Title

Maternal Age at Childbirth and Parity as Predictors of Longevity Among Women in the United States: The Women's Health Initiative.

Journal

American Journal of Public Health, 107(1)

ISSN

0090-0036

Authors

Shadyab, Aladdin H
Gass, Margery LS
Stefanick, Marcia L
et al.

Publication Date

2017

DOI

10.2105/ajph.2016.303503

Peer reviewed

Maternal Age at Childbirth and Parity as Predictors of Longevity Among Women in the United States: The Women's Health Initiative

Aladdin H. Shadyab, PhD, Margery L. S. Gass, MD, Marcia L. Stefanick, PhD, Molly E. Waring, PhD, Caroline A. Macera, PhD, Linda C. Gallo, PhD, Richard A. Shaffer, PhD, Sonia Jain, PhD, and Andrea Z. LaCroix, PhD

Objectives. To examine associations of maternal age at childbirth and parity with survival to age 90 years (longevity).

Methods. We performed a prospective study among a multiethnic cohort of postmenopausal US women in the Women's Health Initiative recruited from 1993 to 1998 and followed through August 29, 2014. We adjusted associations with longevity for demographic, lifestyle, reproductive, and health-related characteristics.

Results. Among 20 248 women (mean age at baseline, 74.6 years), 10 909 (54%) survived to age 90 years. The odds of longevity were significantly higher in women with later age at first childbirth (adjusted odds ratio = 1.11; 95% confidence interval = 1.02, 1.21 for age 25 years or older vs younger than 25 years; *P* for trend = .04). Among parous women, the relationship between parity and longevity was significant among White but not Black women. White women with 2 to 4 term pregnancies compared with 1 term pregnancy had higher odds of longevity.

Conclusions. Reproductive events were associated with longevity among women. Future studies are needed to determine whether factors such as socioeconomic status explain associations between reproductive events and longevity. (*Am J Public Health.* 2017;107:113–119. doi:10.2105/AJPH.2016.303503)

Throughout the past 4 decades, average maternal age at first childbirth has risen dramatically in the United States, and fertility rates have declined.[1,2] First birth rates among US women aged 35 years and older increased 6-fold during this time and continue to rise.[1] The decision to further one's education and career are some of the reasons for delayed childbearing.[3] Whereas the many obstetric complications associated with older maternal age at childbirth are well-known,[3] the relationship of later childbearing to later health outcomes, including survival to old age, has not been extensively studied.

In an early study comparing 78 female centenarians with 54 women from the same birth cohort, centenarians were 4 times more likely to have had children while in their 40s than women who died at age 73 years.[4] A case–control study among 311 women who achieved longevity (i.e., survival to the top 5th percentile of their birth cohorts) and 151 controls who died at younger ages reported that women who had their last child after age 33 years had twice the odds of longevity than women who had their last child before age 30 years.[5] However, these studies were limited by retrospective designs and small sample sizes of women who achieved longevity, and did not examine age at first childbirth, which may be more important from a public health perspective. There are currently 1.3 million women aged 90 years and older in the United States, and by 2050, it is expected that more than 4 million women will be in this age group.[6] Although lifestyle behaviors have been studied in relation to longevity,[7] reproductive factors, which are unique to women, have received little attention in public health and are of current importance given the growing aging population and evolving trends in fertility and age at first childbirth.

In this prospective study, the large number of women in the Women's Health Initiative (WHI) multiethnic cohort of postmenopausal women who survived to age 90 years provided the opportunity to evaluate associations of maternal age at childbirth and parity with longevity and to determine whether associations varied by race/ethnicity.

METHODS

Details of the WHI study population and design have been described.[8,9] Briefly, a multiethnic cohort of 161 808

ABOUT THE AUTHORS

Aladdin H. Shadyab and Andrea Z. LaCroix are with the Division of Epidemiology, Department of Family Medicine and Public Health, University of California, San Diego School of Medicine, La Jolla. Margery L. S. Gass is with the North American Menopause Society, Emeritus, Cleveland, OH. Marcia L. Stefanick is with the Department of Medicine, Stanford Center for Prevention Research, Stanford University School of Medicine, Stanford, CA. Molly E. Waring is with the departments of Quantitative Health Sciences and Obstetrics and Gynecology, University of Massachusetts Medical School, Worcester. Caroline A. Macera and Richard A. Shaffer are with the Division of Epidemiology, Graduate School of Public Health, San Diego State University, San Diego, CA. Linda C. Gallo is with the Department of Psychology, San Diego State University. Sonia Jain is with the Division of Biostatistics and Bioinformatics, Department of Family Medicine and Public Health, University of California, San Diego School of Medicine.

Correspondence should be sent to Aladdin H. Shadyab, PhD, Division of Epidemiology, Department of Family Medicine and Public Health, University of California, San Diego School of Medicine, 9500 Gilman Drive #0725, La Jolla, CA 92093 (e-mail: ahshadya@ucsd.edu). Reprints can be ordered at http://www.ajph.org by clicking the "Reprints" link.

