Fertility and longevity on the American frontier:

Contexts of post-reproductive maternal survival.

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Abstract

The search for a biological mechanism linking maternal fertility and longevity has been a central concern of biodemography since the early twentieth century. Although numerous studies propose fertility–longevity tradeoffs, empirical findings remain mixed, often attributed to the embedding of fertility and mortality within social and institutional environments. Where prior work has often treated this embedding as a challenge, we instead approach environment and biological processes as theoretically entwined. Using Utah as an analytic case characterized by high fertility and low mortality under stable institutional influence, we use the Utah Population Database to analyze linked fertility and mortality histories for 171,784 Utah women born between 1830 and 1940. Results indicate that parity exhibits little systematic association with late-life mortality, whereas fertility timing and spacing become increasingly associated with longevity in post-1890 birth cohorts. We further examine offspring availability in late life as a familial context connecting fertility and mortality. While the presence of proximate adult children after age fifty is associated with lower overall mortality risk, age-specific analyses reveal elevated risk at younger old ages and protective associations at advanced ages. Together, these findings demonstrate that fertility and mortality are best understood as biological processes expressed within historically specific familial and institutional contexts, rather than as outcomes governed by a singular biological mechanism.

1. Introduction

In September 2024, Utah honored 152 of its centenarians (Fredde, 2024). A yearly gathering held since the National Institute on Aging declared September 22 National Centenarian Recognition Day, averaging over 150 members each year (Utah Division of Aging & Adult Services, 2025). Utah's public celebration of centenarians reflects a broader awareness of the state's historically favorable morbidity and mortality profile relative to many U.S. populations (Smith & Wilson 2002; Smith et al. 2025). While the state's primary religious institution maintains a notable prohibition on alcohol and tobacco, this likely only offers a small contribution to the state's health profile (Merrill 2004). Instead, as the centenarian celebration itself suggests, Utah's mortality patterns are not only biological outcomes but are embedded within a broader ecology of social relations, health technology, family structure, cultural norms, and institutional arrangements that have persisted and evolved across its 180-year history. We therefore begin with Utah, known for both high fertility and longevity, as an analytic case for examining how fertility becomes differently associated with longevity across historical regimes.

Previous demographic research has extensively investigated maternal fertility, yet how fertility relates to longevity remains unsettled. Existing frameworks invoking biological trade-offs, selection effects, and slow aging produce mixed results. Studies report positive (McDowell 1939; Lockhart et al. 2016; McArdle et al. 2006; Müller et al. 2002), negative (Gagnon 2009; Le Bourg 2007; Smith et al. 2002; Smith et al. 2009), and neutral (Caselli et al. 2013; Gavrilov & Gavrilova 1999; Henretta 2007; Ehrlich 2015) associations. Taken together, this literature suggests less a single answer to the fertility-longevity question and instead the difficulty conceptualizing fertility as a life course antecedent to biological outcomes observed four or five decades later. This arises from at least two sources: shifting institutional ecologies and the completeness of the data record.

Historic Utah provides an analytic opportunity. Its extensive data holdings, most notably through the Utah Population Database, offer a means to measure demographic events across multiple cohorts and contexts (Smith, et al. 2022). Its strength as a genealogically based dataset linked to census and vital records allows linkage across family histories and the embedding of individual-level outcomes with social, religious, and education factors. At the same time, these data sits within Utah's well-documented transition from a nascent frontier settlement to a modern technological state under stable institutional structures, allowing historical variation in fertility–longevity associations to be observed within a single population.

The intertwined ecologies of childbirth and death are evident in Utah's archival history. Consider this first-hand account of "Mormon Midwife" Patty Bartlett Sessions (Sessions & Broderick, 1992, p. 118). Here, Sessions's daily recordings demonstrate how fertility and mortality were not separable life-course stages, but intertwined processes embedded in everyday economic production, care work, and social life:

> **[September, 1848]** ***Tuesday 26*** *put sister Tubs to bed with a daughter born 5 AM Wednesday 27 carded wool Thursday 28 spun knit Friday 29 I have had co every day this week* ***Saturday 30*** *Elen Sanders babe is dead buried yesterday [sic] I went and had her come to house to comfort her she said she had not felt so composed since it died* ***Sunday Oct 1*** *I went to meeting Adison Pratt was there had returned from the sandwich and been gone more than 5 years Brigham Heber took supper with us* ***Monday 2*** *I washed I am not well Tuesday 3 ironed not well.*

For Sessions, childbirth, death, labor, and care were integral parts of frontier life that sat alongside economic production and personal relations under conditions of uncertainty. Rather than analytically distinct events, fertility and mortality were experienced as interdependent processes shaped by the organization of family, work, and community life.

However, separating “biological” effects from environmental and institutional conditions is not only empirically difficult but conceptually limiting. Rather than adjudicating current biological explanations, this study treats persistent disagreement itself as analytically informative, directing attention toward historical variation in the social organization of reproduction. *To do so, we analyze linked genealogical and vital records across successive birth cohorts, combining fertility histories with late-life mortality models to trace how these associations shift over time.* Our study period captures both the high-fertility conditions of agricultural regimes and the declining fertility associated with modernization and medicalization, offering an opportunity to assess which relations persist and which vary across historic contexts.

2. Background

The relation between fertility and late-life mortality has generated an ongoing and unresolved debate. As Gavrilova and Gavrilov (2005) note, “the nature of the longevity–reproduction relationship is not a single problem but a family of problems,” a formulation that anticipates fragmentation across mechanisms, populations, and historical contexts. Both the earliest literature and later efforts, while rich in plausible biological mechanisms, have difficulty incorporating broader social processes into a coherent explanatory framework.

Beeton, Yule, and Pearson (1900), assuming a survival of the fittest framework, found a strong correlation between higher fertility and longevity, noting it likely reflects a stronger “constitution.” Yet their findings lacked universality as the strength of association differed amongst English and American populations, suggesting findings attenuated by social differences. Powys’ 1905 study of fertility and longevity in New South Wales documented a nonlinear pattern for fertility and longevity with it being positively associated, until later life, where it then becomes an unfavorable factor. Freeman (1935) went further, emphasized the ambiguity of the topic by noting selection effects, the need for proper controls, and warning against treating fertility as a process divorced from marital context, health selection, and survival conditioning.

By the mid-twentieth century, explanatory frameworks increasingly sought biological explanation. Antagonistic Pleiotropy theory (Williams 1957) posits genetic traits that enhance early life reproductive success may act as a double-edged sword by increasing late-life mortality. However, empirical support for this framework appears inconsistent (Gavrilov & Gavrilova 1999; Henretta 2007; Le Bourg 2007; Caselli et al. 2013) and contingent upon cohort and environmental context. Disposable Soma Theory, advanced by Kirkwood (1977), similarly considers the tradeoff between maternal fertility and late-life mortality through a “budgetary” lens, where energy contributed to reproduction is diverted from somatic maintenance, in ways that hasten aging. Yet evidence for this framework likewise varies across populations, and a number of studies suggest that correlations attributed to physiological tradeoffs may reflect data limitations or historical context rather than universal biological processes (Gavrilov & Gavrilova 1999). Because both Antagonistic Pleiotropy and Disposable Soma theories predict increased mortality hazard in tandem with higher fertility, they struggle to explain why high fertility and low mortality coexisted in some historical settings but not others. More specifically, they provide a limited explanation for Utah given the historical levels of higher fertility (DeHart 1941; Gardner Policy Institute 2025) and lower mortality risk (Smith & Wilson 2002; Smith et al. 2025).

Smith and colleagues (2002) advance a late fertility hypothesis, arguing that later-age reproduction may function as a marker of slower biological aging and is associated with longer post-reproductive survival. The authors further discuss the possibility that selective survival and underlying robustness contribute to this pattern, though they interpret late fertility as an indicator rather than a mere artifact of selection. Other studies (Blackburn & Cipriani 2000; Caselli et al., 2013; Ehrlich, 2015; Gavrilov & Gavrilova, 1999; Gagnon et al., 2009; Henretta, 2007; Le Bourg, 2007; Lockhart et al., 2017) demonstrate that much of the association between fertility and longevity depend upon socioeconomic, institutional, and environmental factors. This suggests that any biological process linking reproduction and survival are expressed through historical environments rather than independently of them.

