# Paternal Age and Maternal Age and their Effects on Adult Offspring Mortality

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**Abstract**

This paper assesses the role of paternal and maternal age at conception on the longevity of their offspring. The analysis relies on the Utah Population Database and includes approximately 77,000 offspring. Results indicate a strong adverse effect of parental age at conception on the longevity of offspring, with varying levels of significance based on offspring sex. Male longevity appears less sensitive to late paternal age and more sensitive to late maternal age than female longevity. Female longevity is independent of maternal age at which the mother conceived the target child, as well as the age at which the mother last conceived. These results are somewhat surprising since current theory holds that late, maternal-fertility may be a marker for longevity, a benefit that might be shared with their offspring.

## Introduction

In analyzing the effects of late parental fertility on offspring longevity, we hypothesize that advanced maternal age, a factor associated with increased longevity for mothers themselves, will be associated with better adult offspring survival. Accordinlgly, offspring of late-fertile mothers will have greater longevity than their counterparts with younger mothers. We also hypothesize that adult offspring of late-fertile fathers will have reduced longevity in relation to their counterparts with younger fathers. This result should be especially pronounced among female offspring, based on the findings of Gavrilov and Gavrilov (1997, 1998) who report that daughters of older fathers experience a significant decline in survival. Other investigations report detrimental effects of late-fatherhood on offspring longevity, most of which are associated with the accelerating increase of mutation rates with paternal age (Crow 1993) for specific conditions. Among these are dwarfism (Wilkin et al. 1998), Apert Syndrome (Risch et al. 1987), congenital heart defects (Olshan et al.1994**)**, acute lymphoblastic leukemia (Murray et al. 2002), and schizophrenia (Byrne et al 2003).

The literature on offspring longevity and parental age effects varies in its efforts to control for potential confounders. This analysis makes adjustments for these confounders by introducing appropriate statistical controls. These include measures that may affect later parental age as well as offspring mortality such as deaths of previous children, membership in a religion that encourages large families (Bean, Mineau, and Anderton 1990; Enstrom 1978, 1989), age at first and last birth, and family history of longevity.

*Hypotheses*

We hypothesize that adult offspring of late-fertile fathers will have reduced longevity, an association that will be pronounced for females. We further hypothesize that offspring of late-fertile mothers will have enhanced longevity, as indicated by two different measures of fertility: the mother's age at the child's birth as well as the maximum age at her last birth.

## Data and Methods

*The Utah Population Database*

This study draws upon the Utah Population Database (UPDB), a genealogical database containing information on over six million unique individuals within the state of Utah. It includes genealogies of the founders of Utah as well as their descendants up to the present time. These records were computerized in the 1970s (Skolnick et al. 1979, 1981) and have since been linked to other data sets, most notably vital records for the state of Utah, including birth and death certificates, driver license records, census records, and social security records. The resulting database provides a remarkably comprehensive record of all Utah individuals as well as their families.

The UPDB is a dynamic database that receives annual updates of Utah births, deaths, driver licenses, and health records. The database now includes over two million Utah birth certificates and around 695,000 death certificates spanning almost a century (Smith et al. 2005). Multiple records for an individual are matched to create longitudinally linked data, allowing quality control for demographic information.

The Utah Resource for Genetic and Epidemiologic Research (RGE) administers access to these data through a review process of the project proposal. The confidentiality of individuals represented in these records is maintained based on agreements between RGE and the data contributors. All research requires IRB and RGE approval (Wylie and Mineau 2003).

This database has been extensively utilized in former studies (e.g.: Anderton and Bean, 1985; Bean et al. 2002; Mineau 1988, among others), establishing it as a reliable source of data. Furthermore, studies in population genetics indicate that this population is biologically representative of a broad spectrum of the U.S. population and European populations (O'Brien et al. 1994). Therefore, analyses and results from the present study have widespread applications across many populations.

*Data Selection Methods*

The subset of data used for the present analysis was constructed by first selecting all women born before 1900. The purpose for this data restriction was two-fold: to restrict the sample to a period without effective fertility and to assess a period that allows for adequate follow-up of offspring survival. The sample was restricted to women who had had all their children from their first marriage. Selected women were also required to have lived to at least age 50 to ensure that they would have completed childbearing.