This article was accepted September 27, 2016.

doi: 10.2105/AJPH.2016.303503

postmenopausal women aged 50 to 79 years was recruited from 40 clinical centers across the United States during 1993 to 1998. Women participated in 1 or more clinical trials (n = 68 133), including 1 of 2 hormone therapy trials, or an observational study (n = 93 676). After the main WHI study ended in 2005, women were invited to continue follow-up through 2010 and then 2015 in 2 extension studies.

The present prospective study was restricted to clinical trial, observational study, and extension study participants born on or before August 29, 1924, who had potential to survive to age 90 years during follow-up ending August 29, 2014 (n = 24 932). We excluded those whose survival status at the end of follow-up was unknown (n = 4518) and those who had missing information on parity (n = 166), leaving 20 248 women for analysis.

Data Collection and Study Variables

Participants reported demographic characteristics, medical history, reproductive history, and lifestyle behaviors at baseline with self-administered questionnaires. We defined parity as the number of term pregnancies (i.e., lasting 6 or more months including live births and stillbirths) and divided it into 4 categories (0, 1, 2–4, or ≥ 5).[10,11] We determined age at first and last childbirth from 2 questions assessing age at first and last term pregnancy with the following response choices: younger than 20, 20 to 24, 25 to 29, 30 to 34, 35 to 39, 40 to 44, or greater than or equal to 45 years. For the analysis, we categorized age at first childbirth as younger than 25, 25 to 29, or greater than or equal to 30 years because of smaller sample sizes of women in the 35 years and older categories. We categorized age at last childbirth as younger than 25, 25 to 29, 30 to 34, or greater than or equal to 35 years. Primiparous women were included in both the age at first childbirth and age at last childbirth variables. We defined hormone therapy use according to self-reported use and participation in the hormone therapy trials. Participants also reported past oral contraceptive use.

We defined age at menarche as age at first menstrual period. We defined age at menopause as age at natural or surgical menopause. We defined age at natural menopause as the age at last menstrual bleeding among those without a self-reported history of hysterectomy or bilateral oophorectomy before the age at last menstrual bleeding. We considered women whose age at natural menopause was greater than 60 years to have experienced menopause at age 60 years. For surgical menopause, we defined age at menopause as age at bilateral oophorectomy among those who reported having had this procedure performed before the age at last menstrual bleeding.

Additional baseline covariates included age, race/ethnicity, education, income, marital status, smoking behavior, alcohol consumption, and self-rated health. Participants self-selected race/ethnicity as American Indian/Alaskan Native, Asian/Pacific Islander, Black/African American, Hispanic/Latina, White, or other. For physical activity, participants reported the duration, frequency, and intensity of walking and other recreational activities; we summarized data as metabolic equivalents per week.[12] Trained clinic staff measured height and weight at baseline. Body mass index was calculated as weight in kilograms divided by height in meters squared and categorized according to standard cutpoints.[13]

Participants self-reported information on major chronic diseases including coronary heart disease, cerebrovascular disease, cancer (excluding nonmelanoma skin cancer), diabetes, and hip fracture at baseline and periodic clinic visits and via mailed questionnaires during follow-up, which were conducted biannually for clinical trial participants through 2005, annually for observational study participants, and then annually by mail for all extension study participants. These diseases were selected because they are important causes of morbidity and mortality in older women. Incident diseases except for diabetes were adjudicated by physician medical record review.[14] We defined diabetes as self-reported physician diagnosis that included treatment with oral glucose-lowering medication or insulin.[15]

We classified women as having survived to age 90 years ("longevity") or died before age 90 years. Although "longevity" may be defined according to more extreme ages, such as 95 or 100 years,[7] there are not enough women in the WHI who reached these advanced ages at this time. Nonetheless, living to age 90 years is past average life expectancy and is considered long-lived for contemporary birth cohorts.[7] Trained physician adjudicators verified deaths by medical records and death certificates. In addition, WHI staff performed periodic linkage to the National Death Index for all participants (including those lost to follow-up) for verification if medical records and death certificates could not be obtained. The latest search at the time of this analysis was updated through December 31, 2011.

Statistical Analysis

Baseline descriptive characteristics according to categories of age at first childbirth, parity, and survival status are presented as frequencies (percentages) for categorical variables and means with SDs for continuous variables. We used the χ^2 test to compare categorical variables according to age at first childbirth, parity, and survival status. We compared normally distributed continuous variables by using analysis of variance or the 2-sample t test, and we compared non-normally distributed variables by using the Kruskal–Wallis test or the Wilcoxon rank-sum test.

We used multivariable logistic regression models to evaluate associations of age at first and last childbirth and parity with longevity. We fit separate models for each reproductive factor, with results presented as odds ratios (ORs) and 95% confidence intervals (CIs). Age-adjusted and fully adjusted models are presented. We adjusted the full models for potential confounders selected from the literature including baseline age, study membership (clinical trial or observational study), race/ethnicity, education, income, marital status, smoking, alcohol, physical activity, body mass index, hormone therapy use, past oral contraceptive use, age at menarche, age at menopause (natural or surgical), self-rated health, and a history of chronic diseases.[5,10,11,16,17] We also adjusted models for age at childbirth for parity.[5] We assessed interactions between reproductive factors and race/ethnicity and income by using likelihood ratio tests. We also tested interactions between age at first and last childbirth and parity. We performed tests for

linear trend for age at first and last childbirth by including these variables as ordinal predictors in the models.