2.1 Biology and Environment

The central question emerging from this literature is whether there exists a singular biological mechanism linking fertility to longevity. The diversity of empirical findings points instead to the inherent difficulty of assessing biological processes apart from environmental context, or as Darwin (1859/1996) deemed "…the Unity of Type and the conditions of life." In response, many studies have turned towards populations characterized by "natural fertility" as settings in which biological processes may be more clearly observed. Yet Darwin's evolutionary framework makes clear that biological processes and environments are theoretically entwined, with biology expressed in relation to environmental conditions rather than independently of them. Viewed in this light, pre-industrial “natural fertility” is better understood not as a biological baseline, but instead as a stable reproductive system shaped by earlier social and technological adaptations.

The Neolithic Demographic Transition (NDT), which frames pre-historic fertility increase as part of the broader agricultural revolution, provides a comparative framework for interpreting modern fertility decline (Bocquet-Appel, 2002; Bocquet-Appel & Bar-Yosef, 2008). If NDT represents a moment in which fertility expanded in response to ecological and technological change, modern fertility decline can be interpreted as another phase of human adaptation under altered institutional and environmental conditions. This suggests that what demographers often conceptualize as natural baselines may instead reflect historically specific reproductive regimes.

If fertility is not a biological constant but a social regime, then fertility’s relation to social environment becomes fundamentally different from mortality. For most of modern history, fertility is normatively structured, often situated within institutions like religion and education (Davis & Blake 1956; Udry 1982). While offspring count can certainly reflect biology (e.g. infertility, maternal death, etc.), it can also reflect community values or choice. Conversely, although resource access in the form of health care, food, and shelter certainly can delay mortality, unlike childbearing, mortality imposes a universal biological endpoint. This asymmetry suggests that fertility patterns may contain greater flexibility than mortality patterns as social structures evolve, further complicating the identification of a purely biological process. Consequently, this study treats fertility and mortality as embedded within institutional, familial, and epochal arrangements that define the conditions under which these biological processes unfold (Stinchcombe 1968; Abbott 2001; Trinitapoli & Weinreb 2012).

2.3 Historical Contexts to Fertility in Utah

The historical evolution of Utah provides a unique backdrop to consider the environmental contexts through which fertility and mortality express themselves. The broad view of Utah's fertility is much like the rest of America's: the region's 19^{th}-century fertility was characterized by high parity, long fertility windows, and shorter birth spacing. Bean, et al. (1990) show that evidence of fertility decline—concomitant with industrialization, female education, and public health advancements—in Utah appears during the end of the 19^{th} century as the age of last birth begins to reduce, pointing towards birth control practices much earlier than commonly expected. Yet fertility within Utah, especially among members of its dominant religious group, remains elevated compared to the rest of the nation during this time. Although this compositional change is in many ways predictable, how it emerged is quite unique to Utah's history.

The original settlers in Utah arrived in 1847, with initial settlers displaying reduced fertility, likely due to the difficulty of immigrant and settler life (Bean, et al. 1990). Until the 1870s, life in Utah required population growth through immigrants and childbirths, as settlement efforts centered around the Church's founding of hundreds of colonies across the intermountain West (Anderson 1942; Arrington, 1958). When the railroad arrived in 1869 it not only opened Utah's economy to the larger nation, but also its culture, leading to increasing federal scrutiny of its polygamous practices. Under federal pressure, the Church banned polygamy in 1890 and immediately tried to work its way into larger society. Consequently, women's education became a higher priority among devout Latter-day Saints, leading to delayed fertility but still higher parity among the faithful (Bonham 2024).

During this same time, the Latter-day Saint faith fully embraced public health advancements leading to a dramatic reduction in maternal and infant mortality (Swedin 2025; Whitney 2016). Emigration from Utah increased during this time, both in response to a local agriculture slump in the early 1920's and then the 1930 economic depression (Bushman 2008, pg. 105). This outmigration of Utah's young and healthy to places like southern California likely reorganized family structure and kin networks. As Utah entered the 1930's and 1940's it became increasingly conservative and the Church more bureaucratic (Prince 2002). This in-turn led to a nuclear-styled family, self-sufficient and formally organized. So, while Latter-day Saint families shrunk in size alongside everyone else, they still maintained an elevated fertility that allowed differentiation, with fertility being driven by religious belief as much as household economics.

In sum, maternal fertility patterns in Utah between 1850 to 1960 reflect both broader American and local specific contexts. In our view, these changes among a relatively homogenous community illustrate that fertility's relation to longevity is a process patterned by institutions like religion, family systems, and economic structure. Accordingly, this paper extends the fertility-longevity literature beyond biological mechanisms alone and towards how fertility and mortality are institutionally configured over time. These historical transformations provide the analytic context for the analyses that follow.

2.4 Aims and Hypotheses

Aims

The length of our study period, from the earliest days of Utah settlement, until modern day industrialization and health care provide a clear opportunity to assess fertility and mortality across differing contexts. Because both fertility and mortality embed within cultural and social structures, cross-cohort comparisons between natural and modern fertility regimes can reveal patterns not found within a single context. Consequently, our study pursues three aims, the first two of which center on social aspects of either fertility or longevity, and the last on biological:

1. **Fertility and mortality patterns.** Situate Utah's fertility and mortality patterns within social institutions, across historical epochs, to contextualize later biological interpretations of the fertility-longevity relationship.
2. **Family ecologies.** Assess how maternal all-cause mortality patterns reflect the number of maternal offspring who survived past age 50 and who lived within proximate geographic distance of the mother during late life, as an index of realized kin support.
3. **Maternal fertility-longevity.** Examine how childbearing is associated with maternal survival in older age within institutional structures.

Hypotheses

Because our core argument centers around the interaction of biology and environment, we do not expect a single fertility-mortality effect. Instead, we expect regime specific associations that at first organize around settlement and survival and then later develop in hand with changing family structural norms, women's education, and economic change. The hypotheses below are explicitly historical and institutional predictions, situated within the analytic case of Utah from 1830 to 1940.

Aim 1: General fertility patterns across time in Utah

H1a: Fertility will decrease in Utah maternal birth cohorts from 1830 to 1940.

H1b: Despite overall fertility decline, relative fertility will remain higher among women who participate in Latter-day Saint endowment ceremonies, with this institutional pattern persisting even among women with higher education and socioeconomic status.

H1c. All-cause post-reproductive mortality hazard will decrease in Utah maternal birth cohorts from 1830 to 1940.

H1d. Despite overall declines in mortality hazard, relative mortality hazard will remain lower among women who possess higher socioeconomic status, participate in Latter-day Saint endowment ceremonies, or have higher educational attainment.

Aim 2: Offspring survival (Could Restrict to those who died in Utah)

H2a. Mothers with at least one surviving adult child residing in the same or a contiguous county during late life will have lower mortality risk after age 50 than otherwise similar mothers with no proximate adult children.

H2b. The association between proximate adult children and maternal mortality risk after age 50 will vary across late-life stages.

Aim 3: Fertility and longevity associations

H3a. The associations between maternal fertility history and post-reproductive survival will vary across institutional contexts and maternal birth cohorts.

H3b. Net of institutional and familial characteristics, fertility dimensions that are more directly regulated by institutional norms, particularly the timing and spacing, will show more consistent associations with post-reproductive mortality than parity.

3. Data and Methods

To pursue these aims and hypotheses, we analyze the relation between maternal fertility and late-life mortality using linked genealogical, census, and vital records from the Utah Population Database. We follow 171,784 women born between 1830 and 1940 who survived to age 50, estimating cohort-stratified fertility and mortality models. This design leverages the multigenerational depth of the UPDB while aligning fertility measurement, family structure, and mortality risk within comparable life-course windows.

3.1 Data

We use the Utah Population Database (UPDB), a linked genealogical demographic database now encompassing more than 11 million individuals. The genealogical structure of the UPDB is derived from three-generation family records assembled by the Genealogical Society of Utah (GSU). These multigenerational pedigrees have been integrated with vital records and administrative sources, including statewide birth and death certificates as well as religious and kinship linkages (Smith, et al. 2022).

