

Marital, Reproductive, and Educational Behaviors Covary with Life Expectancy

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Abstract Theories of “life history evolution” suggest that individuals might adjust the timing of marriage and reproduction, as well as their propensity to terminate a marriage or pregnancy and invest in skill development, in response to indicators of the locally prevailing level of life expectancy. In particular, such theories generate the hypothesis that foreshortened time horizons lead to hastened reproduction and marriage whereas lengthier time horizons increase the likelihood of reproductive and marital termination and lead to greater investment in education. Here, I show that the scheduling and occurrence of marital and reproductive behavior (including both initiation and termination), as well as levels of educational attainment and investment, covary with life expectancy, even after controlling for the effects of affluence. In analyses of variation in marital, reproductive, and educational behaviors at two jurisdictional levels in Canada, life expectancy was positively correlated with patterns of age-specific fertility, age at first marriage, divorce, abortion, conferral of high school and higher education degrees (with the exception of the trades) and mean number of years of schooling. The large and highly consistent relationships observed between life expectancy and the behaviors under investigation suggest that these associations may be mediated by individual “perceptions” of life expectancy, though more research is needed before conclusions can be firmly reached.

Keywords Life expectancy · Reproduction · Marriage · Divorce · Abortion · Education

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Introduction

There is considerable variation in the timing of human reproductive behavior. Across nations, for instance, teen pregnancy rates vary from under 4 to over 160 births per 1,000 women aged 15–19 (United Nations Department of Economic and Social Affairs, 2009). Populational variation furthermore exists in the timing of marriage, which typically precedes pregnancy (United Nations Department of Economic and Social Affairs, 2004), and in the base occurrence of other events germane to family composition, such as divorce and abortion. Identifying the interrelationships among these variables is a key challenge to psychologists wishing to understand the development and organization of family structures: Why do some individuals marry and reproduce earlier than others and why are some more likely to terminate their marriages or pregnancies than others?

An answer to this problem may lie in the framework developed by evolutionary biologists known as *life history theory* (Roff, 1992; Stearns, 1992). Animals vary widely in the developmental timing of sexual maturity, relative to species-specific lifespan: some species mature rapidly and reproduce at very early ages whereas others (like ourselves) mature at a much slower pace and reproduce only after several years. Life history theory posits that such aspects of a species’ “life history” are designed by natural selection in part to maximize reproductive success or *fitness* in the face of threats to survival. Individuals can, for instance, affect their investment in their offspring’s development by redistributing resources to individual offspring (e.g., via adjustments to gestation length, postnatal care, the interval between births, or the number of offspring produced). In large part, the function of such investment is to build somatic “capital”—attributes such as health, physical prowess, skills, and knowledge—that can be translated into future reproductive gains (Hill & Kaplan, 1999). Capital accrual takes time, however, and thus trades off against current reproduction. Consequently, time constraints,

such as a foreshortened lifespan, can reduce the utility of investments that provide benefits in the long term at the expense of more immediate gains. That is, the benefits of long-term investment may never be realized under conditions of high mortality risk.

The point at which a species balances the trade-off between current and future reproduction will thus depend on the likelihood of dying before completing reproduction. As mortality risk increases, future reproductive opportunities are curtailed; consequently, individuals that begin reproduction later in life will risk producing too few offspring relative to those beginning reproduction earlier, favoring the evolution of hastened sexual maturity. Conversely, as mortality risk decreases, future reproductive opportunities improve. Given that individuals beginning reproduction later in life will tend to invest more resources per offspring—producing healthier, more competitive offspring in the process—than those beginning reproduction earlier (e.g., Clutton-Brock, 1984; Creighton, Heflin, & Belk, 2009; Lock, Smiseth, Moore, & Moore, 2007; Williams, 1966), natural selection might favor delayed reproduction under conditions of low mortality risk.

Studies of nonhuman animals confirm the expected association between mortality risk and reproductive behavior. For instance, a seminal study of 48 mammalian species found mortality risk to be negatively correlated with age at sexual maturity, gestation length, and the length of the interval between litters, while it is positively correlated with the number of offspring per litter (Promislow & Harvey, 1990). Moreover, chimpanzees, our closest genetic relatives, have shorter expected lifespans and likewise begin reproducing at relatively earlier ages than do humans (Hill & Kaplan, 1999).