P values were 2-sided and considered nominally statistically significant at values less than .05. Because 23 *P* values are presented for analyses comparing baseline characteristics by age at first childbirth, parity, and survival status, the critical *P* value for these analyses was set at .002 (0.05/23) using Bonferroni correction to adjust for type-I error due to multiple comparisons. Kaplan-Meier survival curves for the main exposures are presented in Figures A through E, available as supplements to the online version of this article at http://www.ajph.org. We performed analyses with SAS version 9.3 (SAS Institute Inc, Cary, NC).

RESULTS

Women were aged on average 74.6 (SD = 2.3; range 69–81) years at baseline and were followed for up to 21 years. Overall, 13% of women were nulliparous, 10% were primiparous, 62% had 2 to 4 term pregnancies, and 15% had 5 or more term pregnancies. Among 15 082 women with information on age at childbirth, 47% were younger than 25 years, 37% were aged 25 to 29 years, 12% were aged 30 to 34 years, 3% were aged 35 to 39 years, and 0.6% were aged 40 years or older at first childbirth. At last childbirth, 8% of women were younger than 25 years, 21% were aged 25 to 29 years, 32% were aged 30 to 34 years, 27% were aged 35 to 39 years, and 12% were aged 40 years or older.

TABLE 1—Baseline Characteristics of Older Women by Parity and Age at First Childbirth: Women's Health Initiative, United States, 1993–1998

	Parity				Age at First Childbirth, Years		
Characteristic	0 (n = 2 711)	1 (n = 1 933)	2–4 (n = 12 555)	≥ 5 (n = 3 049)	< 25 (n = 7 147)	25–29 (n = 5 522)	≥ 30 (n = 2 413)
Age, y	74.8 ±2.3	74.9 ±2.3	74.6 ±2.3	74.3 ±2.3	74.4 ±2.3	74.7 ±2.3	74.9 ±2.3
Race/ethnicity							
White	2 271 (84.1)	1 630 (84.5)	11 366 (90.9)	2 633 (86.5)	6 274 (88.1)	5 097 (92.5)	2 184 (90.7)
Black/African American	291 (10.8)	188 (9.8)	513 (4.1)	206 (6.8)	463 (6.5)	158 (2.9)	91 (3.8)
Hispanic/Latina	46 (1.7)	32 (1.7)	147 (1.2)	91 (3.0)	126 (1.8)	54 (1.0)	31 (1.3)
Other	93 (3.4)	78 (4.1)	474 (3.8)	115 (3.8)	259 (3.6)	202 (3.7)	101 (4.2)
Educational level							
< high school	146 (5.4)	160 (8.4)	774 (6.2)	319 (10.5)	740 (10.4)	182 (3.3)	100 (4.2)
High school	363 (13.5)	315 (16.4)	2 262 (18.1)	604 (19.9)	1 605 (22.6)	758 (13.8)	275 (11.5)
Some college	925 (34.3)	842 (44.0)	5 071 (40.6)	1 217 (40.2)	3 105 (43.8)	2 138 (38.9)	867 (36.1)
College graduate	1 262 (46.8)	599 (31.3)	4 370 (35.0)	889 (29.4)	1 645 (23.2)	2 415 (44.0)	1 159 (48.3)
Yearly household income, $							
< 20 000	688 (28.1)	524 (29.7)	3 099 (26.7)	970 (34.3)	2 275 (34.3)	1 090 (21.3)	489 (21.9)
20 000–49 999	1 237 (50.6)	894 (50.7)	5 844 (50.4)	1 376 (48.6)	3 199 (48.2)	2 699 (52.7)	1 132 (50.8)
≥ 50 000	522 (21.3)	344 (19.5)	2 657 (22.9)	486 (17.2)	1 163 (17.5)	1 333 (26.0)	609 (27.3)
Marital status							
Married or living as married	752 (27.9)	771 (40.1)	6 313 (50.5)	1 495 (49.3)	3 362 (47.3)	2 831 (51.4)	1 228 (51.1)
Widowed	820 (30.5)	831 (43.2)	4 993 (39.9)	1 292 (42.6)	3 048 (42.9)	2 137 (38.8)	903 (37.6)
Divorced or separated	235 (8.7)	297 (15.4)	1 188 (9.5)	242 (8.0)	688 (9.7)	533 (9.7)	260 (10.8)
Never married	886 (32.9)	25 (1.3)	8 (0.1)	4 (0.1)	12 (0.2)	6 (0.1)	13 (0.5)
Smoking behavior							
Never smoked	1 464 (54.9)	987 (52.0)	6 906 (56.1)	1 766 (58.8)	3 880 (55.2)	3 034 (55.9)	1 321 (55.8)
Past smoker	1 072 (40.2)	813 (42.8)	4 940 (40.1)	1 110 (37.0)	2 804 (39.9)	2 210 (40.7)	967 (40.8)
Current smoker	130 (4.9)	98 (5.2)	460 (3.7)	126 (4.2)	342 (4.9)	182 (3.4)	80 (3.4)
Body mass index[a]							
Underweight	57 (2.1)	30 (1.6)	159 (1.3)	38 (1.3)	87 (1.2)	73 (1.3)	24 (1.0)
Normal weight	1 072 (40.1)	748 (39.1)	4 820 (38.7)	958 (31.7)	2 397 (33.8)	2 235 (40.9)	1 032 (43.1)
Overweight	947 (35.4)	693 (36.2)	4 622 (37.1)	1 177 (39.0)	2 729 (38.5)	2 024 (37.0)	841 (35.1)
Obese	597 (22.3)	443 (23.2)	2 845 (22.9)	845 (28.0)	1 873 (26.4)	1 136 (20.8)	499 (20.8)
History of major chronic diseases[b]	1 591 (58.7)	1 136 (58.8)	7 099 (56.5)	1 842 (60.4)	4 233 (59.2)	3 088 (55.9)	1 383 (57.3)