The dataset was formed by creating two groups of mothers: the first consisted of women classified as late-fertile, defined as women bearing children past age 45. The second group was selected as a control group—11,000 women (approximately two times the number of women from the first group) were randomly selected whose last children were born before the mother reached 45 years old. Finally, only offspring of these mothers who survived to at least 18 years old were analyzed. The final dataset contained approximately 77,000 individuals.

*Variables*

While the purpose of this study is to analyze the effect of parental age on offspring longevity, we consider numerous other variables that may be associated with parental age and offspring mortality. The additional covariates utilized in this analysis include the offspring's birth year, gender, birth order, parity, age at first and last birth, and LDS status. We also consider parental variables including parity, the number of offspring who died before age 18, and age at death. Tables 1 A and B display descriptive statistics on the variables of interest

**TABLES 1 A AND B HERE**

*Survival Methods*

A series of Cox regression models were fit to the data to test the effect of the predictor variables on longevity (survival time). The models had the following form:

$$h(t,i) = h_0(t)\exp(\sum_{i=1}^{k} \beta_i X_i)$$

where $h(t,i)$ represents the mortality hazard rate for person $i$ at $t$ years after age 18, $h_0(t)$ is the baseline hazard rate, $\beta_i$ are the unknown regression coefficients, and $X_i$ are the observed covariates for person $i$.

**Results**

Table 2 displays results for several Cox proportional hazard models for females and males, as well as combined results for both. The dummy variables “missing afb” and “missing alb” represent whether values for age at first birth and age at last birth information were available. The missing values were imputed to the means of the non-missing values of these variables for the purpose of analysis. The two dummy variables control for the fact that an imputation was used.

*Parental Age at Conception as a Continuous Variable*

The first analysis represents parental age at conception as a continuous variable. In Table 2, parental age at the time of the child’s birth—here referred to as maternal age and paternal age—has a significant impact on the child’s longevity. Both variables are significant contributors to offspring longevity, though with opposite effects. Increases in maternal age at birth result in reduced hazards (HR=0.995); for every one year increase in maternal age, the mortality hazard for offspring decreases by 0.5%. On the other hand, for every one year increase in paternal age at birth, the mortality hazard for offspring increases by 0.3% (H.R.=1.003).

When the data are stratified by offspring gender, maternal age remains a strong predictor for longevity in males, resulting in a lower mortality risk (HR=0.993). The effect of paternal age is slightly less significant ($p<0.10$), with a hazard ratio of 1.002. Females, on the other hand, show more sensitivity to late fatherhood ($p<0.05$) than males do, though the effect of late motherhood is no longer significant ($p>0.10$).

**TABLE 2 HERE**

*Parental Age at Conception as a Categorical Variable*

Data were also analyzed categorically, in an effort to determine if certain parental age ranges at conception affected offspring longevity but only at certain threshold values. Maternal age was divided into six age categories: <20, 20-29, 30-34, 35-39, 40-44 and 45+. The reference category was 20-29 years of age. Results are displayed in Table 3 A. Across both genders, mortality hazards decrease linearly and significantly for the older three age groups in relation to the reference category. Note that there is no significant difference between offspring survival rates for the reference group versus the oldest age group. The overall trend, however, indicates that a general increase in maternal age at the child's birth results in a reduced risk of death, consistent with the results found in Table 3 A.

**TABLE 3 A HERE**

Proportional hazard models were again estimated by gender. For males, the hazard ratio decreases linearly with increased maternal age. Again, this trend is significant for the three age groups ranging from 30-44, moving from a hazard ratio of 0.951 for the first age group to that of 0.932 for the last age group. Although advanced ages of the last group (45+) do not significantly affect longevity, the overall pattern remains that an increase in maternal age results in a general increase in survival.

For females, the trend is quite different. Surprisingly, there appears to be no association between late maternal fertility and longevity for female offspring. This means that male children see the benefit of late, maternal-fertility while females do not.

Paternal age was also divided into age categories: 15-24, 24-34, 35-44, 45-54, 55-64, and 65+; the reference group was 24-34. Results indicate that there is a paternal age effect on both male and female offspring, though it appears most strongly in only the latest paternal age group of 65+ (see Table 3 B). Here, the hazard ratio is 1.597 (p=0.0016), indicating that children of older fathers (65+) are at a 60% higher risk for death past the age of 50 as compared to those in the reference category. The respective risk of offspring mortality due to advanced paternal age is stronger in females (HR=1.799; p=0.0197) than males (HR=1.421; p=0.055) for the 65+ paternal age category.