The UPDB contains more complete follow-up among individuals whose family histories are documented in the original three-generation GSU pedigrees. This pattern reflects the Church of Jesus Christ of Latter-day Saints' institutional emphasis on systematic documentation of its membership (Bean et al. 1980). Moreover, the initial assembly of UPDB prioritized genealogical records identified by GSU to best capture early Utah settlers and their descendants. In light of these data-generating processes, the present analysis is confined to individuals whose histories originate from these foundational records.

3.2 Study Population

Our analytic sample includes 171,784 women born between 1830–1940 who died in Utah and survived to at least age 50. For descriptive analyses, we examine six historical cohorts (1830–1849; 1850–1869; 1870–1889; 1890–1909; 1910–1940). We restrict to women who died in Utah as Aim 2 requires residential records. In alignment with previous studies, we only include women with one marriage before age 50 that remains intact until age 50 (Freeman 1935; Gavrilova & Gavrilov 2004) so that fertility opportunity remains structurally similar and isolated from spousal replacement dynamics. Together, these restrictions align fertility exposure, marital opportunity, and mortality risk within comparable life-course structures among cohorts with largely complete life-histories, allowing observed cohort differences to be interpreted as regime variation rather than compositional noise.

3.3 Measures and strategy

For Aim 1, we use staple measures of maternal fertility—parity (total children ever born, or CEB), maternal age at first birth (in years), maternal age at last birth, and mean birth spacing interval (in months)—as our primary dependent variables.

As predictor variables we use levels of religious commitment according to whether one participated in Latter-day Saint baptism or endowment ceremonies. Latter-day Saint baptism, a ritual performed around age 8, is required for membership within the faith. The endowment ceremony, which generally occurs in early adulthood, takes place in Latter-day Saint temples and includes commitments to the Church and its leadership. For those women found in the 1940 census, we include recorded years of education. Education measures are available only for women observed in the 1940 census; we therefore restrict education analyses to women born between 1858 and 1915, ensuring sufficient cohort size and allowing education completion by 1940.

Next, we construct a socioeconomic status (SES) measure as a harmonized life-course index using a hierarchical decision rule across available historical sources. When present, death-certificate occupations were converted to 1990 Census codes (Sobek 1990) and mapped to Hauser–Warren SEI scores (Turner 2014); when unavailable, census-based Nam–Powers–Boyd SES measures (ages 25–55) derived from IPUMS (Ruggles et al. 2024) were used; and for early cohorts lacking both, 1880 occupational prestige scores were substituted. All component measures were standardized within source type and then within cohort to produce a comparable SES z-score across historical periods (Enders & Tofighi 2007). This approach yields a life-course SES measure that captures individuals' relative socioeconomic position in a manner that is comparable across cohorts and historical contexts.

Covariates include mother's birth year (measured as years past 1830), a UPDB variable that assigns a familial longevity score (Arbeeva, et al. 2018; van den Berg et al. 2018), whether the mother was born outside of Utah (1) as a proxy for migration, and a UPDB composed binary data-quality indicator for complete fertility history. We also include the women's marriage type (Monogamous = 1, polygamous 1st wife = 2, polygamous 2nd or later wife = 3) as studies report significant parity differences among these groups due to timing in husbands' reproductive life span (Moorad et al. 2011).

Aim 2 considers all-cause maternal mortality risk as the dependent variable, with a binary indicator for having at least one adult child residing in the same or a contiguous county during the final decade of life as the primary predictor. This measure captures realized geographic availability of adult offspring during late life, rather than co-residence or emotional support. Aim 3 again employs all-cause maternal mortality risk as the dependent variable and uses fertility measures of fertility as primary predictors. Both aims employ similar covariates as aim 1.

3.4 Analytic Approach

Aim 1. We consider fertility across dominant social structures S_i in Utah—religion, status, and education—interacting with the individual's birth cohort epoch (Epoch_i) according to the individual's other fertility measure C_i and a vector of individual characteristics $\mathbf{X}_i$. Our fertility outcomes are $g(\cdot)$ = log (negative binomial) for parity and $g(\cdot)$ = linear for birth timing and spacing. They take the form of:

$$g(\mathbb{E}[Y_i]) = \alpha + \text{Epoch}_i + S_i + (\text{Epoch}_i \times S_i) + \boldsymbol{\delta}\,\mathbf{C}_i + \boldsymbol{\gamma}\,\mathbf{X}_i$$

Our mortality models diagnose the instantaneous risk of mortality $h_i(t \mid \mathbf{X}_i)$ at age t utilizing Cox proportional hazard models while employing the same main effects and covariates:

$$h_i(t \mid \mathbf{X}_i) = h_0(t)\ \exp\Big(\boldsymbol{\theta}^\top \mathrm{Epoch}_i + \boldsymbol{\beta}^\top S_i + \boldsymbol{\phi}^\top (\mathrm{Epoch}_i \times S_i) + \boldsymbol{\gamma}^\top \mathbf{X}_i\Big)$$

Aim 2. We estimate the instantaneous hazard of maternal mortality, $h_i(t \mid \mathbf{X}_i)$, using age as the time scale, comparing mothers with at least one adult child residing in the same or a contiguous county during the final decade of life to those without proximate offspring. Proximity is represented by a binary indicator, Prox_i and models adjust for a vector of covariates $\mathbf{X}_i$. The model takes the form of:

$$h_i(t \mid \mathbf{X}_i) = h_0(t) \exp\Big(\beta\, \mathrm{Prox}_i + \delta\, \mathrm{BYR}_i + \gamma^\top \mathbf{X}_i\Big)$$

Because mortality occurring nearer to age 50 versus at more advanced ages may reflect distinct underlying processes, and therefore correspondingly different patterns of offspring response, we additionally estimate a model that allows the association between proximity and mortality to vary across late-life age bands. Importantly, age bands modify the proximity–mortality association within shared risk sets defined by age; they do not partition the data or condition analyses on age at death. The age banded model is notated as:

$$h_i(t \mid \mathbf{X}_i) = h_0(t)\ \exp\Big(\beta\, \mathrm{Prox}_i + \phi_1\, \mathrm{Prox}_i \times I(70 \le t < 80) + \phi_2\, \mathrm{Prox}_i \times I(t \ge 80) + \gamma^\top \mathbf{X}_i\Big)$$

Aim 3. This analysis combines descriptive visualization with cohort-stratified Cox models to assess how fertility measures are differentially associated with late-life mortality across institutional regimes. We begin with a descriptive bar plot depicting the relation between key fertility measures to longevity after age 50 and then include additional charts exploring parity and longevity relations over birth cohort epochs and key social structures. The analytic models examine the relation between the instantaneous risk of mortality $h_i(t|X_i)$ at age t according to the interaction between individual fertility measures F_i and alongside a vector of covariates $\mathbf{X}_i$. All analyses stratify models by cohort epoch and take the form of:

$$h_i(t \mid \mathbf{X}_i) = h_0(t)\ \exp\big(\theta^\top \mathrm{Epoch}_i + \beta^\top F_i + \phi^\top \left(\mathrm{Epoch}_i \times F_i\right) + \gamma^\top \mathbf{X}_i\big)$$

4. Results

4.1 Descriptive Table

Our population consists of 171,784 females, under the inclusion requirements listed in the Data and Methods section. Notably, over 70% of the population exists in the last two historic epochs (i.e. 1890-1914 and 1915-1940), consistent with Utah's historic population expansion. Utah higher fertility is demonstrated through its mean parity (5.04). Utah women appear to have higher levels of education with 39% reporting in the 1940 census that had completed high school or additional schooling. Finally, this population is heavily characterized by highly committed Latter-day Saints with polygamous wives comprising about 2% of all females.

