Journals of Gerontology: Biological Sciences
cite as: *J Gerontol A Biol Sci Med Sci*, 2016, Vol. 00, No. 00, 1–6
doi:10.1093/gerona/glw158
Advance Access publication August 12, 2016

Original Article

The Relationship of Fertility, Lifestyle, and Longevity Among Women

Peggy A. Lockhart,[1] Peter Martin,[1] Mary Ann Johnson,[2] Elizabeth Shirtcliff,[1] and Leonard W. Poon[2]

[1]Department of Human Development and Family Studies, Iowa State University, Ames. [2]Department of Gerontology, University of Georgia, Athens.

Correspondence should be addressed to Peggy A. Lockhart, MS, Department of Human Development and Family Studies, Iowa State University, 4380 Palmer Building 2330, Ames, IA 50011. E-mail: peglock@iastate.edu

Received December 29, 2015; Accepted July 23, 2016

Decision Editor: Rafael de Cabo, PhD

Abstract

Longevity in women has been found to be associated with several reproductive factors; the age of women when they give birth, their total number of children, and the age at which they experience menopause. In the context of expectations from the evolutionary theory of aging, the focus of this study examined relationships between lifetime reproduction, age at menopause and longevity, while accounting for various lifestyle factors. The purpose of this study was to assess fertility and age at onset of menopause in 197 women of the Georgia Centenarian Study. It was hypothesized that greater lifetime reproduction would predict earlier menopause and subsequently an earlier death. An independent *t* test was computed to assess ethnic differences between Caucasian and African American participants. Two block-wise multiple regression analyses were computed to evaluate the impact of low socioeconomic status in childhood, the age at the time of the first childbirth, the total number of children, smoking and alcohol use, incidence of heart disease and stroke, and the age at onset of menopause on longevity. Results from this study suggest a positive association between the total number of children to the age at onset of menopause and longevity. However, when considering the lifestyle factor of smoking, the association of the total number of children to longevity is diminished.

Keywords: Menopause—Parity—Reproduction—Centenarian

Longevity in women has been found to be associated with several reproductive factors; the age of women when they give birth (1), the total number of children they have (2), and the age at which they experience menopause (3). The trade-off between an increase in life span and fertility may be explained by evolutionary theories of aging (4,5). This trade-off referred to by researchers has also been called the "biological warranty period" or "longevity determination" (6). The concept of antagonistic pleiotropy introduces the idea that there is an early-life genetic reproductive benefit for humans, which comes at a deleterious effect later on in life (7).

The disposable soma theory proposes a trade-off for humans between fecundity and longevity, in that those women who have a large number of children are more likely to have shorter life spans (8,9). This theory suggests that there is a limited amount of time the human body can devote to reproduction and going over that allotted time will result in an accumulation of cellular damage and decreased life span. However, the error propagation theory of aging proposes that the damage is a byproduct of physiological processes that promote reproduction at younger ages. This cell damage eventually reaches a threshold at older ages above which leads to intrinsic mortality by disrupting normal physiological processes (10).

Although there has been an abundance of past data trying to link longevity and reduced fertility, the results have been mixed. Gavrilova and colleagues (11) completed a validation study on research by Westendorp and Kirkwood (12) who had proposed a negative association between reproduction and longevity. They found that the Westendorp study was based on an incomplete data set. Gavrilov and Gavrilova (13) discussed these findings again in 2005. However, in 2011, Tabatabaie and colleagues (14) assessed a group of Ashkenazi Jewish centenarians who were reproductive in the 1920s, and the results suggested that a lower number of children and delayed reproductive maturity increased longevity at the expense of fertility.

In the context of expectations from the evolutionary theory of aging, the focus of this study examined relationships between lifetime reproduction, age at menopause and longevity, while accounting for various lifestyle factors. It was hypothesized that greater lifetime reproduction would predict earlier menopause and subsequently an earlier death.

Methods

Participants

Participants for this study were participants in Phase 1 of the Georgia Centenarian Study which began in 1988. It included 321 community-dwelling older adults (38 male and 53 female sexagenarians, 31 male and 62 female octogenarians, and 35 male and 102 female centenarians). The centenarian cohort included participants born between 1881 and 1895, the octogenarian cohort was born between 1900 and 1910, and the sexagenarian cohort was born between 1919 and 1929. To test for selection effects, bivariate correlations were computed and yielded negative correlations between birth year and longevity of $r = -.35$, $p < .001$ for centenarians, $r = -.39$, $p < .01$ for octogenarians, and $r = -.23$, $p > .05$ for sexagenarians, indicating that for the older two age groups, later-born birth cohorts had less favorable longevity.