**TABLE 3 B HERE**

There is also a slightly increased hazard ratio (HR=1.037) for offspring of the youngest fathers (15-24) as compared to the reference group (p<0.05). The simplest explanation for this effect is that perhaps younger fathers have fewer material resources with which to provide their children, which may affect their children's life chances.

The adverse effect for female offspring due to late paternal age begins to emerge in the earlier age category of 55-64, with a p-value that is not significant (p=0.1165) but suggestive. These results corroborate other studies' findings that there is a stronger paternal age effect among females rather than males in terms of longevity (e.g. Gavrilova & Gavrilov 2000). As this study also indicates, however, paternal age at birth adversely affects—to at least some extent—both genders (Kemkes-Grottenthaller 2001).

*Maximum Age of Mother for Her Last Child*

There is evidence that late, maternal-fertility is correlated with greater female survival prospects. Some have argued that this is consistent with the concept that such women age more slowly (Smith et al. 2002). With this in mind, a potential marker for longevity in offspring is the age at which the mother conceived her last children. Late-fertile women generally live longer, an attribute that may be heritable resulting in greater offspring longevity.

The maximum age at which the mother last conceived a child was tested as a continuous covariate for offspring survival rates. Results are displayed in Table 4 first for all offspring and then by gender. The mother's age at last birth (maximum maternal age) was significant for predicting survival rates of offspring, with a hazard ratio of 0.997 (p=0.0038). When separated by gender, the effect of maximum maternal age continued to be significant for males (p<0.0001; HR=0.994) but was not significant for females (p=0.7145).

**TABLE 4 HERE**

Maternal age at last birth was also tested as a categorical variable and divided into five groups: <30, 30-37, 38-42, 43-45, and 45+. The reference category was the 38-42 age group. The last age group was a significant predictor of survival rates (HR=0.972, p=0.0184) for the 45+ age group compared to the reference category. When the analysis was separated by gender, the last maternal age group remained significant (HR=0.952, p=0.0024) for males and the second-to-last also became marginally significant (HR=0.975, p=0.0781). However, neither was significant for females. These results support the previous findings of the effect of maternal age on mortality by gender. The mother's age at last birth appears to be a very important factor for male offspring survival, but not for females. Conversely, the father's age is very important for female offspring survival, but not for males.

**TABLE 5 HERE**

## Discussion

*Late Paternal Age at Birth*

We hypothesized that offspring of late-fertile fathers would have a higher mortality rate than others and that this would be especially pronounced among female offspring. The results found in this study are consistent with these hypotheses as well as previous findings indicating that daughters are at greater risk of death than sons when considering the effect of paternal age on offspring longevity. Specifically, Gavrilova and Gavrilov (1993) found that heritability estimates were much higher in daughters than in sons at all paternal ages, though this difference was significant only for advanced paternal ages. Gavrilov & Gavrilova (1998) also showed that daughters of older fathers with paternal ages of 45-55 years had a mean loss of life span of approximately 0.5 per each additional year of paternal age. Although the results from our analysis showed the effect for later paternal ages only, the general result is the same—that daughters conceived by older fathers have a much higher hazard rate of death than do those of younger fathers, and a higher hazard rate than sons of older fathers.

The most predominant theory explaining the effects of higher paternal aging on female offspring is based on the concept of gene mutation. It has been shown that the human mutation rate for chromosomes is much higher in males than in females and increases more-than-linearly with paternal age (Crow 1997). Furthermore, this effect appears to be greater for the female offspring of older fathers than for the male offspring, lending support to the theory that de novo mutations, possibly X-linked, associated with increased parental age might be responsible for greater hazard rates among female versus male children. This theory has also been hypothesized as the source of specific disease incidence among females that is higher than in males. Although the present study found hazard rates to be especially high among female offspring with respect to paternal age, there is strong evidence that advanced paternal age may result in a myriad of genetic defects for both sexes.