Table 1. *Descriptive statistics for married women surviving to age 50, with an intact first marriage at age 50, at least one child, born between 1830 and 1940, and who died in Utah (N = 171,784).*

		Mean	SD	Min	Max
Fertility Measures					
	Age at first birth (years)	22.89	4.26	-50	66
	Age at last birth (years)	34.94	6.24	14	73
	Children Ever Born	5.07	2.8	1	20
Age at death		80.54	10.93	50.07	111.92
Mother's birth cohort epochs					
	1830-1849	0.04	0.2	0	1

1850-1869	0.09	0.28	0	1
1870-1889	0.16	0.36	0	1
1890-1914	0.31	0.46	0	1
1915-1940	0.4	0.49	0	1
≥1 proximate child (conditional proportion)*	0.36	0.48	0	1
Mother's birth year	1902.47	26.15	1830	1940
Born outside of Utah	0.17	0.38	0	1
Maternal Education				
Elementary or less	0.37	0.48	0	1
Some high school	0.24	0.42	0	1
High school graduate or more	0.39	0.49	0	1
Maternal Religious Commitment				
Not Latter-day Saint	0.07	0.25	0	1
Baptized Latter-day Saint only	0.16	0.37	0	1
Endowment	0.77	0.42	0	1
Marriage Type				
Monogamous	0.98	0.14	0	1
Polygamous, 1st wife	0.01	0.09	0	1
Polygamous, 2nd or later wife	0.01	0.11	0	1

*Proportions for proximate offspring are calculated conditional on having at least one child observed in residential records; this restriction applies only to proximity measures (temporal and geographic) and does not define the analytic sample for other variables.

4.2 Aim 1: Fertility and mortality over time

Aim 1 situates Utah's fertility and mortality patterns within social institutions, across historical epochs, providing context for biological interpretations of the fertility-longevity relationship found in Aim 3. Across successive birth cohorts, parity declined steadily while survival after age 50 increased, but education, religion, and socio-economic status pattern these shifts. Consistent with H1a and H1c, the Lexis diagram found in Figure 1 illustrates that increasing longevity coincides with decreasing parity, wider birth interval spacing, and earlier ages at last birth. These patterns are presented descriptively and reflected in cohort-stratified estimates rather than formal trend tests, as the purpose of Aim 1 is contextualization rather than inference.

Figure 1. *Lexis diagram demonstrating longevity and fertility patterns across birth cohort epochs within the study population.*

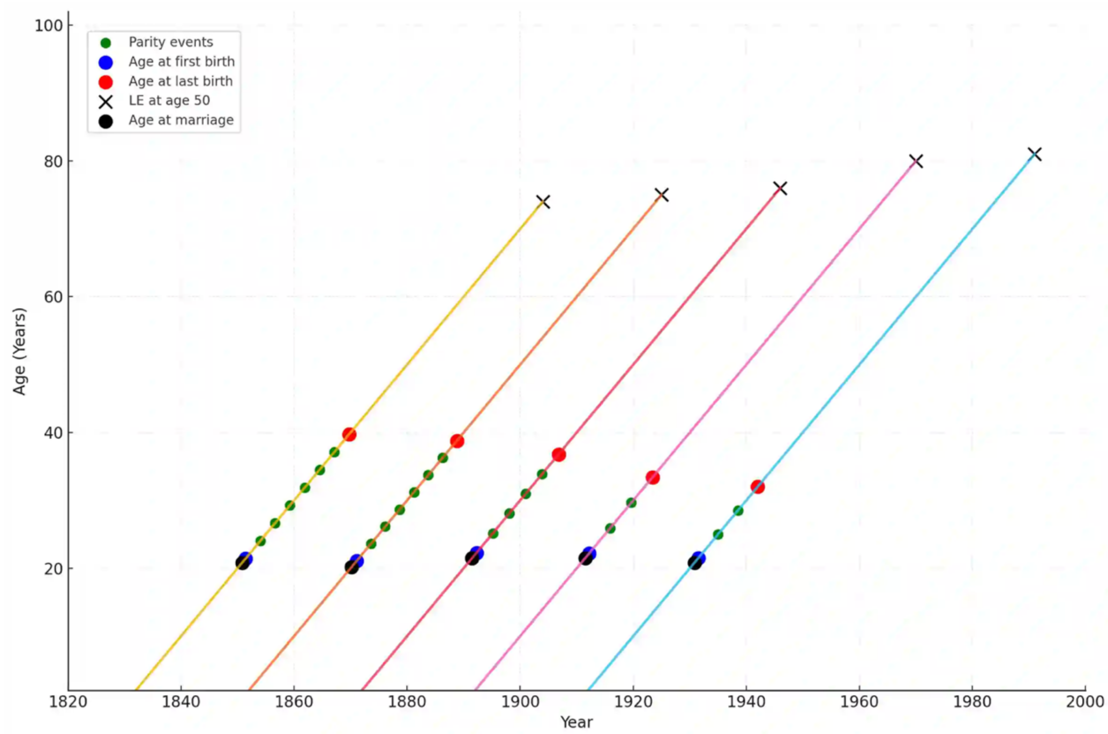


Table 2 provides cohort-stratified estimates that quantify the patterns described in Aim 1. Consistent with H1a, parity declines over maternal birth cohorts. Supporting H1b, endowed Latter-day Saint women exhibit elevated parity compared to non–Latter-day Saint women in every cohort, beginning with an incidence rate ratio (IRR) of 1.18 (95% CI: 1.11, 1.26) among women born 1830–1849 and remaining stable through the 1915–1940 cohorts (IRR = 1.10; 95% CI: 1.08, 1.12).

Regarding mortality, the results of our all-cause mortality tests offer support for H1c and H1d. All-cause mortality hazard declines across successive maternal birth cohorts, but these improvements are increasingly structured by socioeconomic status and religious participation in later epochs. For example, socioeconomic status is weakly associated with mortality in the earliest cohorts (HR = 1.01; 95% CI: 0.98, 1.04 for 1830–1849) but becomes strongly protective by the 1915–1940 cohorts (HR = 0.94; 95% CI: 0.93, 0.95). Religious participation exhibits a similar but more pronounced temporal shift: women who participated in Latter-day Saint endowment ceremonies experience elevated mortality hazard relative to non–Latter-day Saint women in mid-nineteenth-century cohorts (HR = 1.16; 95% CI: 1.05, 1.27 for 1850–1869), but substantially lower mortality hazard in the most recent cohorts (HR = 0.84; 95% CI: 0.80, 0.88 for 1915–1940).

Table 2. *Cohort-specific gradients in fertility timing, spacing, and mortality by education, religion, and socioeconomic status. Married women surviving to age 50, with an intact first marriage at age 50, at least one child, born between 1830 and 1940, and who died in Utah. (N = 171,784)*

	1830-1849	1850-1869	1870-1889	1890-1914	1915-1940
			Panel A. Parity (IRR; negative binomial)		
Education					
Elementary only		(Ref)	(Ref)	(Ref)	(Ref)
Some High school		0.93 (0.86, 1.01)†	0.94 (0.92, 0.96)**	0.91 (0.89, 0.92)**	0.95 (0.83, 1.09)
High school graduate or higher		0.90 (0.84, 0.95)**	0.88 (0.87, 0.90)**	0.84 (0.82, 0.85)**	0.88 (0.78, 1.01)†
Religion					
Not Latter-day Saint	(Ref)	(Ref)	(Ref)	(Ref)	(Ref)
Baptized only	1.07 (0.99, 1.16)	1.12 (1.06, 1.19)**	1.02 (0.98, 1.05)	0.99 (0.96, 1.01)	0.94 (0.92, 0.96)**
Endowed	1.18 (1.11, 1.26)**	1.18 (1.14, 1.22)**	1.16 (1.13, 1.20)**	1.10 (1.07, 1.12)**	1.10 (1.08, 1.12)**
SES (continuous)	1.01 (1.00, 1.02)†	0.98 (0.97, 0.99)**	0.95 (0.94, 0.96)**	0.94 (0.94, 0.95)**	1.00 (0.99, 1.00)
			Panel B. Age at first birth (Δ units; linear model)		
Education					
Elementary only		(Ref)	(Ref)	(Ref)	(Ref)
Some High school		0.68 (-0.01, 1.38)†	0.97 (0.78, 1.16)**	0.50 (0.39, 0.62)**	0.41 (-0.56, 1.38)
High school graduate or higher		1.86 (1.34, 2.37)**	1.72 (1.56, 1.88)**	2.24 (2.13, 2.35)**	2.88 (1.97, 3.79)**
Religion					
Not Latter-day Saint	(Ref)	(Ref)	(Ref)	(Ref)	(Ref)
Baptized only	-1.17 (-2.00, -0.35)**	-0.20 (-0.73, 0.33)	0.33 (0.02, 0.64)*	0.39 (0.21, 0.56)**	0.31 (0.14, 0.47)**
Endowed	-0.82 (-1.46, -0.19)**	-0.24 (-0.59, 0.10)	0.38 (0.15, 0.60)**	0.92 (0.77, 1.08)**	1.14 (0.99, 1.30)**
SES (continuous, per 1 unit)	-0.11 (-0.22, -0.01)*	0.12 (0.05, 0.19)**	0.22 (0.17, 0.27)**	0.38 (0.34, 0.42)**	0.59 (0.55, 0.63)**
			Panel C. Age at last birth (Δ units; linear model)		
Education					
Elementary only		(Ref)	(Ref)	(Ref)	(Ref)