As shown in Table 1, this study included women ($N = 197$) and all of the participants of this study are now deceased. Of those women, 74.6% were Caucasian, 25.4% were African American and ranged in age from 60 to 106 years.

The centenarians were interviewed on a one-to-one basis in their homes. The others were interviewed at central locations around the state of Georgia; schools, churches, and senior centers.

All study participants were cognitively intact as assessed by the Mini-Mental Status Examination (15) and the Global Deterioration Scale (16).

Table 1. Descriptive Information

	N	*M*	*SD*	Frequency	Percent
Low socioeconomic status in childhood	197	0.26	0.44		
Age at first pregnancy	158	24.09	5.00		
Total number of children	193	2.41	2.87		
Age at menopause	147	47.52	7.04		
Age at death	197	96.61	10.41		
Ethnicity	197				
White = 1				147	74.6
African American = 2				50	25.4
Incidence of heart disease	195				
No = 0				131	67.2
Yes = 1				64	32.8
Incidence of stroke	195				
No = 0				189	96.9
Yes = 1				6	3.1
Did you ever smoke or smoke now?	175				
No = 0				127	72.6
Yes = 1				48	27.4
Do you try to avoid alcohol usage?	177				
Try a lot = 0				28	15.8
Try a little = 1				134	75.7
Don't try at all = 3				15	8.5

Measures

Health of the participants was addressed by self-report and health examination protocol. Self-reported health was measured by the Older Americans Resources and Services (OARS) self-rating of physical health (17). Other variables included in this study were ethnicity, low socioeconomic status in childhood, age of the participant at the time of her first pregnancy, participant's age at onset of menopause, and their age at death.

Using the PERI-Life Events scale (18), variables analyzed in this study included the participant's age at the onset of menopause and the participant's age at their first childbirth. Socioeconomic status in childhood was assessed by asking whether participants' socioeconomic conditions during childhood were "poor," "average," or "wealthy." The participants' age at death was obtained using family reports and the Social Security Death Index. The use of cigarettes was assessed by asking study participants if they smoked and if they did not, had they ever smoked. Alcohol use was assessed using a health-seeking behavior questionnaire (19) during the physical assessment. The question was "Do you try to avoid the use of alcohol?" The answers were "don't try at all," "try a little," or "try a lot." Each participant answered yes or no to the question, "Do you currently have, or have you ever experienced a stroke?" The same was asked of heart disease, and both questions were asked during a health assessment done by a physician or nurse practitioner.

Data Analysis

An independent *t* test was computed to determine any ethnic differences in this group of women. A blocked multiple regression analysis was used to develop a model for predicting participant's age at onset of menopause using ethnicity (Block 1), low socioeconomic status in childhood (Block 2), total number of children, age at first birth (Block 3), and alcohol and smoking use (Block 4).

An additional blocked multiple regression analysis was computed to test the impact of ethnicity (Block 1), low socioeconomic status in childhood (Block 2), age at the time of their first birth, total number of children (Block 3), smoking and alcohol use (Block 4), age at menopause (Block 5), and incidence of heart disease and stroke (Block 6), on longevity.

Results

Table 1 shows the frequencies of heart disease, smoking, and alcohol use. Seventy-two percent of the participants never smoked (34.4% sexagenarians, 65.5% octogenarians, and 91.8% centenarians). Sixty-seven percent of the participants reported no incidence of heart disease and 97% reported no incidence of stroke. The mean age at onset of menopause was 47.52 years, below the average age of 55 years (20). There were no significant ethnic differences between Caucasians ($M = 96.82$, $SD = 9.81$) and African Americans ($M = 96.00$, $SD = 12.08$) to age at death, $t(197) = .48$, $p = .63$. In the first and second models of the hierarchical multiple regression for menopause (Table 2), ethnicity and low socioeconomic status in childhood did not predict the age at onset of menopause. Adding the total number of children and age at first childbirth to Model 3 and alcohol and smoking to Model 4, only the total number of children was shown to be a significant predictor of menopause ($\beta = .18$, $p < .05$).

