe the effect of month of birth on adult lifespan (50+) in the United States in three ways. First, we estimate it between and within groups of siblings, accounting for unobserved factors at the family level. Second, we estimate the effect of birth month across a period of about 200 years (1700–1899). Third, we examine geographical variation in the effect of birth month across US census areas.

METHODS
We estimate descriptive statistics and OLS regression models between and within sibling groups.

RESULTS
We find an effect of birth month on lifespan. Individuals born in spring and summer have on average a shorter lifespan than those born in fall and winter. The effect is relatively consistent across cohorts, geographical census areas, and between and within families. We test different possible explanations for this result and find residual evidence that in utero debilitation may account for this result.

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CONTRIBUTION

Twenty years ago, Gabriele Doblhammer and James W. Vaupel published an influential paper, showing the importance of birth month for lifespan and arguing that circumstances experienced in utero are the likely explanation for this result. We extend these insights by exploiting new crowdsourced data that allows us to study the phenomena over 200 years, across space, and between and within families.

1. Introduction

In a seminal paper, Doblhammer and Vaupel (2001) showed that the month of birth influences the timing of death. They documented that children born in the northern hemisphere during spring and early summer have, on average, a shorter adult lifespan than those born in winter and fall, with the reversed pattern in the southern hemisphere. Building on the fetal origin hypothesis of the effect of prenatal health on the risk of later-life metabolic diseases (Barker 1990), they argue that the month of birth proxies environmental exposures leading to in utero debilitations, which in turn shape later-life mortality patterns. This finding has been replicated in some studies (Doblhammer 2004, 2019; Gagnon 2012; Gavrilov and Gavrilova 2011; Moore et al. 1997; Vaiserman et al. 2002), while others fail to find any association between birth month and lifespan (Moore et al. 2004; Simondon et al. 2004; Su 2009). These mixed results may reflect different study populations, different contexts, or different cohorts analyzed.

In this study we expand Doblhammer and Vaupel's (2001) work and study the association between birth month and adult lifespan in the United States (US) between 1700 and 1899. We draw on online crowdsourced genealogy data that reconstruct family networks over centuries and give us several advantages. First, since our data allow for cohort analyses, we extend Doblhammer and Vaupel's (2001) work, as they could only reconstruct mortality from death registers and thus did not take into account exposure at time of birth. We were able to analyze birth cohorts over two centuries. Second, we explore geographical variability across US census areas. Third, we estimate lifespan differences by birth month using within-family variation, excluding potentially unobserved factors associated with the shared family environment. Finally, we test the main pathways which may link birth month to lifespan.

2. Methods

2.1 Data

To explore the link between birth month and adult lifespan we draw on FamiLinx data (Kaplanis et al. 2018). They contain over 86 million records reporting individuals' basic demographic information, made by genealogists and online users who recreated lineages across centuries for the Western world (Kaplanis et al. 2018). Genealogical data allows the reconstruction of family networks and enables the exploration of variation within different groups of relatives, and they have been used to investigate a vast set of bio-demographic phenomena (Blanc 2021; Fire and Elovici 2015; Hsu et al. 2021; Rawlik, Canela-Xandri, and Tenesa 2019).

However, genealogy data are not without limitations. Genealogies of the ascendant type, such as the one analyzed in this paper, may be subject to certain design biases (Hollingsworth 1976). First, the inclusion of individuals in a family tree is typically dependent on the existence of living descendants. As a consequence, childless individuals are less likely to be included in the data. Also, the backwards reconstruction of family geneaologies creates an incomplete picture of premature deaths and marriages that do not result in offspring, and a selection of genealogies based on survivorship bias and lineage extinction (Zhao 2001). Second, genealogists may selectively record ancestors deemed more worthy of incorporation into the family tree or those more easily traceable through existing family and historical sources. Indeed, recent studies attempting to validate the Familinx data against comparable and representative data sources have shown that, while they can fairly represent historical trends in life expectancy, they tend to underestimate mortality rates, especially for younger age groups (Chong et al. 2022; Stelter and Alburez-Gutierrez 2022).