Mortality risk is expected to influence reproductive decision-making not only between species, but within them as well. The risk of death is neither constant across environments nor over time and so individuals can be expected to make use of cues of probable future survival and reproductive opportunities to inform reproductive decisions. Hence, theory predicts adaptive flexibility in the development of life history traits, such as the timing of reproduction, in response to cues of expected reproductive lifespan or other time horizons. This sort of “phenotypic plasticity” is a means by which organisms can develop traits or behaviors in response to locally varying conditions (such as mortality risk) and thus be better able to maximize fitness. In other species, there is indeed evidence of such phenotypic plasticity (e.g., Charmantier et al., 2008), as well as evidence that natural selection acts on it (Nussey, Postma, Glenapp, & Visser, 2005). Consistent with these findings, research has shown that variation in human reproductive scheduling can be predicted by indices of time constraints. As the number of future offspring a woman is expected to produce (her “residual reproductive value”) diminishes with age, beginning after the period of sexual maturity, she has a decreasing incentive to value future over current reproduction. Provided with cues, then, to a foreshortened reproductive lifespan, women are hypothesized to hasten reproduction and

to increasingly value current pregnancies and extant young. As predicted, age of menarche is positively associated with life expectancy (Chisholm, Quinlivan, Petersen, & Coall, 2005; Thomas, Renaud, Benefice, de Meeus, & Guegan, 2001), as is age of reproduction (Low, Hazel, Parker, & Welch, 2008; Nettle, 2011; Wilson & Daly, 1997), and abortion and infanticide risk decline over the years following puberty (Daly & Wilson, 1984; Hill & Low, 1992; Tullberg & Lummaa, 2001).¹

The logic of time constraints extends beyond reproductive scheduling and termination decisions to other decisions affecting family structure. Marriage, a culturally ubiquitous phenomenon, serves as the central locus of human reproduction (Wilson & Daly, 1992). Thus, marital decisions should follow similar patterns to reproductive scheduling and termination: as time horizons draw increasingly near, single individuals should become more motivated to marry and married individuals should become less motivated to divorce, all else being equal. As age and age at marriage are reliably negatively correlated with the risk of divorce (Martin & Bumpass, 1989; Pettit & Bloom, 1984), there is some support for this hypothesis.

Finally, gains from investment in long-term capital acquisition require that time constraints be somewhat relaxed. Human development towards sexual maturity is slower than expected (Hill & Kaplan, 1999; Worthman, 1998) and this extended period of childhood may have evolved so that individuals can acquire skills and other aspects of capital that can be translated into reproductive opportunities (Hill & Kaplan, 1999). To the degree that capital acquisition relies on psychological mechanisms designed to gather information from adult and peer models, modern educational institutions may exploit these mechanisms, despite differing from ancestral forms of education in many respects. Indeed, educational attainment is correlated with financial status (Card, 1999) and resource accrual would have served as a good proxy for expected fitness in ancestral environments. Given the tradeoff between capital acquisition and current reproduction, the motivational systems underlying personal investment in education may be sensitive to cues of mortality risk in ways favorable to reproductive scheduling decisions. Thus, individuals are hypothesized to reduce investment in education in relation to expected age at death, in order to expedite reproduction.

Here, I use aggregate data from various Canadian jurisdictions (analyses among the 10 provinces and the 139 health regions) to examine hypothesized associations between marital, reproductive, and educational decision-making and an index of future survival and reproductive opportunities, namely life expectancy at birth, which can be construed as an indicator of an individual's moment-to-moment likelihood of dying. The overarching hypothesis of the study is that cues of life expectancy shape human physiological and psychological systems designed to affect the

¹ There remains some debate as to the relationship between age and abortion rate in the years leading up to menopause: compare Hill and Low (1992) and Tullberg and Lummaa (2001).

reproductive behavior of individuals, in order to maximize fitness in variable environments. Specifically, I predict that life expectancy will be positively associated with: (1) age of reproduction; (2) age at first marriage; (3) abortion rate; (4) divorce rate; and (5) educational attainment and investment.