Models 1 and 2 of the blocked multiple regression analysis for longevity indicated no significant association of ethnicity or low childhood socioeconomic status with longevity (Table 3). The total number of children was significantly associated with longevity in

Table 2. Predictors of Age at Menopause in Georgia Centenarians

Variables	*B*	*SE* (*B*)	*β*	*t*
Model 1				
Ethnicity	−1.65	1.47	−0.10	−1.12
Model 2				
Ethnicity	−1.32	1.53	−0.08	−0.86
Low childhood socioeconomic status	−1.28	1.51	−0.08	−0.85
Model 3				
Ethnicity	−1.48	1.53	−0.09	−0.97
Low childhood socioeconomic status	−1.23	1.49	−0.07	−0.76
Total number of children	0.64	0.28	0.22	2.31*
Age at first childbirth	0.16	0.14	0.12	1.20
Model 4				
Ethnicity	−1.64	1.55	−0.10	−1.06
Low childhood socioeconomic status	−0.99	1.51	−0.06	−0.66
Total number of children	0.65	0.28	0.22	2.31*
Age at first childbirth	0.16	0.37	0.12	1.19
Smoke now or ever?	−2.24	3.73	−0.05	−0.60
Avoid alcohol usage	−0.73	1.32	−0.05	−0.55

Note: *p < .05.

Table 3. Predictors of Longevity in Georgia Centenarians

Variable	*B*	*SE* (*B*)	*β*	*t*
Block 1				
Ethnicity	−0.82	2.20	−0.03	−0.37
Block 2				
Ethnicity	−0.04	2.28	−0.00	−0.02
Low childhood socioeconomic status	−2.96	2.25	−0.13	−1.32
Block 3				
Ethnicity	−0.00	2.28	0.00	0.00
Low childhood socioeconomic status	−2.68	2.22	−0.11	−1.20
Total number of children	0.82	0.42	0.19	1.97*
Age at first childbirth	0.34	0.20	0.16	1.67
Block 4				
Ethnicity	−0.50	2.05	−0.02	−0.22
Low childhood socioeconomic status	−0.57	2.02	−0.02	−0.28
Total number of children	0.34	0.38	0.08	0.90
Age at first childbirth	0.20	0.18	0.95	1.09
Smoke now or ever	−10.43	1.98	−0.45	−5.28***
Avoid alcohol usage	−2.14	1.74	−0.10	−1.23
Block 5				
Ethnicity	−0.27	2.08	−0.01	−0.13
Low childhood socioeconomic status	−0.53	2.08	−0.02	−0.26
Total number of children	0.29	0.39	0.07	0.74
Age at first childbirth	0.19	0.19	0.09	1.00
Smoke now or ever	−10.30	1.99	−0.44	−5.19***
Avoid alcohol usage	−2.07	1.75	−0.10	−1.41
Age at menopause	0.10	0.12	0.07	0.78
Block 6				
Ethnicity	−0.27	2.08	−0.01	−0.13
Low childhood socioeconomic status	−0.53	2.05	−0.02	−0.26
Total number of children	0.28	0.39	0.06	0.70
Age at first childbirth	0.19	0.19	0.09	1.00
Smoke now or ever	−10.20	1.99	−0.44	−5.12***
Avoid alcohol usage	−2.22	1.75	−0.10	−1.27
Age at menopause	0.09	0.13	0.06	0.72
Presence of cardiac disease	1.90	1.87	0.09	1.01
Presence of stroke	−5.21	5.03	−0.09	−1.04

Note: *p < .05. ***p < .001.

Model 3 ($\beta = .19$, $p = .05$), however, once smoking and alcohol usage were added to the fourth model, the total number of children was no longer significant. Smoking was highly associated with longevity ($\beta = -.41$, $p < .001$) in Model 4 and remained so in Models 5 and 6 ($\beta = -.45$, $p < .001$). As a follow-up analysis, we computed bivariate correlations for smoking and longevity separately by age groups: no significant within-group correlations for sexagenarians, $r(34) = -.06$, $p = .74$, octogenarians, $r(61) = .03$, $p = .83$ or centenarians, $r(102) = -.12$, $p = .22$ were obtained.