We limit our sample to individuals born in the US between 1700 and 1899, for whom we have valid information on the month and year of birth and death, state of birth, and gender, and who lived for between 50 and 100 years, similar to Doblhammer and Vaupel (2001). We determine whether an individual is born in the United States using location information in the FamiLinx data, which is reported in both unstructured text and coordinates. In order to obtain consistent and harmonized strings for country and state of birth we reverse geo-parsed coordinates into categorical information on location (Becker et al. 2018). The final full sample consists of around 1.3 million individuals. We also define a subsample consisting of only individuals for whom we also have information on both parents. We call this the sibling sample (N = 396,941). In our replication package we provide full details of missing values and the procedure to extract the data, extract and attribute birth locations, and select the analytical sample. Finally, it is worth noticing that sample restrictions based on the availability of information are unavoidable.

However, individuals who report very precise and complete information are likely a selected subset of the population on a number of characteristics, such as socioeconomic status and health. Missing information is more common in earlier periods and progressively declines. Records with dates of birth and death recorded down to the month typically display higher average lifespan, lower lifespan inequality, and a lower percentage of females (Minardi, Corti, and Barban 2023).

2.2 Variables

Outcome variables. We measure lifespan as the deviation in years from the year-of-birth and sex-specific average age at death. We compute deviation from average lifespan as:

$$\Delta DA_i = DA_{iys} - \overline{DA_{YS}}$$

where i is the individual, y is the year of birth, s is the sex, ΔDA is the individual i deviation in the age of death, DA_{iys} is the actual age at death in years (accounting for the last birthday) of an individual i born in a year y and being of a sex s, and $\overline{DA_{YS}}$ is the average age at death of the individuals born in a year Y and being of a sex S. This measure allows us to capture deviations from average lifespan which are not driven by cohort changes or sex-specific differences, and it is comparable with other studies on birth-month differences in lifespan (Doblhammer 2019; Doblhammer and Vaupel 2001). We replicated our analyses using a measure of longevity defined as reaching the top 10% of the year-of-birth and sex-specific age-at-death distribution (results are fully consistent and available in the supplementary material in the replication bundle).

Independent variables. We use birth month, comparing each calendar month to January, and the season of birth, comparing each season to winter. Despite Familinx data being non-representative user-generated, we expect birth month to be independent of the data generation process. In the descriptive statistics section below we compare the birth month distribution in FamiLinx with the birth month distribution in the 1900 census from IPUMS (Ruggles et al. 2022).

Controls. We control for sex (female vs. male), cohort of birth in 10-year intervals (i.e., 1700–1709, 1710–1719, .., 1890–1899), the state of birth (excluding Hawaii and Alaska), and birth order as a metric variable.

2.3 Analytical strategy

To estimate the effect of birth month on adult lifespan we estimate a set of three OLS models:

$$Y_i = \alpha + \Sigma\mu_b + \theta X_i + \varepsilon_i \quad (1)$$
$$Y_i = \alpha + \Sigma\mu_b \times \beta Z_i + \theta X_i + \varepsilon_i \quad (2)$$
$$Y_{ip} = \alpha + \Sigma\mu_b + \theta X_i + v_p + \varepsilon_i \quad (3)$$

where i refers to the individual, b is the month or the season of birth, p are the individual's parents, Y_i is the outcome as deviation from the average year-of-birth and sex-specific average age at death, μ_b is a set of binary indicators referring to either the months or the seasons of birth, θX_i is the vector of control variables, and ε_i is the error term. In Equation (2) we add βZ_i as an indicator of the moderating variable for the analyses which we break down by cohort (grouped in 50-year intervals) or geographical area of birth (defined as US census areas: Northeast, Midwest, West, and South). In Equation (3) we apply v_p as an indicator of family fixed effects.

2.4 Descriptive results

Table 1 provides the descriptive statistics of the variables used in our analyses. Column (1) reports the descriptives for the full sample, column (2) the descriptives for the sibling sample, and column (3) the birth month distribution from the 1900 US census from IPUMS. Across the two samples the average age at death varies only a little, with the full sample displaying a slightly longer lifespan of about 0.4 years. The largest share of births happens in the first trimester of the year and the lowest between June and July. This pattern is consistent across all samples and in the 1900 census, lending validity to the birth month distribution in the FamiLinx data. FamiLinx show an over-representation of men, consistent with previous studies (Kaplanis et al. 2018; Stelter and Alburez-Gutierrez 2022). The smallest number of individuals were born in the West of the US, consistent with the historical westward expansion. The more recent birth cohorts are also the largest.