Method

Data Source

Data were acquired from Statistics Canada. Data for the provincial analyses were collected from the 10 Canadian provinces for all years available between 2000 and 2006 (Table 1). Where relevant, age-specific rates were partitioned into age bins. Data for the health region analyses were collected from the 139 health regions across the provinces in 1996 (Table 2). Health regions are geographic areas defined by the various provincial ministries of health in Canada and represent the areas of service responsibility for the local hospital boards or regional health authorities.

Statistical Methods

Arguably, affluence might underlie any relationship between life expectancy and the life history traits under investigation, as these traits—and life expectancy itself—may be affected by resource

availability. Thus, all analyses used partial correlations to control for income at the relevant jurisdictional level.

As life expectancy is predicted to be positively associated with reproductive and marital scheduling decisions, correlations were computed between (1) the partial correlation (holding income constant) of life expectancy and age-specific fertility or first marriage rate and (2) age. Thus, the statistics reported regarding these scheduling decisions were correlations between a continuous variable (age) and a partial correlation (life expectancy and age-specific fertility, controlling for income; life expectancy and first marriage rate, controlling for income). The hypotheses regarding the scheduling of fertility and marriage predict the partial correlations between these variables and life expectancy to be negative at the earliest ages and to grow increasingly positive at later ages, because individuals with longer life expectancies are hypothesized to begin reproduction later than individuals with shorter life expectancies.

Moreover, as life expectancy is predicted to be positively associated with divorce, abortion, and educational attainment and investment, irrespective of age, partial correlations (holding income constant) were computed between (1) life expectancy and (2) divorce rate, abortion rate, and rates of educational attainment and investment. Thus, the statistics reported regarding these (not age-dependent) decisions were partial correlations between life expectancy and a second continuous variable (divorce rate, abortion rate, and rates of educational attainment and investment), each

Table 1 Variable information for provincial analyses

Variable	Measure	Years
Life expectancy	Number of years an individual can expect to live, starting from birth, based on sex- and age-specific mortality rates	2000–2006
Age-specific fertility rate	Number of live births/1,000 same-aged women	2000–2006
Age-specific first marriage rate ^a	Number of first marriages/1,000 same-aged, same-sex individuals	2000–2004
Divorce rate	Number of divorces/1,000 same-sex individuals	2004–2005
Abortion rate ^{b,c}	Number of abortions/1,000 same-aged females	2000–2006
Educational attainment ^d	Proportion of individuals ≥ 35 years of age having attained specified level of schooling	2001
Income	Median household income	2006

^a For Ontario, data span the years 2000–2002

^b Excludes Prince Edward Island and New Brunswick for unreliable or unavailable data

^c Age-specific rates for females under 15 and over 40 years of age are unavailable for Newfoundland in 2004 and Nova Scotia in 2005 and 2006

^d Educational attainment levels comprise: no degree at the high school level or above, high school degree, certificate or diploma in the trades, college certificate or diploma, university certificate or diploma below a Bachelor's degree, Bachelor's degree, university certificate or diploma above a Bachelor's degree, medical degree, Master's degree, and earned Doctorate of Philosophy

Table 2 Variable information for health region analyses

Variable	Measure
Life expectancy	See Table 1
High school graduates	Proportion of individuals aged 25–29 that are high school graduates
Post-secondary graduates	Proportion of individuals aged 25–54 that are post-secondary graduates
Years of schooling	Mean number of years of schooling for individuals aged 25–54
Income	Annual personal income for individuals aged ≥ 15 years (1995 dollars)

controlling for income. All hypotheses tested were directional, so all p -values reported were one-tailed.