Note. Data are presented as No. (%) or mean ±SD. Data for each variable do not sum to total N for each column because of missing data. All *P* values for comparisons across variables are significant at the Bonferroni-corrected level of significance ($P < .002$).

[a]Underweight defined as < 18.5 kg/m^2, normal weight as 18.5–24.9 kg/m^2, overweight as 25.0–29.9 kg/m^2, and obese as ≥ 30.0 kg/m^2.

[b]Includes baseline self-reported and incident adjudicated diseases (coronary heart disease, stroke, diabetes, cancer, or hip fracture) during follow-up.

At baseline, women with later age at first childbirth were more likely to be college graduates, to be married or living as married, and to have higher income, and were less likely to be obese or to have a history of chronic diseases (Table 1). They were also more likely to be older at menopause and to have had only 1 term pregnancy (Table A, available as a supplement to the online version of this article at http://www.ajph.org). Women with 5 or more term pregnancies were less likely to be college graduates and more likely to be obese, to have lower income, to have never smoked, and to have a history of chronic diseases (Table 1). In addition, they were more likely to have never used hormone therapy, to be younger at first childbirth, and to be older at menopause and last childbirth (Table A).

During follow-up, a total of 10 909 (54%) women survived to age 90 years. Average age at death was 83.7 (SD = 3.8) years, and the most common causes of death were cardiovascular disease, cerebrovascular disease, and cancer. At baseline, women who survived to age 90 years were more likely to be older, to be college graduates, to be married or living as married, and to have higher income, and were less likely to be current smokers, to be obese, or to have a history of chronic diseases (Table 2). In addition, they were more likely to be current drinkers, to be in excellent or very good health, and to be older at menopause (Table B, available as a supplement to the online version of this article at http://www.ajph.org).

TABLE 2—Baseline Characteristics of Older Women in Relation to Survival to Age 90 Years: Women's Health Initiative, United States, 1993–1998

Characteristic	Survived to Age 90 Years (n = 10 909)	Died Before Age 90 Years (n = 9339)
Age, y	75.1 ±2.2	74.1 ±2.3
Race/ethnicity		
White	9677 (89.1)	8223 (88.4)
Black/African American	601 (5.5)	597 (6.4)
Hispanic/Latina	161 (1.5)	155 (1.7)
Other	428 (3.9)	332 (3.6)
Educational level		
< high school	676 (6.2)	723 (7.8)
High school	1829 (16.9)	1715 (18.5)
Some college	4326 (40.0)	3729 (40.2)
College graduate	4020 (37.1)	3100 (33.5)
Yearly household income, $		
< 20 000	2580 (25.7)	2701 (31.4)
20 000–49 999	5052 (50.4)	4299 (49.9)
≥ 50 000	2399 (23.9)	1610 (18.7)
Marital status		
Married or living as married	5221 (48.1)	4110 (44.3)
Widowed	4210 (38.8)	3726 (40.1)
Divorced or separated	943 (8.7)	1019 (11.0)
Never married	489 (4.5)	434 (4.7)
Smoking behavior		
Never smoked	6492 (60.5)	4631 (50.7)
Past smoker	4021 (37.5)	3914 (42.8)
Current smoker	221 (2.1)	593 (6.5)
Body mass index[a]		
Underweight	119 (1.1)	165 (1.8)
Normal weight	4205 (38.9)	3393 (36.7)
Overweight	4173 (38.6)	3266 (35.3)
Obese	2311 (21.4)	2419 (26.2)
History of major chronic diseases[b]	4922 (45.1)	6746 (72.2)

Note. Data are presented as No. (%) or mean ±SD. Data for each variable do not sum to total N for each column because of missing data. All *P* values for comparisons across variables except for race/ethnicity are significant at the Bonferroni-corrected level of significance ($P < .002$).

[a]Underweight defined as < 18.5 kg/m^2, normal weight as 18.5–24.9 kg/m^2, overweight as 25.0–29.9 kg/m^2, and obese as ≥ 30.0 kg/m^2.

[b]Includes baseline self-reported and incident adjudicated diseases (coronary heart disease, stroke, diabetes, cancer, or hip fracture) during follow-up.

In the fully adjusted model, there was a significant linear trend toward higher odds of longevity among women with later age at first childbirth (*P* for trend = .04), with ORs of 1.11 (95% CI = 1.02, 1.22) and 1.10 (95% CI = 0.98, 1.25) for those aged 25 to 29 years and 30 years or older compared with those younger than 25 years (Table 3). In a separate model, compared with women who had their first child before age 25 years, the odds of longevity were significantly higher among women aged 25 years or older at first childbirth (OR = 1.11; 95% CI = 1.02, 1.21). Compared with women who had their last child before age 25 years, the odds of longevity were not significantly higher among women who were older at last childbirth (*P* for trend = .27). Associations of age at first and last childbirth with longevity did not vary by race/ethnicity, income, or parity (data not shown).