Table 1: Descriptive statistics

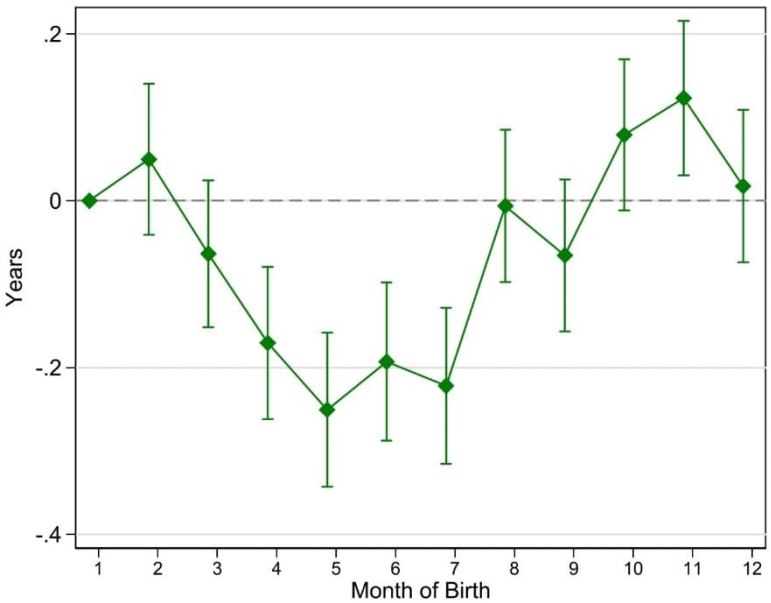
	(1) Full sample		(2) Sibling sample		(3) 1900 Census	
	Mean /%	SD/N	Mean /%	SD/N	Mean /%	SD/N
Outcome						
Death age (years)	74.82	11.16	74.47	11.14		
Birth Month						
January	8.87	115,546	8.91	35,387	9.39	70,680
February	8.64	112,585	8.67	34,430	8.45	63,616
March	9.48	123,550	9.54	37,854	9.86	74,190
April	8.4	109,429	8.44	33,501	8.61	64,823
May	8.06	105,032	8.1	32,165	9.54	71,805
June	7.22	94,039	7.22	28,665	7.21	54,244
July	7.58	98,779	7.57	30,058	7.32	55,123
August	8.39	109,288	8.3	32,930	8.29	62,383
September	8.5	110,766	8.5	33,748	8.09	60,938
October	8.65	112,712	8.57	34,025	8.15	61,335
November	7.92	103,172	7.89	31,299	7.23	54,405
December	8.31	108,239	8.28	32,879	7.87	59,273
Sex						
Male	56.94	741,975	60.38	239,687		
Female	43.06	561,162	39.62	157,254		
Birth order	1.37	1.25	2.23	2.03		
Census area						
Northeast	34.16	445,201	41.1	163,134		
Midwest	30.21	393,667	25.34	100,568		
South	29.85	388,993	27.94	110,913		
West	5.78	75,276	5.62	22,326		
Cohort of birth						
1700	1.31	17,050	1.45	5,736		
1710	1.3	16,876	1.56	6,208		
1720	1.44	18,786	1.89	7,485		
1730	1.62	21,057	2.22	8,806		
1740	1.88	24,475	2.69	10,685		
1750	2.32	30,228	3.35	13,309		
1760	2.52	32,870	3.65	14,492		
1770	2.57	33,553	3.71	14,713		
1780	3.02	39,307	4.29	17,009		
1790	3.45	44,994	4.74	18,823		
1800	3.84	49,993	5.05	20,031		
1810	4.22	55,032	5.25	20,827		
1820	4.63	60,360	5.31	21,065		
1830	5.12	66,761	5.47	21,728		
1840	6.11	79,608	5.88	23,328		
1850	7.56	98,535	6.72	26,659		
1860	8.57	111,640	7.32	29,046		
1870	10.32	134,535	8.4	33,357		
1880	12.77	166,383	9.84	39,058		
1890	15.43	201,094	11.23	44,576		
N	100	1,303,137	100	396,941	100	752,815