Results

Provincial Analyses

Life expectancy was positively correlated with median household income ($r = .64, p = .024$). The partial correlation between life expectancy and age-specific fertility rate was positively correlated with age ($r = .97, p < .001$) (Fig. 1). Likewise, the partial correlation between life expectancy and age-specific first marriage rate was positively correlated with age for both men ($r = .78, p = .019$) and women ($r = .88, p = .005$) (Fig. 2). The partial correlation between life expectancy and divorce rate was significantly positive for men ($r_p = .59, p = .046$) and marginally so for women ($r_p = .58, p = .052$). Moreover, the partial correlation between life expectancy and abortion rate was significantly positive ($r_p = .73, p = .032$). Finally, the partial correlation between life expectancy and educational attainment was positive for every degree level (range $r_p = .46$ – $.75$, range $p = .107$ – $.020$), with the exception of a degree in the trades ($r_p = -.57, p = .053$). Predictably, there was a strong negative partial correlation between life expectancy and the lack of a degree at the high school level or above ($r_p = -.93, p < .001$).

Health Region Analyses

Relevant data regarding educational attainment and investment also exist at the level of the health regions. Across health regions, the partial correlation between life expectancy and the proportion of high school graduates was significantly positive ($r_p = .34, p < .001$), as was the partial correlation between life expectancy and the proportion of post-secondary graduates ($r_p = .23, p = .004$). Likewise, the partial correlation between life expectancy

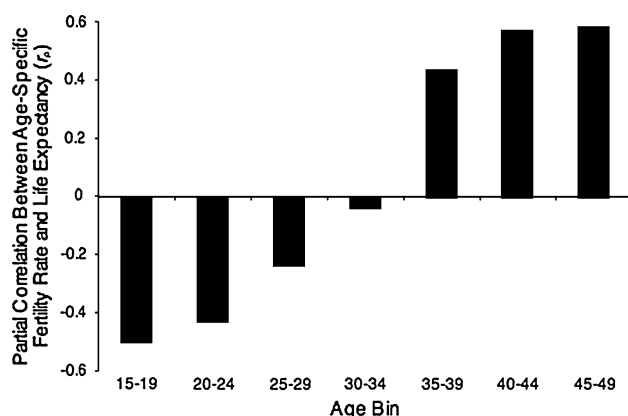


Fig. 1 Partial correlation between age-specific fertility rate and life expectancy as a function of age

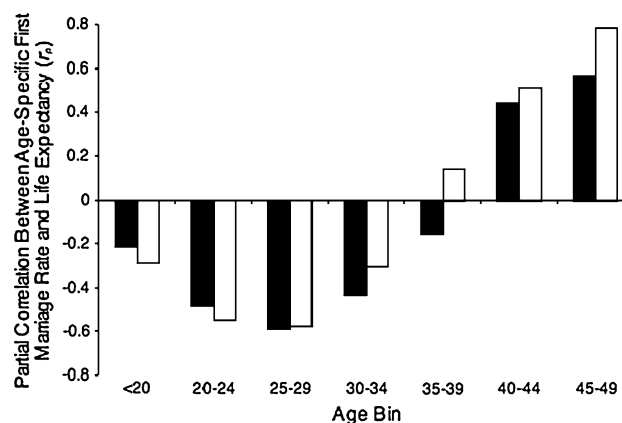


Fig. 2 Partial correlation between age-specific first marriage rate and life expectancy as a function of age, among men (filled bars) and women (open bars)

and number of years of schooling was significantly positive ($r_p = .34, p < .001$).

Discussion

Natural selection is hypothesized to have designed organismal development to be sensitive to information about constraints on future survival and reproduction. In support of this hypothesis, the findings of the current study demonstrated that life expectancy—a putative index of individual “perceptions” of time constraints—was positively associated with a number of traits that affect family structure: timing of reproduction and marriage, propensity to terminate a pregnancy or a marriage, and investment in education. Specifically, an increase in life expectancy at birth was associated with an increase in the ages of reproduction and first marriage, as well as increases in the rates of abortion, divorce, and measures of educational attainment (degree achieved, proportion of high school and post-secondary graduates) and years spent in school.

Despite low statistical power at the provincial level, the majority of the results were statistically significant and the pattern among them was highly consistent: 18 of 19 tests were in the expected direction, which is itself significantly different from the chance value of 9.5 tests in the expected direction ($t_{18} = 8.50, p < .001$, two-tailed). The sole inconsistency was the negative association between life expectancy and the proportion of individuals having attained a degree in the trades. This result, however, was not surprising, as schooling in the trades is a more immediate path to securing employment, typically of lower income (Boothby & Drewes, 2006), than degrees in other areas of post-secondary education.