Compared with nulliparous women, women with 2 term pregnancies had higher odds of longevity, with an OR of 1.15 (95% CI = 1.00, 1.32) in the fully adjusted model (Table 3). Findings were not significant in other parity categories and did not vary by race/ethnicity or income (data not shown). In an analysis restricted to parous women, the association of parity with longevity varied by race/ethnicity (*P* value for interaction = .03) and was statistically significant among White women only (Table 4). Among parous White women, the odds of longevity were significantly higher among those with 2, 3, or 4 term pregnancies compared with 1 term pregnancy in the final model (OR = 1.35 [95% CI = 1.17, 1.56]; OR = 1.31 [95% CI = 1.13, 1.51]; and OR = 1.22 [95% CI = 1.04, 1.42], respectively). With increasing parity, the

TABLE 3—Associations of Age at First and Last Childbirth and Parity With Survival to Age 90 Years Among Older Women: Women's Health Initiative, United States, 1993–2014

Variable	Survived to 90 Years, No./Total No. (%)	Age-Adjusted, OR (95% CI)	Multivariable-Adjusted, OR (95% CI)
Age at first childbirth[a], y			
< 25	3624/7147 (50.7)	1 (Ref)	1 (Ref)
25–29	3133/5522 (56.7)	1.22 (1.13, 1.31)	1.11 (1.02, 1.22)
≥ 30	1369/2413 (56.7)	1.17 (1.07, 1.29)	1.10 (0.98, 1.25)
Age at last childbirth[a], y			
< 25	549/1172 (46.8)	1 (Ref)	1 (Ref)
25–29	1725/3186 (54.1)	1.32 (1.15, 1.51)	1.17 (0.98, 1.40)
30–34	2619/4848 (54.0)	1.32 (1.16, 1.51)	1.13 (0.95, 1.35)
≥ 35	3233/5876 (55.0)	1.35 (1.19, 1.54)	1.16 (0.97, 1.40)
Parity[b]			
0	1441/2711 (53.2)	1 (Ref)	1 (Ref)
1	965/1933 (49.9)	0.87 (0.77, 0.98)	0.91 (0.78, 1.07)
2	2735/4874 (56.1)	1.15 (1.05, 1.27)	1.15 (1.00, 1.32)
3	2572/4643 (55.4)	1.15 (1.04, 1.27)	1.14 (0.99, 1.30)
4	1659/3038 (54.6)	1.13 (1.02, 1.26)	1.05 (0.91, 1.22)
≥ 5	1537/3049 (50.4)	0.99 (0.89, 1.10)	0.98 (0.85, 1.14)
Parity (among parous women)[b,c]			
1	965/1933 (49.9)	1 (Ref)	1 (Ref)
2	2735/4874 (56.1)	1.32 (1.19, 1.47)	1.26 (1.10, 1.44)
3	2572/4643 (55.4)	1.32 (1.18, 1.47)	1.24 (1.08, 1.42)
4	1659/3038 (54.6)	1.30 (1.16, 1.46)	1.15 (0.99, 1.33)
≥ 5	1537/3049 (50.4)	1.13 (1.01, 1.27)	1.07 (0.93, 1.24)

Note. CI = confidence interval; OR = odds ratio.

[a]Multivariable model adjusts for study membership (clinical trial or observational study), demographics (baseline age, race/ethnicity, educational level, income, and marital status), lifestyle behaviors (baseline smoking behavior, alcohol intake, and physical activity), baseline body mass index, reproductive factors (ever used hormone therapy, past oral contraceptive use, age at menopause, age at menarche, and parity), and health-related factors (self-rated health and history of chronic diseases [coronary heart disease, stroke, cancer, diabetes, or hip fracture]).

[b]Multivariable model adjusts for study membership (clinical trial or observational study), demographics (baseline age, race/ethnicity, educational level, income, and marital status), lifestyle behaviors (baseline smoking behavior, alcohol intake, and physical activity), baseline body mass index, reproductive factors (ever used hormone therapy, past oral contraceptive use, age at menopause, and age at menarche), and health-related factors (self-rated health and history of chronic diseases [coronary heart disease, stroke, cancer, diabetes, or hip fracture]).

[c]*P* value for interaction with race/ethnicity = .03.

association between parity and longevity was attenuated and not significantly higher in those with 5 or more term pregnancies.

Among parous Black women, the odds of longevity were 48% (OR = 0.52; 95% CI = 0.34, 0.78) lower among those with at least 5 term pregnancies compared with 1 term pregnancy in the age-adjusted model; in the fully adjusted model, findings were no longer significant. We did not fit separate models for Hispanic and other race/ethnicity women because of smaller sample sizes in these groups.

In a sensitivity analysis, findings were similar when we restricted the analysis to only women who experienced natural menopause. Findings were similar after we excluded women who reported ever having difficulties becoming pregnant or visiting a doctor or clinic because they could not get pregnant (data not shown).