3. Results

3.1 Differences in lifespan by birth month

Figure 1 displays differences in lifespan by birth month compared to January. Lifespan is measured in years as deviation from the year-of-birth and sex-specific average age at death. The graph is generated by estimating Equation (1) on the full sample. Each dot represents the average lifespan difference for those born in a given month compared to January, and the whiskers are 95% confidence intervals (CIs). We observe a clear pattern in differences in lifespan across birth months. Individuals born between April and July display on average shorter lifespans compared to January, whereas those born in fall display longer lifespans. This pattern is fully consistent with the results from previous work by Doblhammer and Vaupel (2001). Moreover, the size of the differences in lifespan are comparable to and only slightly smaller than the range found by Doblehammer and Vaupel (2001: 2935) of –0.35 in May and +0.35 in November.

Figure 1: Difference in adult lifespan by birth month



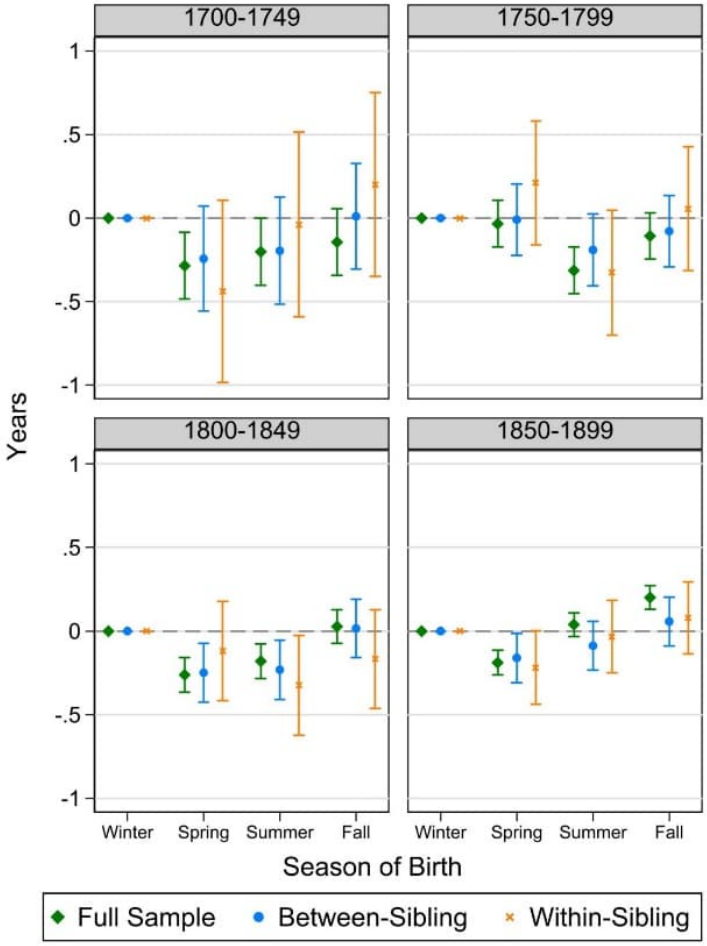
Note: Differences in average lifespan by birth month and 95% confidence intervals obtained by estimating Equation (1) on the full sample (N = 1,303,137). Results are reported using January as the reference category. Control variables include sex of the respondent, cohort of birth in 10-year intervals, state of birth, and birth order. Robust standard errors.

3.2 Results by cohort and geographical area

Figure 2 below displays the differences in lifespan by the season of birth compared to winter, by cohort. The graph is generated by estimating Equation (2) on the full sample (green diamond) and sibling sample (blue dot), and by including parents' fixed effects as specified in Equation (3) (yellow cross). Whiskers are 95% CIs. Overall, results point towards a lower lifespan in both spring and summer across the four cohorts considered. Estimates including parents' fixed effects show larger uncertainty around the estimates, but point estimates remain quite consistent across model specifications.