Some High school		-0.18 (-1.28, 0.92)	-0.04 (-0.34, 0.26)	-0.46 (-0.65, -0.28)**	0.36 (-1.16, 1.88)
High school graduate or higher		-0.08 (-0.89, 0.73)	-0.18 (-0.43, 0.08)	0.39 (0.21, 0.56)**	1.92 (0.49, 3.36)**
Religion					
Not Latter-day Saint	(Ref)	(Ref)	(Ref)	(Ref)	(Ref)
Baptized only	-0.24 (-1.46, 0.99)	0.96 (0.18, 1.75)*	0.02 (-0.44, 0.47)	0.45 (0.19, 0.70)**	-0.25 (-0.50, -0.01)*
Endowed	1.03 (0.09, 1.97)*	1.50 (0.98, 2.02)**	2.04 (1.71, 2.37)**	2.18 (1.95, 2.41)**	2.09 (1.86, 2.32)**
SES (continuous, per 1 unit)	0.02 (-0.13, 0.18)	-0.18 (-0.28, -0.08)**	-0.34 (-0.42, -0.27)**	-0.14 (-0.20, -0.08)**	0.39 (0.33, 0.45)**
Panel D. Birth interval spacing (Δ units; linear model)					
Education					
Elementary only		(Ref)	(Ref)	(Ref)	(Ref)
Some High school		2.17 (-2.12, 6.45)	0.60 (-0.59, 1.78)	1.89 (1.16, 2.61)**	3.07 (-3.01, 9.16)
High school graduate or higher		0.25 (-2.96, 3.46)	1.20 (0.20, 2.20)*	3.25 (2.56, 3.95)**	3.24 (-2.51, 8.99)
Religion					
Not Latter-day Saint	(Ref)	(Ref)	(Ref)	(Ref)	(Ref)
Baptized only	-3.35 (-8.16, 1.46)	-2.59 (-5.65, 0.48)	-1.55 (-3.37, 0.27)	0.87 (-0.17, 1.91)	0.65 (-0.33, 1.63)
Endowed	-5.79 (-9.49, -2.09)**	-4.19 (-6.22, -2.17)**	-2.92 (-4.24, -1.60)**	-0.56 (-1.49, 0.37)	-1.41 (-2.33, -0.49)**
SES (continuous, per 1 unit)	-0.23 (-0.82, 0.37)	0.39 (-0.00, 0.77)†	0.89 (0.58, 1.19)**	0.84 (0.61, 1.07)**	-0.46 (-0.69, -0.23)**
Panel E. Mortality (HR; Cox model)					
Education					
Elementary only		(Ref)	(Ref)	(Ref)	(Ref)
Some High school		0.93 (0.76, 1.13)	0.95 (0.90, 1.01)	0.91 (0.88, 0.94)**	0.95 (0.72, 1.26)
High school graduate or higher		0.99 (0.86, 1.15)	0.91 (0.86, 0.95)**	0.85 (0.82, 0.87)**	0.84 (0.65, 1.09)
Religion					
Not Latter-day Saint	(Ref)	(Ref)	(Ref)	(Ref)	(Ref)
Baptized only	1.02 (0.82, 1.28)	1.16 (1.01, 1.35)*	0.93 (0.85, 1.01)†	0.98 (0.93, 1.02)	0.97 (0.93, 1.02)
Endowed	1.01 (0.85, 1.20)	1.16 (1.05, 1.27)**	1.18 (1.11, 1.26)**	0.96 (0.92, 1.00)†	0.84 (0.80, 0.88)**
SES (continuous, per 1 unit)	1.01 (0.98, 1.04)	0.98 (0.96, 0.99)*	0.95 (0.94, 0.97)**	0.95 (0.94, 0.96)**	0.94 (0.93, 0.95)**

Notes:

[1]Significance: † p<0.10, * p<0.05, ** p<0.01.

[2]All models adjust for SES, valid Reproductive history, maternal birth year, age at marriage, mother's polygamous status, whether mother was born outside of Utah, and family longevity history.
[3]Education models are blank in 1830 to 1850 cohorts because no education data exists for this epoch. Additionally, education is not used as covariate in non-Education models for mortality.

4.3 Aim 2: Offspring caregiving availability

Aim 2 examines family ecologies as a context for fertility and mortality patterning by focusing on the geographic availability of offspring in late-life. We hypothesize that having at least one proximate adult child during late life will be associated with lower mortality risk, but that this association will vary across stages of older adulthood. In particular, proximity at younger old ages may reflect reactive responses to health shocks, whereas proximity at advanced ages may indicate caregiving availability that mitigates mortality risk.

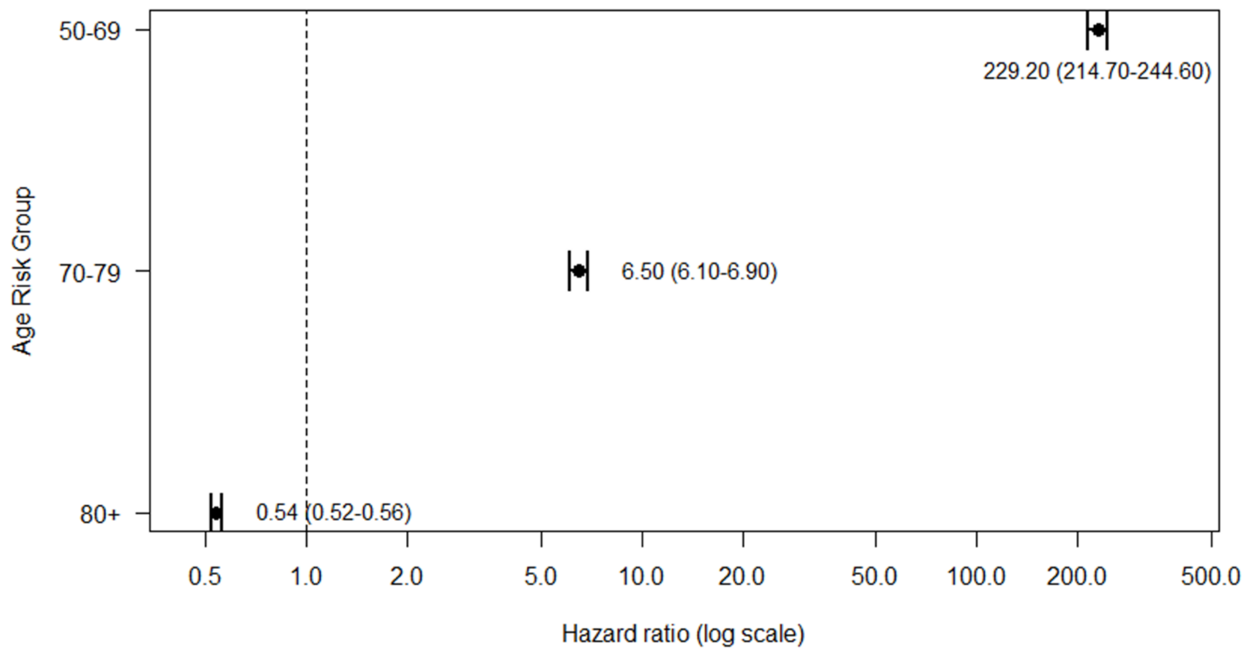
Table 3. *Age-specific maternal mortality hazards associated with having at least one adult child residing in the same or a contiguous county during the final decade of life, compared to having no proximate children.*

		HR (95% CI)
50 and older		0.813 (0.795, 0.831)***
Age-banded risk association		
	50-69	229.20 (214.70, 244.60)***
	70-79	6.50 (6.10, 6.90)***
	80+	0.54 (0.52, 0.56)***

*** p<0.001

Table 3 provides strong support for these hypotheses. Averaged across ages 50 and older, having at least one proximate adult child during the final decade of life is associated with a substantially lower mortality hazard (HR = 0.81; 95% CI: 0.80, 0.83). However, when the association is estimated according to age bands, a sharply age-graded pattern emerges. Proximity to adult offspring is associated with markedly elevated mortality hazard at ages 50–69 (HR = 229.20; 95% CI: 214.70, 244.60), attenuates considerably at ages 70–79, and becomes strongly protective at ages 80 and older (HR = 0.54; 95% CI: 0.52, 0.56).