DISCUSSION

In this large, prospective study, later maternal age at first childbirth was associated with increased likelihood of living to age 90 years among older women. Compared with nulliparous women, women with 2 term pregnancies had higher odds of longevity. Among parous White women, having 2 to 4 term pregnancies compared with 1 term pregnancy was associated with higher likelihood of longevity. Findings were independent of demographic characteristics, socioeconomic status (SES), lifestyle behaviors, reproductive factors, and health-related factors.

Although several studies have investigated the association of age at childbirth with mortality,[16–23] few have determined whether age at childbirth is associated with longevity.[4,5] In a case–control study among Long Life Family Study participants, each 1-year increase in age at last childbirth was associated with 5% higher odds of exceptional longevity (defined as survival to or past the fifth percentile of one's birth cohort, or age 97 years or older).[5] However, health-related factors, such as chronic diseases, were not controlled in this study. We did not find an association between age at last childbirth and longevity in the fully adjusted model, which included health-related factors. In addition, we did not evaluate associations with exceptional longevity, such as survival to age 95 years or older, given the smaller number of women who reached very advanced ages. Future prospective studies with large numbers of exceptional survivors are needed to determine the relationship between age at childbirth and survival to extreme old age.

The association of age at childbirth with all-cause mortality has been inconsistent.[18,19,21] A prospective study among White women observed that having one's last child after age 40 years was associated with higher risk of mortality.[19] A study among a national sample of Black and White women found that early age at first childbirth was associated with higher mortality risk in Whites, whereas later age at first childbirth was associated with higher mortality risk in Blacks.[18] A prospective study among White women found that risk of mortality was lowest among those with 3 or 4 children who were aged 25 to 29 years at first childbirth.[21] Our findings for age at childbirth did not vary by race/ethnicity or parity.

Several factors may explain the association between later age at first childbirth and longevity. The ability to deliver a term infant at an older age may be associated with later age at menopause.[24,25] Women with later age

TABLE 4—Racial/Ethnic–Specific Associations of Parity With Survival to Age 90 Years Among Parous Women: Women's Health Initiative, United States, 1993–2014

Parity	Survived to 90 Years, No./Total No. (%)	Age-Adjusted, OR (95% CI)	Multivariable-Adjusted,[a] OR (95% CI)
White women			
1	794/1630 (48.7)	1 (Ref)	1 (Ref)
2	2476/4393 (56.4)	1.41 (1.25, 1.58)	1.35 (1.17, 1.56)
3	2326/4231 (55.0)	1.37 (1.21, 1.53)	1.31 (1.13, 1.51)
4	1510/2742 (55.1)	1.40 (1.23, 1.58)	1.22 (1.04, 1.42)
≥ 5	1350/2633 (51.3)	1.24 (1.09, 1.40)	1.14 (0.98, 1.33)
Black women			
1	109/188 (58.0)	1 (Ref)	1 (Ref)
2	106/223 (47.5)	0.61 (0.40, 0.91)	0.54 (0.30, 0.96)
3	99/168 (58.9)	0.98 (0.63, 1.52)	0.93 (0.50, 1.73)
4	59/122 (48.4)	0.62 (0.39, 1.01)	0.66 (0.34, 1.29)
≥ 5	82/206 (39.8)	0.52 (0.34, 0.78)	0.57 (0.31, 1.06)

Note. CI = confidence interval; OR = odds ratio.

[a]Multivariable model adjusts for study membership (clinical trial or observational study), demographics (baseline age, race/ethnicity, educational level, income, and marital status), lifestyle behaviors (baseline smoking behavior, alcohol intake, and physical activity), baseline body mass index, reproductive factors (ever used hormone therapy, past oral contraceptive use, age at menopause, and age at menarche), and health-related factors (self-rated health and history of chronic diseases [coronary heart disease, stroke, cancer, diabetes, or hip fracture]).

at menopause may be more likely to live longer, which may be explained by their better overall health because of their lifestyle behaviors and different childhood exposures.[24–27] For example, women with later age at menopause have been found to have better nutrition, less stress, and higher SES in childhood, which may influence their behaviors and overall health in adulthood.[24] Our findings, however, were independent of age at menopause.

The risk of obstetric complications, including gestational diabetes and hypertension, is higher at older maternal ages, and the risk of maternal mortality increases with age across all races and ethnicities.[28,29] It is possible that surviving a pregnancy at an older age may be an indicator of good overall health and thus higher likelihood of longevity. However, delivering her first child at a later age does not imply that a woman will achieve longevity, as longevity may be influenced by many factors (e.g., lifestyle behaviors).[7]

Residual confounding by SES may also explain our findings. Women who are older at first childbirth usually have higher educational attainment and income,[1] both of which are associated with increased longevity.[7] Although our findings were independent of these factors, other indicators of SES (e.g., occupation) that influence age at first childbirth may also explain the association with longevity.