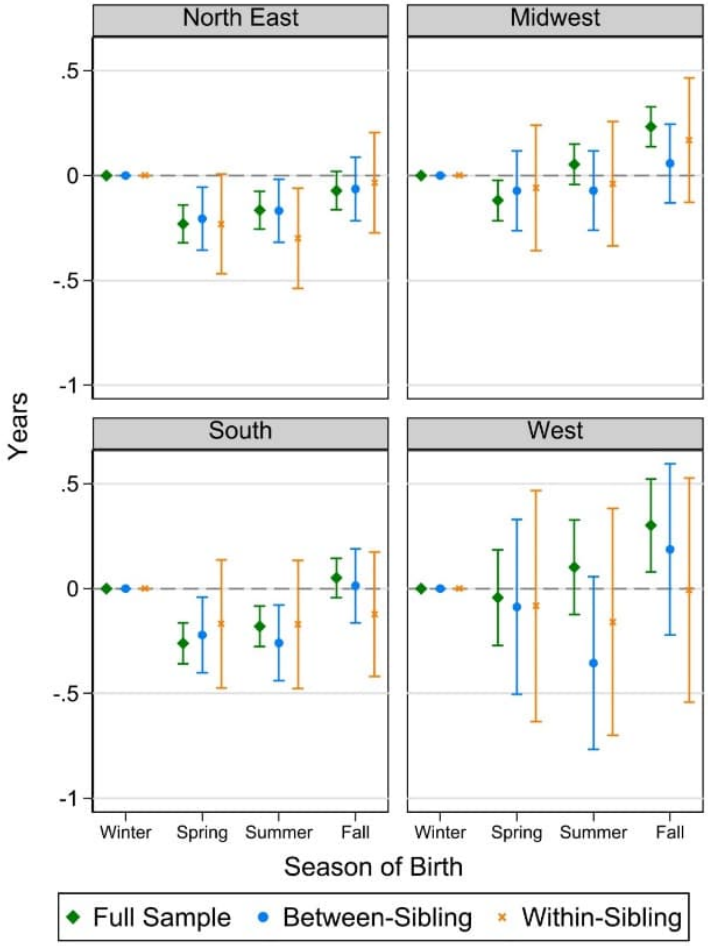
Figure 3 replicates Figure 2 by geographical area, with estimates from Equation (2) on the full sample and Equation (3) with parental fixed effects. The pattern remains consistent across areas, with spring and summer still showing shorter lifespans than winter for most of the census areas (Northeast, Midwest, and South). The only exception is the West, where we do not observe any seasonal pattern in lifespan. There are two possible explanations for this result. First, because the West was the last region to be annexed by the US, living conditions for the earliest generations born there might have been more volatile than those in other regions. This may have meant that their health was predominantly influenced by factors such as infectious diseases, climate, and nutrition, rather than the conditions experienced in early life. Second, since only a very minor share of our sample (about 5%) was born in the West, birth month effects may not be apparent.

Figure 2: Difference in adult lifespan by season of birth and birth cohort



Note: Differences in average lifespan by season of birth and 95% confidence intervals obtained by estimating Equation (2) by cohort on the full sample (N = 1,303,137) and sibling sample (N = 396,941) and also including parental fixed effects as defined in Equation (3). Results are reported using winter as the reference category. Control variables include sex of the respondent, state of birth, and birth order. Robust standard errors.

Figure 3: Difference in adult lifespan by season of birth and census area



Note: Differences in average lifespan by season of birth and 95% confidence intervals obtained by estimating Equation (2) by census area on the full sample (N = 1,303,137) and sibling sample (N = 396,941), and by including parental fixed effects as defined in Equation (3). Results are reported using winter as the reference category. Control variables include sex of the respondent, birth cohort, and birth order. Robust standard errors.

3.3 Pathways

We conducted a set of additional analyses to test possible explanations for the the differences in lifespan by birth month. First, we investigated whether there was sorting into the season of death. For example, assuming everyone is born in the same year, individuals born in the spring are older than those born in the fall when there is high mortality in winter; thus, the birth month may reflect different frailties at the month of death. We re-estimated Equation (1) including a indicators for each month of death to control for sorting into the season of death. The results fully corroborate Figure 1 (Table 2), and show an independent effect of both month of birth and month of death.