*Late Maternal Age at Birth*

Our hypothesis regarding maternal age and offspring longevity predicted that increases in maternal age would reduce mortality risk for offspring. This hypothesis was partially confirmed, though we found that male offspring were affected more by maternal effects of late-fertility than were female offspring. While increasing paternal age resulted in higher hazard rates, increasing maternal age lowered them. This maternal age effect was evident for mothers who gave birth to their last child in their mid-forties and later, reducing the hazard rate for male offspring from 0.975 (43-45) to 0.952 for 45+. Interestingly, there was no benefit of maternal late-fertility on female offspring. The positive effect of maternal late fertility on survival in male offspring and the lack of an effect for females support recent arguments of evolutionary theorists. Bio-demographers and evolutionary biologists have recently argued that female fertility patterns may be useful markers for rates of biological aging (Vaupel et al. 1998), and may therefore be related to enhanced longevity. Some theorize that forces that prolong the period during which female reproduction occurs will postpone aging and increase female longevity. Therefore, offspring who inherit such genes allowing for prolonged reproduction and enhanced longevity will also have enhanced longevity. Although it was speculated that this theory would apply to both males and females (Smith et al., 2002), it appears only relevant for males in our study. The reasons for this sex difference are—as yet—not fully understood. One possibility is that our analysis failed to control for the effect of paternal conceive age in regression models regarding maternal age. But the inclusion of this variable did not change the results. The sex difference found with respect to the effects of maternal age on offspring occurs across all sex-specific analyses in this study. Daughters of late-fertile women have no survival benefit, regardless of whether the daughters themselves were the late-born child or if it was a later-born sibling. Sons, on the other hand, show benefits for both types of analyses of maternal age effects on mortality.

Another explanation for the null effect of maternal benefits for female offspring involved the covariates. In our analyses, the daughter's age at last birth was controlled for, perhaps masking the overall effect of the daughter's longevity, since age at last birth and longevity are highly correlated for women. However, removal of this variable for women and a re-analysis of the data still failed to show significance for a maternal benefit among female offspring.

Future analyses will need to further explore the gender discrepancies regarding late maternal child-bearing effects. Perhaps there is a biological or genetic explanation for these differences in addition to social ones. Furthermore, it would also be beneficial to analyze the fertility patterns of daughters of late-fertile mothers. Are they also late fertile, or is the pattern lost, since what was formerly thought as a genetic transfer of longevity has no effect on daughters? Is this marker non-transferable along the female line?

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**Table 1A. Descriptive Statistics for Males**

| Variable | Mean | Std. Dev. | Minimum | Maximum |
|---|---|---|---|---|
| Birth year | 1896.7400 | 23.7730 | 1775.00 | 1949.00 |
| Active LDS | 0.8262 | 0.3789 | 0.0000 | 1.0000 |
| Inactive LDS | 0.1161 | 0.3203 | 0.0000 | 1.0000 |
| Birth order | 5.0905 | 3.1716 | 1.0000 | 22.0000 |
| Mother: number of children | 9.0878 | 3.2477 | 1.0000 | 22.0000 |
| Mother: number of children dead | 1.6973 | 1.6788 | 0.0000 | 16.0000 |
| Number of children | 2.9867 | 3.5807 | 0.0000 | 25.0000 |
| Age at first birth | 26.8481 | 5.3508 | 12.0000 | 68.0000 |
| Age at last birth | 37.0938 | 7.5247 | 13.0000 | 72.0000 |
| Mother: age at death | 77.0113 | 11.2437 | 50.0068 | 108.1807 |
| Father: age at death | 75.4420 | 10.0933 | 50.0042 | 107.7864 |
| Age at death | 66.7767 | 19.4040 | 18.0014 | 105.2868 |
| Censored | 0.1799 | 0.3841 | 0.0000 | 1.0000 |
| Mother: age when child born | 31.0526 | 7.3139 | 12.0000 | 55.0000 |
| Father: age when child born | 34.6427 | 8.0069 | 15.0000 | 91.0000 |
| Mother: age at last child | 41.1117 | 5.2595 | 15.0000 | 55.0000 |
| Father: age at last child | 44.6796 | 6.6699 | 18.0000 | 92.0000 |