Discussion

This study examined the relationship between fertility, menopause, and longevity and how socioeconomic conditions in childhood and lifestyle choices related to the onset of menopause and with longevity. We first assessed possible effects of low socioeconomic status in childhood. Low socioeconomic status in childhood has also been shown to be predictive of mortality in later life. One hypothesis is that those with a lower socioeconomic status at a young age have less access to material resources that maintain or promote health (21). According to life history theory, the environment may affect fertility, such as mortality rates and availability of resources (22). Guralnik, Land, Blazer, Fillenbaum, and Branch (23) found that having a lower socioeconomic status was related to early mortality. Furthermore, early stress from those circumstances may lead to unhealthy behaviors throughout the life span, such as substance abuse (i.e., smoking) which is shown to reduce one's life expectancy. The results of this study suggested that low socioeconomic status in childhood did not affect the age at onset of menopause or longevity of these participants.

It is unclear why we did not find an association between childhood socioeconomic status and mortality. The influence of childhood socioeconomic circumstances could have been underestimated due to a reporting bias. This could occur if participants from lower socioeconomic groups reported unfavorable childhood conditions less accurately than participants from higher social status groups. There may have been numerous factors occurring from early to late adulthood that might have moderated the effect of low socioeconomic status in childhood, which were not addressed in this study.

We then assessed the timing of their first childbirth and the total number of children as they related to the age at onset of menopause and longevity. The first childbirth was not related to their age at onset of menopause or longevity, however, the total number of children was significantly associated to the age at onset of menopause. Furthermore, the total number of children had a positive effect on the longevity of these women prior to controlling for smoking.

Traditionally, a large number of children has an adverse effect on the length of life in women, supporting the cost of reproduction hypothesis which suggests that there is a trade-off of resources for women, between reproduction and longevity (9,24,25). Other research has found that a greater number of children may be linked to a life-prolonging effect because of increased caregiving requirements (26). In addition, this cohort of women may have been having more children with the thought that they would need a caregiver in their old age. A third explanation links the number of births and longevity to the timing of childbirth.

Perls and Fretts (1) compared two similar birth cohorts born in 1896 that were made up of 78 centenarians and 54 non-centenarians. They reported that 19.2% of the centenarians gave birth to children after the age of 40 years, compared with 5.5% of those women who died in their early 70s. They concluded that selection for a long life has the secondary effect of extending the human reproductive period, as evidenced by some women giving birth into their 40s and 50s. They believe that it is not giving birth over 40 years that promotes longevity but rather it is an indicator that their reproductive system is aging slowly. It is the slow rate of aging that may lead to increased longevity. Therefore, a woman giving birth late in life, Perls and Fretts would suggest, has a particularly slow rate of overall aging and would thus be predicted to live a long life.

Although this study did not show a significant relationship with the first childbirth to longevity, this was not unexpected because the last childbirth appears to have the greater link to longevity in women (1,26). The event of last childbirth for these participants was not reported in the PERI-Life Events questionnaire.

Past research has indicated the later in life women give birth, the longer their rate of mortality (12,27). Müller and colleagues (26) agreed with this finding reporting that the age of the last child may be more significant in predicting longevity than the total number of births. This may be due to the decreased frailty found in high parity women, coupled with the caregiver hypothesis which is related to life extension in postmenopausal women.

Data collected from an American frontier population in the 19th and 20th century, which represented one of the largest data sets of natural fertility cohorts, were analyzed for fertility-related outcomes (28). Again, this was an especially useful study in that it was representative of true human female fertility because of the lack of adequate birth control at that time. The results suggested that the more times a woman gave birth in her lifetime, the shorter her life span, which is in agreement with findings from Jacobsen and colleagues (24) and Lawler (9). Interestingly, however, the same study found that the later in life a woman gave birth to her last child, the longer her longevity, which confirms findings from the Müller and colleagues (26) study.

Kopp and Medzhitov (27), along with Westendorp and Kirkwood (12), also demonstrated that delayed reproduction tended to increase life span. Some evolutionary biologists might reason this to be "nature's way" for women to live long enough to care for all of her children. Evolutionary anthropologists would argue there is a trade-off between the mortality risk of late-life childbearing and the benefit of longevity to provide for offspring or grandchildren (28).

The number of children was shown to have a positive effect on the age at which these women experienced menopause. Menopause occurs with the permanent cessation of ovarian function and amenorrhea lasting at least 12 consecutive months (20). Some researchers have gone so far as to refer to menopause as an "adaptive response" in humans, because women have more to gain from being able to care for current offspring rather than continued fertility, thereby increasing the survival risk to subsequent generations (29).