In previous studies, women with 2 to 4 term pregnancies had lower risk of all-cause mortality compared with nulliparous, primiparous, and higher parity women.[10,11,18,30,31] Concordantly, we observed that, compared with nulliparous women, women with 2 term pregnancies had higher odds of longevity. Furthermore, among parous White women, the odds of longevity were higher among those with 2 to 4 term pregnancies. However, the odds of longevity were attenuated with increasing parity and were not significant among White women with 5 or more term pregnancies, consistent with previous findings showing a nonlinear, J-shaped association between parity and mortality.[10]

The higher likelihood of longevity among women with 2 to 4 term pregnancies may be partly explained by better overall health in those who are capable of childbearing compared with nulliparous or primiparous women.[31,32] Alternatively, the association may be explained by residual confounding attributable to SES, early life factors, or lifestyle factors. For example, a previous study observed that, among women, number of children was linearly associated with adult socioeconomic indicators (e.g., social class, car ownership, and housing tenure) and childhood social class.[33] The absence of a significant association with longevity for White women with 5 or more term pregnancies may reflect lifestyle factors such as obesity that are associated with having large families.[33] The inverse association between high parity and longevity in Black women may be attributable to weight gain with numerous pregnancies. A prospective, 25-year study showed that weight gain following childbearing was highest in overweight, multiparous Black women than in other racial/ethnic groups.[34] In our study, the inverse association was no longer significant in the fully adjusted model, which included body mass index.

Limitations and Strengths

This study has several limitations. Women who enrolled for additional follow-up were more likely to be White, educated, and healthier at baseline. Women included in this study were aged on average 75 years at enrollment and may have had a higher likelihood of achieving longevity as they had already survived to their 70s. Because of this potential selection bias, our findings may not be applicable to the general population of childbearing women. The small number of minority women limited power to evaluate associations of reproductive factors with longevity in these groups separately. Participants may have had different experiences with respect to historical events that may have influenced their life expectancy; however, any confounding attributable to birth cohort effects was minimized because of the narrow age range of the cohort.

Although information was available on a large number of covariates, we did not have information on family history of longevity or whether pregnancies were achieved with assisted reproductive technology. However, findings were similar after we excluded women who reported ever having difficulties becoming pregnant. In addition, assisted reproductive technology was uncommon during the years when these women were giving birth.

Study strengths include the prospective design, long-term follow-up, high retention of study participants over time, and multiethnic cohort with a large number of women who reached age 90 years.

Public Health Implications

Our findings have several public health implications. First, our findings do not imply that intentionally delaying childbearing will increase the likelihood of living to age 90 years and do not support delaying childbearing, given the complications associated with older maternal age. Furthermore, although parity was positively associated with longevity, increasing parity was associated with a decreasing trend for the odds of longevity. It is possible that age at first childbirth and parity reflect underlying factors such as SES. For example, women with later age at first childbirth may have been of a higher SES, which may explain the association of delayed childbearing with longevity in our study. Therefore, further research is needed to determine which modifiable and social factors explain associations of age at first childbirth and parity with longevity. This may help identify targets for future public health interventions among women in the preconception and family planning phases of their lives, which may improve women's healthy longevity in the long term. AJPH

CONTRIBUTORS

A. H. Shadyab and A. Z. LaCroix designed the study. A. H. Shadyab conducted the statistical analysis and wrote the article. All authors participated in the interpretation of the data and critical revision of the article, and approved the final version.

ACKNWLEDGMENTS

The Women's Health Initiative program is funded by contracts HHSN268201100046C, HHSN268201100001C, HHSN268201100002C, HHSN268201100003C, HHSN268201100004C, and HHSN271201100004C from the National Heart, Lung, and Blood Institute, National Institutes of Health, US Department of Health and Human Services. M. Waring was supported by grant KL2TR000160 from the National Institutes of Health.

The Women's Health Initiative investigators include—Program office (National Heart, Lung, and Blood Institute, Bethesda, MD): Jacques Rossouw, Shari Ludlam, Dale Burwen, Joan McGowan, Leslie Ford, and Nancy Geller; clinical coordinating center (Fred Hutchinson Cancer Research Center, Seattle, WA): Garnet Anderson, Ross Prentice, Andrea LaCroix, and Charles Kooperberg; investigators and academic centers: JoAnn E. Manson, Brigham and Women's Hospital, Harvard Medical School, Boston, MA; Barbara V. Howard, MedStar Health Research Institute/Howard University, Washington, DC; Marcia L. Stefanick, Stanford Prevention Research Center, Stanford, CA; Rebecca Jackson, The Ohio State University, Columbus, OH; Cynthia A. Thomson, University of Arizona, Tucson/Phoenix, AZ; Jean Wactawski-Wende, University at Buffalo, Buffalo, NY; Marian Limacher, University of Florida, Gainesville/Jacksonville, FL; Robert Wallace, University of Iowa, Iowa City/Davenport, IA; Lewis Kuller, University of Pittsburgh, Pittsburgh, PA; Sally Shumaker, Wake Forest University School of Medicine, Winston-Salem, NC.

Note. The National Heart, Lung, and Blood Institute has representation on the Women's Health Initiative Steering Committee, which governed the design and conduct of the study, the interpretation of the data, and preparation and approval of manuscripts.

HUMAN PARTICIPANT PROTECTION

This study was approved by the institutional review boards of the University of California, San Diego, and Fred Hutchinson Cancer Research Center. Informed consent was obtained from all participants.