Figure 2. *Age-specific maternal mortality hazards associated with having at least one adult child residing in the same or a contiguous county during the final decade of life, compared to having no proximate children.*



The extremely large hazard ratio observed at ages 50–69 reflects two features of the analytic design. First, mortality risk in this age range is rare by construction, as all women in the analytic sample survive to age 50. Second, proximity at these ages likely captures reactive kin mobilization in response to severe or unexpected health events rather than caregiving that reduces mortality risk. In contrast, at advanced ages, proximity more plausibly reflects caregiving availability that is less tightly coupled to acute health shocks, consistent with the protective associations observed after age 80. Together, these findings indicate a shift from reactive to protective kin proximity as women age into later stages of old age.

4.4 Aim 3: Maternal fertility and longevity

The final analysis examines the association between maternal fertility history and post-reproductive survival across institutional contexts and birth cohort epochs. Together, Figures 3 and 4 and Table 4 provide support for both hypotheses: fertility–longevity associations vary across historical regimes, and fertility dimensions more directly shaped by institutional norms—particularly timing and spacing—exhibit more consistent relationships with late-life mortality than parity. Descriptively, parity shows limited and institutionally contingent associations with longevity across cohorts (Figure 3a), whereas the relationship between fertility timing and mortality shifts markedly over time. Age at first birth displays little association with mortality in cohorts born before 1890, but develops a clear gradient thereafter, with earlier childbearing increasingly associated with higher mortality risk (Figure 3c). The opposite pattern emerges for age at last birth: among women born between 1830 and 1890, later childbearing is associated with greater longevity, a gradient that attenuates in post-1890 cohorts (Figure 3d). Birth interval spacing similarly shows little association with longevity in early cohorts but exhibits a coherent gradient aligned with later cohort survival. Taken together, the 1890 birth cohorts mark a clear realignment in how fertility characteristics—other than parity—are associated with maternal longevity.

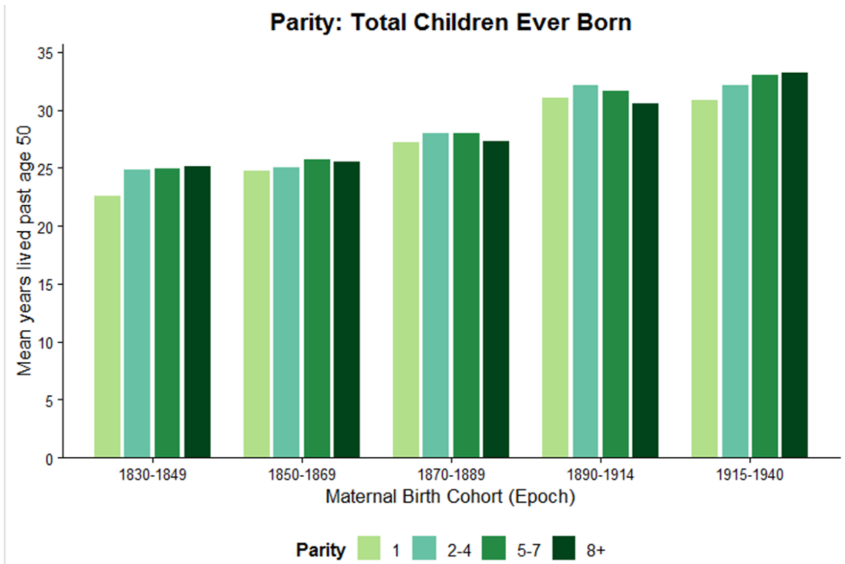
Figures 4a–4f illustrate the association between parity and post-reproductive mortality across institutional contexts defined by religious participation. The patterning of parity and longevity shifts sharply around the 1890 birth cohorts. Among women born prior to 1890, higher parity is similarly associated with greater longevity across all three levels of religious commitment. In contrast, among cohorts born after 1890, this association largely dissipates among non–Latter-day Saint women and those who were baptized but not endowed, while women who participated in endowment ceremonies retain the parity–longevity pattern characteristic of earlier cohorts.

Descriptively, parity–longevity associations vary across cohorts and institutional contexts; however, in adjusted models that account for institutional, socioeconomic, and life-course factors, parity exhibits comparatively weak and stable associations with post-reproductive mortality. Table 4 presents these adjusted cohort-specific estimates, showing that parity is weakly associated with mortality in early cohorts, while having only one child becomes increasingly associated with elevated mortality risk in the most recent cohorts (HR = 1.11; 95% CI: 1.06, 1.16 for 1915–1940). In contrast, fertility timing exhibits stronger and more systematic cohort patterning: later ages at last birth are increasingly associated with lower mortality risk in later cohorts, with childbearing after age 40 corresponding to a 7% reduction in mortality hazard in the 1915–1940 cohorts (HR = 0.93; 95% CI: 0.88, 0.97), while early ages at first birth are associated with progressively higher mortality risk across cohorts, culminating in a 17% increase in hazard among women whose first birth occurred before age 18 (HR = 1.17; 95% CI: 1.14, 1.21).

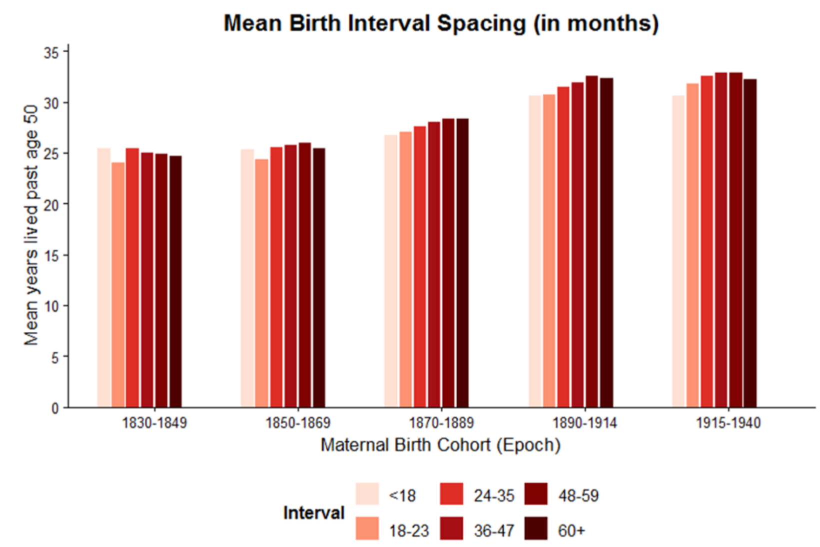
Together, these adjusted results indicate that fertility timing and spacing, rather than parity, account for the most consistent fertility–longevity associations in later institutional regimes, and institutional norm strongly structured these associations.

Figure 3a to 3d.

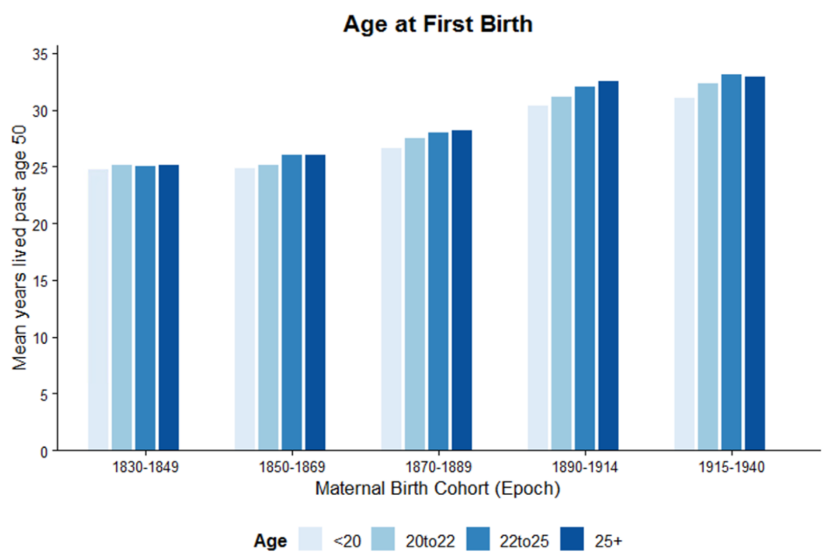
3a.