This positive relationship suggests that having more children may delay the onset of menopause, however, it is also possible that a delay in the onset of menopause may have provided more opportunities for having children, so this relationship may not be easily explained. All of these participants had their children before 1960 and the development of the birth control pill, therefore they were most likely having a greater number of children than had they had that option.

A study using a sample of just more than 5,000 Seventh-day Adventist women aged 55 to 100 years (3) found that substantial excess mortality was associated with early age onset of natural menopause. It was suggested that premature natural menopause may be related to higher mortality due to the adverse physiologic processes associated with early menopause (i.e., breast cancer and heart disease). In addition, this study found that women aged 55 and older at the time of menopause had a slightly higher risk of death than those aged 54 and younger.

In a study out of Japan, there was a 21% increased risk of stroke in women who had begun menopause under the age of 44 years, regardless of whether it was natural or induced (30). Other past research studies have also identified the association between the increased risk of cardiovascular disease and early menopause (3,24,31,32). Using a large cohort of 35,000 nurses, there was a significant relationship between early menopause and heart attacks, but only in smokers. On the other hand, Wellons and colleagues (33) did not show a statistical association to early menopause and smoking following an adjustment for family history of cardiovascular disease; however, they noted that may be because family history is a better predictor of heart disease than smoking.

This study tested for null parity by comparing women who had children with those who did not and found no significant differences in age at menopause or length of life span. Rizvanovic and colleagues (34) did not show a statistical importance to null parity and age at menopause, however, several other studies found the age at menopause occurred earlier in those having no children (35,36).

Delayed menopause has been shown to lengthen a woman's life (3), whereas early menopause was found to be related to the premature development of certain diseases such as breast cancer and heart disease. This study did not show a relationship in the presence of heart disease and stroke, regardless of the age at menopause. In addition, the mean age of the onset of menopause of these participants was below the U.S. average of 55 years, yet the participants reported relatively low incidence of heart disease and stroke.

Research has shown that there may be a connection between the exposure to a number of environmental factors and the age at which women go through natural menopause (37,38). Smoking and alcohol abuse have been found to precipitate early onset menopause and, in turn, premature menopause was shown to be a significant predictor for stroke and cardiac heart disease (33). In a longitudinal, multiethnic study of American women, Wellons and colleagues (33) reported that women who started menopause at an early age were two times more likely to have a future stroke or cardiac event, regardless of the reason for the early menopause. In another study, smoking and age of menopause were highly correlated and women began menopause an average of two years earlier when compared with non-smokers (39).

The evolutionary medicine theory rejects the idea that disease rates following menopause naturally increase and that menopause itself is a disease process (40). Evolutionary medicine posits that the occurrence of disease postmenopause is more likely due to lifestyle, especially in modern industrialized societies (40). This is consistent with the findings of this study because smoking was shown to be the strongest link to longevity in women. The number of children was initially significant; however, that relationship was diminished once smoking was considered.

When interpreting these data, a few limitations need to be considered. These data were reported by the recollection of participants, which may introduce retrospective bias in the ages at which birth and menopause occurred. In addition, more of the participants were from the centenarian group. Most previous studies have drawn from different parts of the country, whereas participants in this study were from the Southeast and potentially had cultural uniqueness which may have accounted for a lack of replication in specific variable relationships.

In addition, data for these centenarians and the other shorter lived age groups do not belong to the same birth cohort. Centenarians were born in 1881 to 1895, octogenarians were born in 1900 to 1910, and sexagenarians were born in 1919 to 1929. This study reported a positive association between the total number of births and longevity and due to an historical decline in birthrate over that time period this may have produced a spurious result.

Finally, smoking may have been more accepted in this cohort of participants who were from the early 1900s southern area of the United States, whereas alcohol usage might not have been accepted. Therefore, the incidence of alcohol usage may be underreported. In addition, the questions used in this study about alcohol and smoking were not specific in the timing of occurrence or the amount consumed, and alcohol was only measured as health behavior, not as alcohol intake (e.g., number of drinks per day).

Past literature has found that fertility and menopause may affect longevity (26), however, in this study, behavior was shown to be more influential to the length of life of these participants (i.e., smoking). Although Snowden (3) and Mondul and colleagues (41) reported a link between early menopause and longevity, there was no significant finding between these participants' longevity and their onset of menopause. The onset of menopause is defined as the absence of a menses for at least 1 year, however, some women may experience starting menopause again after that amount of time has passed, therefore specific onset dates may be misinterpreted. Furthermore, menopause was measured as a life event so it is unknown what participants considered as the timing of menopause. In addition, this study obtained all data via recollection which may have led to some misclassification of reported age at onset of menopause.