**Table 1B. Descriptive Statistics for Females**

| Variable | Mean | Std. Dev. | Minimum | Maximum |
|---|---|---|---|---|
| Birth year | 1896.75 | 23.7502 | 1778.00 | 1948.00 |
| Active LDS | 0.8369 | 0.3694 | 0.0000 | 1.0000 |
| Inactive LDS | 0.1171 | 0.3216 | 0.0000 | 1.0000 |
| Birth order | 5.1005 | 3.1937 | 1.0000 | 20.0000 |
| Mother: number of children | 9.1008 | 3.2436 | 1.0000 | 22.0000 |
| Mother: number of children dead | 1.6984 | 1.6924 | 0.0000 | 17.0000 |
| Number of children | 3.0494 | 3.3615 | 0.0000 | 20.0000 |
| Age at first birth | 23.7793 | 4.9176 | 12.0000 | 53.0000 |
| Age at last birth | 34.0706 | 6.9279 | 13.0000 | 65.0000 |
| Mother: age at death | 77.0135 | 11.2362 | 50.0068 | 108.9966 |
| Father: age at death | 75.5309 | 10.0240 | 50.0042 | 107.7864 |
| Age at death | 67.7127 | 21.7675 | 18.0014 | 109.1499 |
| Censored | 0.2521 | 0.4342 | 0.0000 | 1.0000 |
| Mother: age when child born | 31.0489 | 7.3319 | 12.0000 | 55.0000 |
| Father: age when child born | 34.6531 | 8.0545 | 17.0000 | 92.0000 |
| Mother: age at last child | 41.1236 | 5.2409 | 13.0000 | 55.0000 |
| Father: age at last child | 44.7024 | 6.6607 | 17.0000 | 92.0000 |

**Table 2.** **Proportional Hazards for Maternal and Paternal Age**

| Variable | Both Genders | | Males | | Females | |
|---|---|---|---|---|---|---|
| | p-value | HR | p-value | HR | p-value | HR |
| Birth year | <.0001 | 0.993 | <.0001 | 0.994 | <.0001 | 0.991 |
| Male | <.0001 | 1.429 | . | . | . | . |
| Birth order | 0.0054 | 1.009 | 0.0008 | 1.014 | 0.4656 | 1.003 |
| Active LDS | <.0001 | 0.764 | <.0001 | 0.744 | <.0001 | 0.783 |
| Inactive LDS | 0.8926 | 0.997 | 0.0096 | 1.093 | 0.0152 | 0.912 |
| Mother: number of children | <.0001 | 0.992 | 0.0018 | 0.992 | 0.0036 | 0.992 |
| Mother: number of children dead | <.0001 | 1.016 | 0.0017 | 1.012 | <.0001 | 1.021 |
| Number of Children | 0.1946 | 0.997 | 0.0005 | 0.991 | <.0001 | 1.017 |
| Age at first birth | <.0001 | 0.995 | 0.0017 | 0.995 | 0.411 | 1.002 |
| Age at last birth | <.0001 | 0.996 | 0.0177 | 0.997 | <.0001 | 0.991 |
| Missing afb | 0.0001 | 0.682 | 0.0127 | 0.704 | 0.0107 | 0.704 |
| Missing alb | <.0001 | 1.662 | 0.0007 | 1.604 | <.0001 | 1.71 |
| Mother: age at death | <.0001 | 0.993 | <.0001 | 0.993 | <.0001 | 0.993 |
| Father: age at death | <.0001 | 0.992 | <.0001 | 0.991 | <.0001 | 0.994 |
| Maternal age | 0.0002 | 0.995 | 0.0001 | 0.993 | 0.1077 | 0.997 |
| Paternal age | 0.0051 | 1.003 | 0.0992 | 1.002 | 0.0203 | 1.003 |