3b.



3c.



3d.

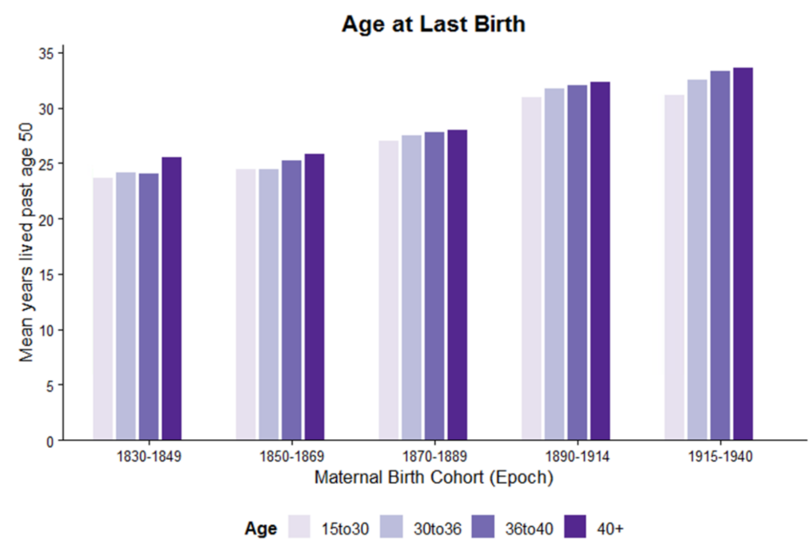
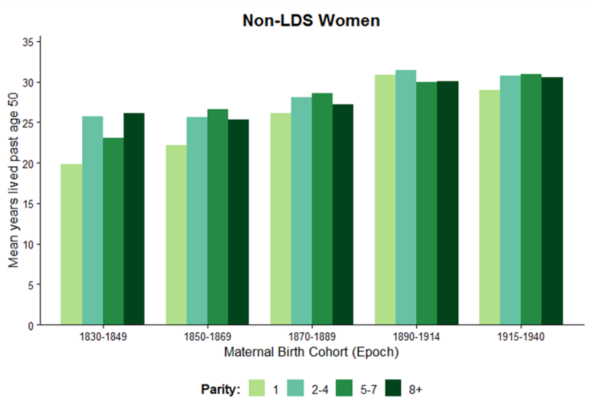
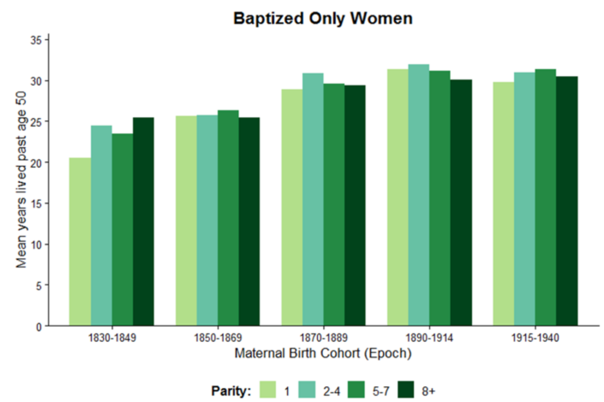


Figure 4a to 4f.

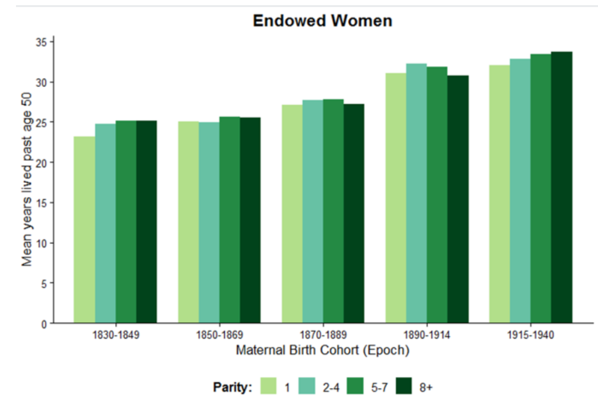
4a.



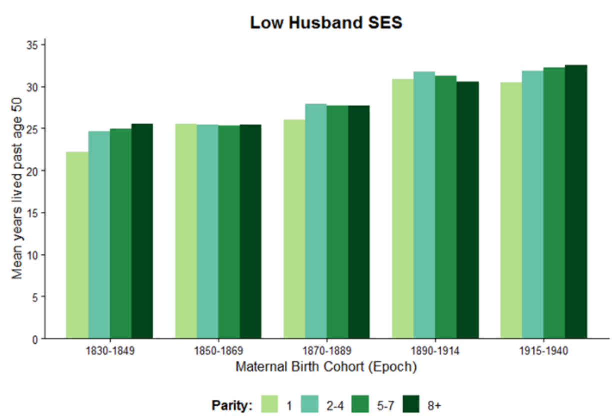
4b.



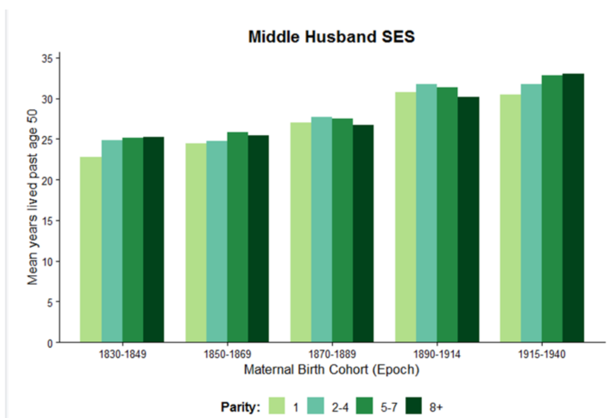
4c.



4d.



4e.



4d.

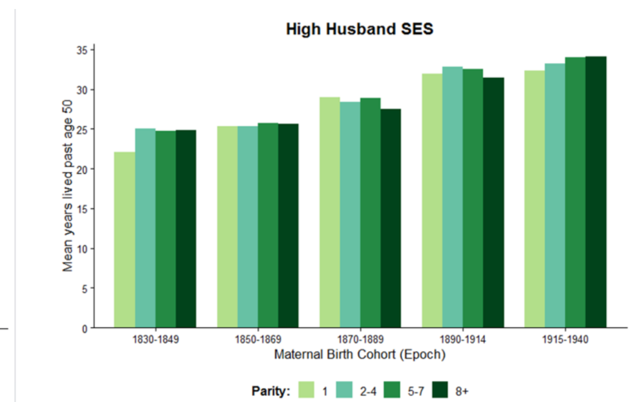


Table 4. *Cohort-specific associations between fertility history and post-reproductive maternal mortality, adjusted for education, religion, and socioeconomic status. Married women surviving to age 50, with an intact first marriage at age 50, at least one child, born 1830–1940, who died in Utah (N = 171,784)*