Longevity researchers have found that genetic, hormonal, psychological, and sociological factors all play a role in human longevity. The reasons for achieving longevity in women are complex. These findings suggest implications for the future of healthy aging in women based on the number of children they conceive and the age at which they give birth. The introduction of "the Pill" in 1960 caused the fertility of women to change forever. Future studies are needed to examine the association of fertility, smoking, and early menopause on longevity in women who manage their fertility with birth control. It is important for women to understand how lifestyle choices may affect the onset of menopause which in turn may affect their life span and how regulating their fertility may be predicting their longevity.

Funding

This project was supported by the National Institutes of Health (RO1-43435-10) and by U.S.D.A. Hatch Project (IOW03716).

References

1. Perls TT, Fretts RC. The evolution of menopause and human life span. *Ann Hum Biol*. 2001;28:237–245.
2. Wang X, Byars SG, Stearns SC. Genetic links between post-reproductive lifespan and family size in Framingham. *Evol Med Public Health*. 2013;2013:241–253. doi:10.1093/emph/eot013
3. Snowdon DA, Kane RL, Beeson WL, et al. Is early natural menopause a biologic marker of health and aging? *Am J Public Health*. 1989;79:709–714. doi:10.2105/AJPH.79.6.709
4. Gavrilov LA, Gavrilova, NS. Evolutionary theories of aging and longevity. *Sci World J*. 2002;2:339–356. doi:10.1100/tsw.2002.96
5. Kuningas M, Altmäe S, Uitterlinden AG, Hofman A, van Duijn CM, Tiemeier H. The relationship between fertility and lifespan in humans. *Age*. 2011;33:615–622. doi:10.1007/s11357-010-9202-4
6. Carnes BA, Olshansky SJ, Grahn D. Biological evidence for limits to the duration of life. *Biogerontology*. 2003;4:31–45.
7. Kirkwood TB, Rose MR. Evolution of senescence: late survival sacrificed for reproduction. *Philos Trans Biol Sci*. 1991;332:15–24.
8. Kirkwood TB. Evolution of ageing. *Nature*. 1977;270:301–304.
9. Lawler DF. Aging as a purposeful biological program. *J Interprof Healthcare*. 2014;1:1–12.
10. Orgel LE. The maintenance of the accuracy of protein synthesis and its relevance to aging. *Proc Natl Acad Sci USA*. 1963;67:517–21.
11. Gavrilova NS, Gavrilov LA, Semyonova VG, Evdokushkina GN. Does exceptional human longevity come with high cost of infertility? Testing the evolutionary theories of aging. *Ann NY Acad Sci*. 2004;1019:513–517.
12. Westendorp RG, Kirkwood TB. Human longevity at the cost of reproductive success. *Nature*. 1998;396:743–746.
13. Gavrilov LA, Gavrilova NS. Human longevity and reproduction: an evolutionary perspective. In: Voland E, Chasiotis A, Schiefenhoevel W, eds. *Grandmotherhood—The Evolutionary Significance of the Second Half of Female Life*. New Brunswick, NJ: Rutgers University Press; 2005. ISBN-10: 0813571413; ISBN-13: 978-0813571416
14. Tabatabaie V, Atzmon G, Rajpathak SN, Freeman R, Barzilai N, Crandall J. Exceptional longevity is associate with decreased reproduction. *Aging*. 2011;12:1202–1205.
15. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *J Psychiatr Res*. 1975;12:189–198.
16. Reisberg B, Ferris SH, de Leon MJ, Crook T. The global deterioration scale for assessment of primary degenerative dementia. *Am J Psy*. 1982;139:1136–1139.
17. Fillenbaum GG. The development, validity, and reliability of the OARS multidimensional functional assessment questionnaire. *J Gerontol*. 1981;36:428–434. doi:10.1093/geronj/36.4.428
18. Dohrenwend BS, Krasnoff L, Askenasy AR, Dohrenwend BP. Exemplification of a method for scaling life events: the Peri Life Events Scale. *J Health Soc Behav*. 1978;19:205–229.
19. Bausell RB. Health-seeking behavior among the elderly. *Gerontologist*. 1986;26:556–559.
20. Greendale GA, Lee NP, Arriola ER. The menopause. *Lancet*. 1999;353:571–580. doi:10.1016/S0140-6736(98)05352-5
21. Schwartz JE, Friedman HS, Tucker JS, Tomlinson-Keasey C, Wingard DL, Criqui MH. Sociodemographic and psychosocial factors in childhood as predictors of adult mortality. *Am J Public Health*. 1995;85:1237–1245.
22. Griskevicius V, Delton AW, Robertson TE, Tybur JM. Environmental contingency in life history strategies: the influence of mortality and socioeconomic status on reproductive timing. *J Pers Soc Psychol*. 2011;100:241–254. doi:10.1037/a0021082
23. Guralnik JM, Land KC, Blazer D, Fillenbaum GG, Branch LG. Educational and active life expectancy among older blacks and whites. *N Engl J Med*. 1993;329:110–116.
24. Jacobsen B, Nilssen S, Huech I, Kvăle G. Does age at natural menopause affect mortality due to ischemic heart disease? *J Clin Epidemiol*. 1997;50:475–479.
25. Kirkwood TB, Austad SN *Nature*. 2000;408:743–746.
26. Müller HG, Chiou JM, Carey JR, Wang JL. Fertility and life span: late children enhance female longevity. *J Gerontol A Biol Sci Soc Sci*. 2002;57:B202–B206. doi:10.1093/gerona/57.5.B202
27. Kopp EB, Medzhitov R. Infection and inflammation in somatic maintenance, growth and longevity. *Evol App*. 2009;2:132–141.
28. Alvarez HP. Grandmother hypothesis and primate life histories. *Am J Phy Anthropol*. 2000;113:435–450.
29. Williams GC, Williams DC. Natural selection of individually harmful social adaptations among sibs with special reference to social insects. *Evolution*. 1957;11:32–39.
30. Rocca WA, Grossardt BR, Miller VM, Shurster LT, Brown RD. Premature menopause or early menopause and risk of ischemic stroke. *Menopause*. 2012;19:272–277.