**Table 3 A. Proportional Hazards for Maternal Age by Age Category**

| Variable | Both Genders | | Males | | Females | |
|---|---|---|---|---|---|---|
| | p-value | HR | p-value | HR | p-value | HR |
| Birth year | <.0001 | 0.993 | <.0001 | 0.994 | <.0001 | 0.991 |
| Male | <.0001 | 1.428 | . | . | . | . |
| Birth order | 0.0045 | 1.008 | 0.0009 | 1.012 | 0.3703 | 1.004 |
| Active LDS | <.0001 | 0.765 | <.0001 | 0.744 | <.0001 | 0.784 |
| Inactive LDS | 0.949 | 0.998 | 0.0084 | 1.094 | 0.0172 | 0.914 |
| Mother: number of children | 0.0001 | 0.993 | 0.0049 | 0.993 | 0.0035 | 0.992 |
| Mother: number of children dead | <.0001 | 1.016 | 0.0021 | 1.012 | <.0001 | 1.021 |
| Number of Children | 0.194 | 0.997 | 0.0005 | 0.991 | <.0001 | 1.017 |
| Age at first birth | <.0001 | 0.995 | 0.0021 | 0.995 | 0.3869 | 1.002 |
| Age at last birth | <.0001 | 0.996 | 0.0164 | 0.997 | <.0001 | 0.991 |
| Missing afb | 0.0001 | 0.683 | 0.0133 | 0.706 | 0.0107 | 0.705 |
| Missing alb | <.0001 | 1.661 | 0.0008 | 1.601 | <.0001 | 1.708 |
| Mother: age at death | <.0001 | 0.993 | <.0001 | 0.993 | <.0001 | 0.993 |
| Father: age at death | <.0001 | 0.992 | <.0001 | 0.991 | <.0001 | 0.994 |
| Maternal Age | | | | | | |
| <19 | 0.1081 | 1.037 | 0.286 | 1.035 | 0.0744 | 1.055 |
| 30-34 | 0.0021 | 0.963 | 0.0026 | 0.951 | 0.1299 | 0.973 |
| 35-39 | 0.0614 | 0.97 | 0.0008 | 0.929 | 0.5065 | 1.016 |
| 40-44 | 0.1081 | 0.967 | 0.0146 | 0.932 | 0.9483 | 0.998 |
| 45+ | 0.6968 | 1.011 | 0.4142 | 0.97 | 0.2006 | 1.053 |

| Maternal Age Category | N |
|---|---|
| <19 | 2,554 |
| 20-29 | 32,457 |
| 30-34 | 16,706 |
| 35-39 | 13,567 |
| 40-44 | 7,802 |
| 45+ | 3,448 |

**Table 3 B.** **Proportional Hazards for Paternal Age by Age Category**

| Variable | Both Genders | | Males | | Females | |
|---|---|---|---|---|---|---|
| | p-value | HR | p-value | HR | p-value | HR |
| Birth year | <.0001 | 0.993 | <.0001 | 0.994 | <.0001 | 0.991 |
| Male | <.0001 | 1.429 | . | . | . | . |
| Birth order | <.0001 | 0.764 | <.0001 | 0.744 | <.0001 | 0.783 |
| Active LDS | 0.9373 | 0.998 | 0.008 | 1.095 | 0.0173 | 0.914 |
| Inactive LDS | 0.0812 | 1.004 | 0.1148 | 1.005 | 0.2864 | 1.003 |
| Mother: number of children | 0.0012 | 0.994 | 0.0839 | 0.996 | 0.0025 | 0.992 |
| Mother: number of children dead | <.0001 | 1.016 | 0.0022 | 1.012 | <.0001 | 1.021 |
| Number of Children | 0.175 | 0.997 | 0.0004 | 0.991 | <.0001 | 1.017 |
| Age at first birth | <.0001 | 0.995 | 0.0017 | 0.995 | 0.4066 | 1.002 |
| Age at last birth | <.0001 | 0.996 | 0.0191 | 0.997 | <.0001 | 0.991 |
| Missing afb | <.0001 | 1.663 | 0.0007 | 1.609 | <.0001 | 1.706 |
| Missing alb | <.0001 | 0.682 | 0.0119 | 0.702 | 0.0111 | 0.706 |
| Mother: age at death | <.0001 | 0.993 | <.0001 | 0.993 | <.0001 | 0.993 |
| Father: age at death | <.0001 | 0.992 | <.0001 | 0.991 | <.0001 | 0.994 |
| Paternal Age | | | | | | |
| 15-24 | 0.0117 | 1.037 | 0.0057 | 1.056 | 0.4372 | 1.016 |
| 25-34 | 0.6784 | 0.995 | 0.6695 | 0.993 | 0.6635 | 0.993 |
| 45-54 | 0.179 | 1.024 | 0.3783 | 1.022 | 0.4347 | 1.021 |
| 55-64 | 0.3584 | 1.043 | 0.9876 | 1.001 | 0.116 | 1.105 |
| 65+ | 0.0016 | 1.597 | 0.0552 | 1.421 | 0.0197 | 1.799 |

| Paternal Age Category | N |
|---|---|
| 15-24 | 7,125 |
| 25-34 | 35,548 |
| 35-44 | 26,363 |
| 45-54 | 8,751 |
| 55-64 | 678 |
| 65+ | 45 |