	1830-1849	1850-1869	1870-1889	1890-1914	1915-1940
	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)	HR (95% CI)
Parity (total children ever born)					
1	1.25 (0.99–1.58)†	1.02 (0.89–1.18)	1.03 (0.95–1.11)	1.06 (1.02–1.10)**	1.11 (1.06–1.16)***
2 to 4	Ref	Ref	Ref	Ref	Ref
5 to 7	1.02 (0.91–1.13)	0.95 (0.89–1.02)	1.02 (0.98–1.06)	1.05 (1.03–1.08)***	0.98 (0.96–1.00)
8+	1.01 (0.90–1.14)	0.96 (0.89–1.03)	1.07 (1.02–1.13)**	1.11 (1.06–1.15)***	0.99 (0.95–1.04)
Age at first birth (in years)					
<20	1.02 (0.94–1.10)	1.10 (1.04–1.16)***	1.07 (1.03–1.12)**	1.12 (1.08–1.15)***	1.17 (1.14–1.21)***
20 to 22	0.99 (0.92–1.07)	1.05 (0.99–1.10)†	1.03 (0.99–1.07)	1.06 (1.03–1.09)***	1.07 (1.04–1.10)***
22 to 25	Ref	Ref	Ref	Ref	Ref
25+	0.99 (0.91–1.08)	0.96 (0.90–1.02)	0.99 (0.95–1.03)	0.98 (0.95–1.00)†	1.00 (0.97–1.03)
Age at last birth (in years)					
15 to 30	Ref	Ref	Ref	Ref	Ref
30 to 36	1.06 (0.87–1.28)	1.04 (0.94–1.16)	0.96 (0.91–1.02)	0.96 (0.93–0.99)**	0.97 (0.94–1.00)*
36 to 40	1.04 (0.86–1.27)	1.04 (0.93–1.16)	0.93 (0.87–0.99)*	0.94 (0.90–0.97)***	0.93 (0.90–0.97)***
40+	0.93 (0.76–1.14)	1.01 (0.91–1.14)	0.90 (0.84–0.97)**	0.90 (0.87–0.94)***	0.93 (0.88–0.97)**
Birth interval space (in months)					
<18	1.03 (0.82–1.28)	1.01 (0.85–1.21)	1.04 (0.92–1.17)	1.12 (1.05–1.20)***	1.14 (1.08–1.21)***
18–23	1.18 (1.09–1.28)***	1.12 (1.05–1.19)***	1.05 (0.99–1.11)†	1.09 (1.04–1.13)***	1.06 (1.02–1.10)**
24–35	Ref	Ref	Ref	Ref	Ref
36–47	1.01 (0.93–1.11)	0.95 (0.89–1.00)†	0.99 (0.95–1.03)	1.01 (0.98–1.04)	0.99 (0.96–1.02)
48–59	1.01 (0.85–1.21)	0.94 (0.85–1.03)	0.96 (0.91–1.02)	0.97 (0.93–1.00)†	0.97 (0.93–1.01)†
60+	1.12 (0.92–1.36)	0.90 (0.80–1.01)†	0.99 (0.92–1.05)	1.01 (0.97–1.05)	1.01 (0.97–1.05)

Significance: † p<0.10, * p<0.05, ** p<0.01.

Mothers with one birth are not included in Birth interval spacing.

5. Discussion

This paper addresses longstanding variation in findings concerning the relation between maternal fertility patterns and late-life mortality. Rather than treating this variation as evidence for a particular biological mechanism between fertility and mortality, we argue that it reflects the difficulty of assessing fertility–longevity relationships outside of their historical and institutional contexts. Using Utah as an analytic case where high fertility and low mortality coexisted across regimes under stable social institutions, we demonstrate that fertility-mortality relations are not fixed-biological relationships, but context dependent processes embedded in social life. Importantly, these findings do not adjudicate between biological aging mechanisms, but instead specify the institutional conditions under which fertility dimensions become predictive of late-life survival.

Across three analytic aims, our results show that fertility and mortality change together over time, but in institutionally patterned ways. Aim 1 establishes that declining fertility and improving survival across cohorts are strongly structured by education, religion, and socioeconomic status, underscoring the importance of regime-specific context for interpreting fertility–longevity associations. Aim 2 demonstrates that family ecologies provide a plausible pathway linking fertility histories to late-life mortality, but that this association varies sharply by age, consistent with reactive kin mobilization at younger old ages and protective caregiving availability at advanced ages. Finally, aim 3 shows that parity itself exhibits weak and inconsistent associations with mortality across cohorts. Alternatively, fertility timing and spacing dimensions, more directly regulated by institutional norms, emerge as the most consistent predictors of post-reproductive survival in later regimes.

Aim 1 establishes epoch-specific institutional patterning. The Lexis diagram and cohort-stratified models show that fertility declined and longevity increased across successive birth cohorts, but these trajectories were not uniform. Instead, SES in later cohorts held strong implication for birth interval spacing, as did education on both birth timing and spacing. Mortality, in contrast, exhibited comparatively modest institutional differentiation across epochs. Together, these findings suggest that fertility, more than mortality, is the primary channel through which institutional regimes shape later-life demographic outcomes.

Family ecologies, as examined in Aim 2, reinforce this institutional interpretation. the association between offspring proximity and maternal mortality varies sharply across stages of older adulthood. Proximity during younger old ages is associated with substantially elevated mortality risk, consistent with reactive mobilization in response to parental health shocks, whereas proximity at advanced ages is strongly protective, consistent with sustained caregiving availability. Because geographic proximity of adult children is unlikely to reflect biological processes, these patterns underscore how fertility-related life-course outcomes intersect with longevity through socially organized family and economic structures rather than through physiological tradeoffs alone.

Aim 3 yields this paper’s central finding: parity itself shows little systematic association with post-reproductive longevity, whereas fertility timing and spacing display increasingly coherent associations with mortality in later cohorts. This divergence suggests that fertility dimensions most aligned to institutional regulation are also most predictive of late-life survival across historical epochs. Religious participation, socioeconomic position, and educational trajectories are consistently associated with when women bear children and with patterns of late-life mortality, even as the total number of children remains comparatively weakly related to survival. In contrast, parity remains noisy, reflecting heterogenous cultural values, household preferences, that are less connected to biological aging or late-life health. Rather than clarifying a universal fertility-longevity tradeoff, these underscore how fertility-mortality associations are historically contingent and institutionally patterned, clouding biological implications while sharpening the role of social institutions in fertility and maternal late-life survival.

5.1 Contribution

Freeman's (1935) response to the contradictions between Beeton, Yule, and Pearson (1900) and Powys (1905), calling for improved controls to disentangle the relation between fertility and mortality, highlights the motivation for this paper. Fertility is not a scalar exposure with a fixed biological meaning across time, but a set of behaviors that include timing, spacing, and parity, whose social organization varies across institutional regimes. When analyses collapse distinct time periods and social contexts into a single framework, associations with late-life mortality may appear contradictory across different populations. Rather than controls helping the researcher to identify biological trade-offs, the results instead highlight Darwin's contribution: that fertility is a process embedded in environmental response.

5.2 Limitations

Design limitations in this paper center around selection, both into the UPDB and into the study population. Prior to the introduction of statewide death certificates in 1905, inclusion in the UPDB disproportionately reflects individuals who appear in genealogical or census records. As a result, the population is likely weighted toward those who were Latter-day Saint or geographically stable, as many of Utah's earliest residents were short-term or transient laborers.

Selection concerns are amplified in the Aim 2 analysis. Aim 2 requires that women in the study population died in Utah and was limited to those who had at least one child with an observed residential record in Utah within ten years of the mother's death. This restriction may exclude children who lived near their mothers but were not observed within this window, or mothers with children who moved out of state. In addition, geographic proximity should not be interpreted as a direct measure of caregiving. Proximity is therefore best understood as an imperfect indicator of availability rather than care itself. More broadly, as a historical observational study, the findings are intended to describe patterned associations across cohorts rather than to support causal inference.

5.3 Conclusion

In Utah, the relationship between fertility and longevity does not appear as a uniform biological tradeoff, but rather as a set of biologically relevant processes that are socially organized and historically contingent. Fertility behaviors that are more directly shaped by institutional norms, particularly birth timing and spacing, exhibit more consistent associations with late-life mortality than parity. This suggests that fertility trajectories are best understood in relation to the social environments in which they occur, rather than as fixed biological exposures. Focusing on parity alone may therefore obscure how institutions structure reproductive behavior, as timing and spacing more closely reflect normative constraints and life-course organization, with parity emerging as an outcome of these processes rather than a parallel dimension.

Replication across other historical and institutional contexts is needed. Although data limitations are inherent to historical demographic research, comparative analyses of fertility timing and spacing across populations may offer a productive avenue for further study. Further attention to kin availability, which arises from fertility histories and is associated with late-life mortality, may also help clarify how family structures intersect with survival in later life. Taken together, this study highlights how historical and institutional context shapes the ways fertility histories are associated with late-life mortality.

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