31. Kannel WB, Hjortland MC, McNamara PM, Gordon T. Menopause and risk of cardiovascular disease: the Framingham study. *Ann Intern Med*. 1976;85:447–452.
32. Ossewaarde ME, Bots ML, Verbeek AL, et al. Age at menopause, cause-specific mortality and total life expectancy. *Epidemiology*. 2005;16:556–562.
33. Wellons M, Ouyang P, Schreiner PJ, Herrington DM, Vaidya D. Early menopause predicts future coronary heart disease and stroke: the Multi-Ethnic Study of Atherosclerosis. *Menopause*. 2012;19:1081–1087. doi:10.1097/gme.0b013e3182517bd0
34. Rizvanovic M, Balic D, Begic Z, Babovic A, Bogadanovic G, Kameric L. Parity and menarche as risk factors of time of menopause occurrence. *Med Arch*. 2013;67:336–338.
35. Gold EB, Bromberger J, Crawford S, Samuels S, Greendale GA. Factors associated with age at natural menopause in multi-ethnic sample of midlife women. *Am J Epidemiol*. 2001;153:865–874.
36. Henderson KD, Berstein L, Henderson B, Kolonel L, Pike MC. *Am J Epidemiol*. 2008;67:1287–1294.
37. Li C, Samsioe G, Borgfeldt C, Lidfeldt J, Agardh CD, Nerbrand C. Menopause-related symptoms: What are the background factors? A prospective population-based cohort study of Swedish women. *Am J Obstet Gynecol*. 2003;189:1646–1653.
38. Stanford JL, Hartge P, Brinton LA, Hoover RN, Brookmeyer R. Factors influencing the age at natural menopause. *J Chronic Dis*. 1987;40:995–1002.
39. Kaufman DW, Slone D, Rosenberg L, Miettinen OS, Shapiro S. Cigarette smoking and age at natural menopause. *Am J Public Health*. 1980;70:420–422.
40. Froehle AW. Postmenopausal health and disease from the perspective of evolutionary medicine. *J Asso Anthro Gertontol*. 2013;34:61–72.
41. Mondul AM, Rodriguez C, Jacobs EJ, Calle EE. Age at natural menopause and cause-specific mortality. *Am J Epidemiol*. 2005;162:1089–1097.