**Table 4.** **Proportional Hazards for Maximum Maternal Age**

| Variable | Both Genders | | Males | | Females | |
|---|---|---|---|---|---|---|
| | p-value | HR | p-value | HR | p-value | HR |
| Birth year | <.0001 | 0.993 | <.0001 | 0.994 | <.0001 | 0.991 |
| Male | <.0001 | 1.429 | . | . | . | . |
| Birth order | 0.0069 | 1.004 | 0.0463 | 1.004 | 0.0609 | 1.004 |
| Active LDS | <.0001 | 0.765 | <.0001 | 0.745 | <.0001 | 0.784 |
| Inactive LDS | 0.9422 | 0.998 | 0.0083 | 1.095 | 0.0182 | 0.915 |
| Mother: number of children | 0.2233 | 0.998 | 0.3652 | 1.002 | 0.0039 | 0.992 |
| Mother: number of children dead | <.0001 | 1.014 | 0.0568 | 1.008 | <.0001 | 1.021 |
| Number of Children | 0.1777 | 0.997 | 0.0004 | 0.991 | <.0001 | 1.017 |
| Age at first birth | <.0001 | 0.995 | 0.0017 | 0.995 | 0.4172 | 1.002 |
| Age at last birth | <.0001 | 0.996 | 0.0185 | 0.997 | <.0001 | 0.991 |
| Missing afb | 0.0001 | 0.683 | 0.0134 | 0.706 | 0.011 | 0.706 |
| Missing alb | <.0001 | 1.66 | 0.0008 | 1.6 | <.0001 | 1.707 |
| Mother: age at death | <.0001 | 0.993 | <.0001 | 0.993 | <.0001 | 0.993 |
| Father: age at death | <.0001 | 0.992 | <.0001 | 0.991 | <.0001 | 0.994 |
| Maximum maternal age | 0.0038 | 0.997 | <.0001 | 0.994 | 0.7155 | 1.001 |

**Table 5.** **Proportional Hazards for Maximum Maternal Age by Age Category**

| Variable | Both Genders | | Males | | Females | |
|---|---|---|---|---|---|---|
| | p-value | HR | p-value | HR | p-value | HR |
| Birth year | <.0001 | 0.993 | <.0001 | 0.994 | <.0001 | 0.991 |
| Male | <.0001 | 1.429 | . | . | . | . |
| Birth order | 0.0074 | 1.004 | 0.0505 | 1.004 | 0.0609 | 1.004 |
| Active LDS | <.0001 | 0.765 | <.0001 | 0.745 | <.0001 | 0.784 |
| Inactive LDS | 0.9273 | 0.998 | 0.0088 | 1.094 | 0.0182 | 0.915 |
| Mother: number of children | 0.1701 | 0.997 | 0.4684 | 1.002 | 0.0038 | 0.992 |
| Mother: number of children dead | <.0001 | 1.014 | 0.0455 | 1.008 | <.0001 | 1.021 |
| Number of Children | 0.1741 | 0.997 | 0.0004 | 0.991 | <.0001 | 1.017 |
| Age at first birth | <.0001 | 0.995 | 0.0017 | 0.995 | 0.4227 | 1.002 |
| Age at last birth | <.0001 | 0.996 | 0.0183 | 0.997 | <.0001 | 0.991 |
| Missing afb | 0.0001 | 0.684 | 0.0136 | 0.706 | 0.011 | 0.706 |
| Missing alb | <.0001 | 1.658 | 0.0008 | 1.598 | <.0001 | 1.707 |
| Mother: age at death | <.0001 | 0.993 | <.0001 | 0.993 | <.0001 | 0.993 |
| Father: age at death | <.0001 | 0.992 | <.0001 | 0.991 | <.0001 | 0.994 |
| Max Maternal Age Category | | | | | | |
| <30 | 0.0489 | 1.051 | 0.002 | 1.113 | 0.5749 | 0.98 |
| 30-37 | 0.7757 | 1.004 | 0.5109 | 1.012 | 0.8128 | 0.996 |
| 43-45 | 0.1991 | 0.987 | 0.0781 | 0.975 | 0.9244 | 1.001 |
| 46+ | 0.0184 | 0.972 | 0.0024 | 0.952 | 0.8819 | 0.997 |

| Max Maternal Age Category | N |
|---|---|
| <30 | 2,893 |
| 30-37 | 13,600 |
| 38-42 | 24,259 |
| 43-45 | 22,274 |
| 46+ | 14,076 |