Table 2: Lifespan differences by birth month net of month of death

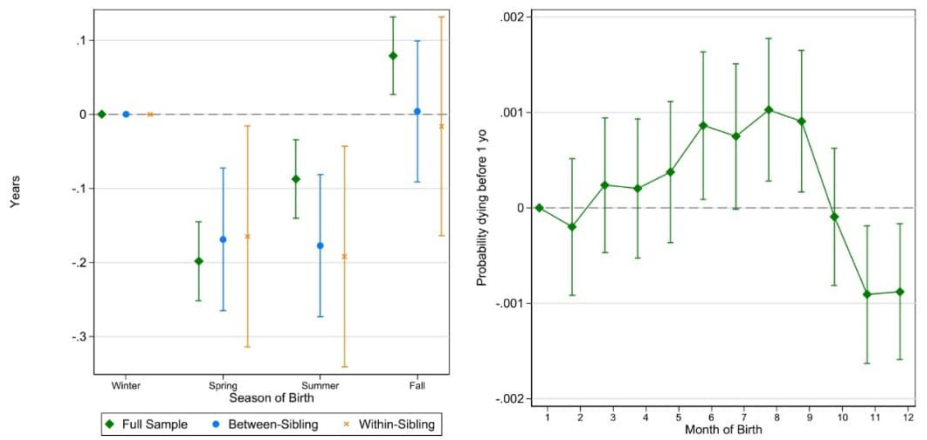
	(1) Beta	(2) 95% CI
Month of birth		
January	Ref.	Ref.
February	0.051	[–0.0395, 0.142]
March	–0.0611	[–0.149, 0.0271]
April	–0.167	[–0.258, –0.0754]
May	–0.246	[–0.338, –0.154]
June	–0.186	[–0.281, –0.0909]
July	–0.218	[–0.312, –0.124]
August	0.0003	[–0.091, 0.091]
September	–0.0603	[–0.151, 0.0307]
October	0.0808	[–0.010, 0.171]
November	0.126	[0.0336, 0.219]
December	0.0179	[–0.074, 0.109]
Month of death		
January	Ref.	Ref.
February	0.0252	[–0.063, 0.113]
March	–0.156	[–0.242, –0.070]
April	–0.354	[–0.442, –0.266]
May	–0.448	[–0.538, –0.359]
June	–0.489	[–0.581, –0.397]
July	–0.486	[–0.577, –0.394]
August	–0.617	[–0.708, –0.526]
September	–0.653	[–0.745, –0.561]
October	–0.426	[–0.516, –0.335]
November	–0.346	[–0.437, –0.256]
December	–0.103	[–0.191, –0.015]
Constant	0.252	[–0.008, 0.511]
N	1,303,137	

Note: Results obtained by estimating Equation (1) including indicators for the month of death. Table does not display indicators for sex, birth order, state of birth, or cohort of birth. Robust standard errors.

Second, we investigated whether differences in lifespan by birth month are due to different SES groups giving birth at different times of the year. To this end we estimated

Equation (3) comparing individuals born within the same family, thus accounting for sorting of fertility choices made due to family-constant characteristics. Figure 4 (left panel) below reports the results on differences in lifespan by season of birth and 95% CIs. Overall, we observe that those born in spring and summer display a lifespan disadvantage compared to those born in winter and fall, even when we include parental fixed effects, thus suggesting that SES sorting does not explain the lifespan differential by birth month.

Figure 4: Difference in adult lifespan and infant mortality by season of birth



Note: **Left panel**. Differences in average lifespan by season of birth and 95% confidence intervals obtained by estimating Equation (1) on the full sample (N = 1,303,137) and sibling sample (N = 396,941), and by estimating Equation (3). Results are reported using winter as the reference category. Control variables include sex of the respondent, birth cohort, and birth order. Robust standard errors**. Right panel**. Probability of dying within one year of birth by birth month and 95% confidence intervals, obtained by estimating Equation (1) on the full sample without restricting it to individuals 50+. Results are reported using January as the reference category. Control variables include sex of the respondent, birth cohort in 10-year intervals, state of birth, and birth order. Robust standard errors..

Third, we tested whether lifespan differentials by birth month can be explained by selection into survival in early life. To this end we removed the restriction to individuals over 50 years of age, and estimate Equation (1) using whether an individual died within the first year of life as an outcome. Figure 4 (right panel) below displays differences and 95% CIs in the probability by birth month (in respect to January) of dying within the first year of life. Individuals born between June and September experience higher infant mortality, whereas those with lower infant mortality are born in the fall. Despite the fact that FamiLinx data are known to under-report infant mortality, this result resembles that found in the 1940 US vital statistics, with the lowest infant mortality in the first month of life observed in November (Gavrilov and Gavrilova 2011). Infant mortality does not seem

to explain patterns in adult lifespan as the birth months linked to a shorter lifespan also experience the same or even higher infant mortality than January. This suggests that if any selection occurs in early life, those born in months with a lower lifespan are more positively selected, and those born in months with a longer lifespan are less selected.