Affluence likely influences a number of the life history traits studied here (Bulled & Sosis, 2010), as it likely influences life expectancy. Nonetheless, the analyses herein controlled for median household income (provincial analyses) and annual

personal income (health region analyses), so the effects shown in the current study should be understood as independent of resource availability. In any case, epidemiological analysis cannot unequivocally demonstrate that variation in life expectancy *causes* a shift in marital, reproductive, or educational decision-making. Still, the consistent, and at times spectacularly large, effects reported here converge with other findings. For instance, in comparisons across nation-states, Bulled and Sosis (2010) found that life expectancy was positively associated with educational investment and negatively associated with adolescent birth rates. Similarly, Nettle (2011) found that age at first birth increased with female life expectancy in a comparison of English neighborhoods.

This suggests that perceptions of life expectancy are important to human decision-making processes. Accordingly, future research should attempt to describe the psychological mechanisms involved in the perception of and response to life expectancy cues (Chisholm, 1993; Geronimus, Bound, & Waidmann, 1999; Hill, Ross, & Low, 1997; Nettle, 2011; Quinlan, 2010) and, further, find methods to manipulate such perceptions to determine whether a causal relationship exists between life expectancy and reproductive decision-making.

Humans might use any number of cues to infer poor prospects for longevity. For instance, individuals might assess their own health (Geronimus, 1996; Geronimus et al., 1999), the predictability of resource availability (Hill et al., 1997), or the continuing survival of relatives and other conspecifics. Moreover, exposure to stressful or otherwise threatening events (particularly chronically occurring ones) is likely to affect perceptions of life expectancy: a rather large literature on “mortality salience” manipulations demonstrates that humans are sensitive to death-related thoughts (reviewed in Burke, Martens, & Faucher, 2010), and attitudes towards reproduction vary as a consequence of manipulations of life expectancy (Dunkel, Mathes, & Decker, 2009; Mathews & Sear, 2008). Further experimental studies of the effects of life expectancy on reproductive decision-making, including more visceral manipulations (e.g., the priming of fear), might yield interesting results.

In the human case, it is tempting to suggest that conscious evaluations of life expectancy play a role in reproductive decision-making. However, numerous species that are not likely to be endowed with consciousness, such as wasps (Roitberg, Sircom, Roitberg, van Alphen, & Mangel, 1993) and scorpionflies (Engqvist & Sauer, 2002), are also capable of making reproductive decisions based on cues of foreshortened time horizons. Thus, conscious input is not required for an understanding of the putative effects of life expectancy cues on human reproductive decision-making. That humans can consciously articulate their expected time horizons and cite these as reasons for hastening or delaying reproduction (e.g., Geronimus, 1996; Hill et al., 1997) is not sufficient evidence that they actually make use of these expectations to inform their reproductive decisions. Rather, conscious rationalizations of the relevance of life expectancy to reproduction may follow post

hoc from unconscious decision-making processes, as it does in many other domains (Wegner, 2002; Wilson, 2002).

Similarly, contraceptive use is also not required to explain variation in reproductive behavior, though it may nonetheless play an important part. Ancestral humans would not have had access to contraceptives *per se* but could have used a variety of imperfect, yet effective, “family planning” methods, including prolonged breast-feeding of extant offspring to induce and maintain lactational amenorrhea (Short, 1994). Moreover, effects of putative life expectancy cues on the timing of sexual maturation and interest in sexual activity (e.g., Chisholm et al., 2005; Ellis, Shirtcliff, Boyce, Deardorff, & Essex, 2011; Thomas et al., 2001) could have played a fundamental role in reproductive scheduling in the past and could continue to do so today.

Should the associations between perceived life expectancy and reproductive timing decisions prove causal, they may help to explain the demographic transition from pre- to post-industrialization in fertility, age of reproduction, and age of marriage (e.g., Hill & Kaplan, 1999; Low, Simon, & Anderson, 2002), among other aspects seemingly unique to modern, industrialized societies, such as their lower rates of violent conflict (Eisner, 2001; Keeley, 1996; Wilson & Daly, 1997). Research is needed to investigate such claims further.

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