4. Conclusion and discussion

We investigated differences in adult lifespan by month of birth and their variation across cohorts, geographical areas, and between and within families. We have two main findings. First, we show that individuals born in spring and early summer (March to July) have a shorter lifespan, whereas those born in fall and early winter have the longest, with a relatively consistent pattern across cohorts and geographical areas. Our results replicate those of Doblhammer and Vaupel (2001) for the northern hemisphere which found a shorter lifespan among children born between March and July, as well as those of Vaiserman et al. (2002) who found a shorter lifespan between April and July.

Second, our secondary analyses suggest that the lifespan differences by birth month are not explained by sorting into the season of death, SES sorting into birth month, or selection into survival in early life. A possible alternative mechanism is in utero debilitation, as discussed in previous work (Doblhammer 2004, 2019; Doblhammer and Vaupel 2001).

What is less clear is what kind of in utero debilitation might be in play. The season of birth may be a proxy for several factors, including maternal nutrition, climatic conditions, and infectious diseases. The quantity and quality of nutrition available to mothers in the last trimester of pregnancy may be crucial for fetal development (Susser and Stein 1994; van Ewijk 2011). In historical societies, diet and nutrition were highly seasonal and followed the harvest periods, leading to scarcity in late winter and spring and abundance in fall (Doblhammer 2019). Nutritional deficiencies for the mother can translate into nutritional deficiencies for the fetus. In utero nutrition has been shown to have strong effects on children's health and survival at birth and in infancy, and has also been linked to the onset of other diseases later in life (Antonov 1947; Susser and Stein 1994). However, whether this ultimately affects adult mortality is more contested, with studies providing mixed evidence (Doblhammer 2019).

Climatic conditions have also been shown to be important for fetal development, with potentially long-lasting consequences later in life. Children exposed in utero to hot temperatures have been linked to poorer perinatal health (Conte Keivabu and Cozzani 2022; Deschênes, Greenstone, and Guryan 2009) and to lower income later in life (Isen, Rossin-Slater, and Walker 2017). Children conceived in summer are also likely to be born in spring, suggesting a possible link between the two factors. Whether this kind of

debilitation results in mortality differentials in adulthood remains an open empirical question, as actual research only points toward possible middling factors (i.e., infant health, income in adulthood) rather than mortality itself.

Finally, the birth month may also proxy seasonality in infectious diseases, as exposure to chronic infections in early life may translate into later-life mortality (Finch and Crimmins 2004). The flu season, for example, has been linked to poor perinatal health (Currie and Schwandt 2013), and to a large set of later-life outcomes such as hampered cognitive development (Kelly 2011) and lower earning and disability (Almond 2006). Moreover, food and water-borne diseases follow seasonal patterns and may also contribute to in utero debilitation and have lost-lasting consequences for individuals' lives.

This study is not free from caveats. First, the data we use are not representative, as they are generated by individuals reconstructing family histories online. What we have nonetheless shown is that that the birth month distribution in FamiLinx resembles the one in the 1900 census, suggesting that despite their non representativeness, our main predictors should not be biased. That is, the procedure we used to select the sample and related missingness was independent of the month of birth. Second, selecting on detailed information from the genealogies, such as month of birth and death, may lead to positive selection into the sample, as individuals with higher socioeconomic status – which may be associated with higher resilience to exogenous stressors and better health – are more likely to have detailed information (Minardi, Corti, and Barban 2023). Nevertheless, if this positive selection is the case, it suggests that the effect of birth month on adult lifespan may be underestimated. Finally, the assessment of mechanisms involving under-represented occurrences within genealogies, such as children's early deaths and siblings, demands for a cautious interpretation of these results.

This work provides consistent evidence from new crowdsourced data, corroborating the idea that birth month may impact lifespan. Future research should explore the possible mechanisms in more detail, including whether they change across cohorts and geographical areas.

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