REFERENCES

1. Matthews TJ, Hamilton BE. First births to older women continue to rise. *NCHS Data Brief*. 2014;(152):1–8.

2. US Census Bureau. Fertility of women in the United States: 2012. 2014. Available at: https://www.census.gov/content/dam/Census/library/publications/2014/demo/p20-575.pdf. Accessed August 16, 2016.

3. Balasch J, Gratacos E. Delayed childbearing: effects on fertility and the outcome of pregnancy. *Curr Opin Obstet Gynecol*. 2012;24(3):187–193.

4. Perls TT, Alpert L, Fretts RC. Middle-aged mothers live longer. *Nature*. 1997;389(6647):133.

5. Sun F, Sebastiani P, Schupf N, et al. Extended maternal age at birth of last child and women's longevity in the Long Life Family Study. *Menopause*. 2015;22(1):26–31.

6. US Census Bureau. 90+ in the United States: 2006–2008. 2011. Available at: http://www.census.gov/prod/2011pubs/acs-17.pdf. Accessed August 15, 2016.

7. Newman AB, Murabito JM. The epidemiology of longevity and exceptional survival. *Epidemiol Rev*. 2013;35:181–197.

8. The Women's Health Initiative Study Group. Design of the Women's Health Initiative clinical trial and observational study. *Control Clin Trials*. 1998;19(1):61–109.

9. Anderson GL, Manson J, Wallace R, et al. Implementation of the Women's Health Initiative study design. *Ann Epidemiol*. 2003;13(9, suppl):S5–S17.

10. Dior UP, Hochner H, Friedlander Y, et al. Association between number of children and mortality of mothers: results of a 37-year follow-up study. *Ann Epidemiol*. 2013;23(1):13–18.

11. Koski-Rahikkala H, Pouta A, Pietilainen K, Hartikainen AL. Does parity affect mortality among parous women? *J Epidemiol Community Health*. 2006;60(11):968–973.

12. Ainsworth BE, Haskell WL, Leon AS, et al. Compendium of physical activities: classification of energy costs of human physical activities. *Med Sci Sports Exerc*. 1993;25(1):71–80.

13. National Institutes of Health. Clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults: the evidence report. *Obes Res*. 1998;6(suppl 2):51S–209S.

14. Curb JD, McTiernan A, Heckbert SR, et al. Outcomes ascertainment and adjudication methods in the Women's Health Initiative. *Ann Epidemiol*. 2003;13(9, suppl):S122–S128.

15. Margolis KL, Qi L, Brzyski R, et al. Validity of diabetes self-reports in the Women's Health Initiative: comparison with medication inventories and fasting glucose measurements. *Clin Trials*. 2008;5(3):240–247.

16. Chang HS, Odongua N, Ohrr H, Sull JW, Nam CM. Reproductive risk factors for cardiovascular disease mortality among postmenopausal women in Korea: the Kangwha Cohort Study, 1985–2005. *Menopause*. 2011;18(11):1205–1212.

17. Merritt MA, Riboli E, Murphy N, et al. Reproductive factors and risk of mortality in the European Prospective Investigation Into Cancer and Nutrition; a cohort study. *BMC Med*. 2015;13:252.

18. Spence NJ, Eberstein IW. Age at first birth, parity, and post-reproductive mortality among White and Black women in the US, 1982–2002. *Soc Sci Med*. 2009;68(9):1625–1632.

19. Cooper GS, Baird DD, Weinberg CR, Ephross SA, Sandler DP. Age at menopause and childbearing patterns in relation to mortality. *Am J Epidemiol*. 2000;151(6):620–623.

20. Henretta JC. Early childbearing, marital status, and women's health and mortality after age 50. *J Health Soc Behav*. 2007;48(3):254–266.

21. Lund E, Arnesen E, Borgan JK. Pattern of childbearing and mortality in married women—a national prospective study from Norway. *J Epidemiol Community Health*. 1990;44(3):237–240.

22. McArdle PF, Pollin TL, O'Connell JR, et al. Does having children extend life span? A genealogical study of parity and longevity in the Amish. *J Gerontol A Biol Sci Med Sci*. 2006;61(2):190–195.

23. Helle S, Lummaa V, Jokela J. Are reproductive and somatic senescence coupled in humans? Late, but not early, reproduction correlated with longevity in historical Sami women. *Proc Biol Sci*. 2005;272(1558):29–37.

24. Crawford SL. What explains the link between reproductive events and women's longevity? *Menopause*. 2015;22(1):6–8.

25. Jacobsen BK, Heuch I, Kvale G. Age at natural menopause and all-cause mortality: a 37-year follow-up of 19,731 Norwegian women. *Am J Epidemiol*. 2003;157(10):923–929.

26. Shadyab AH, Macera CA, Shaffer RA, et al. Ages at menarche and menopause and reproductive lifespan as predictors of exceptional longevity in women: The Women's Health Initiative. *Menopause*. 2016; Epub ahead of print.

27. Kok HS, van Asselt KM, van der Schouw YT, et al. Heart disease risk determines menopausal age rather than the reverse. *J Am Coll Cardiol*. 2006;47(10):1976–1983.

28. Health Resources and Services Administration. Maternal morbidity and mortality. 2012. Available at: http://mchb.hrsa.gov/whusa12/hs/hsrmh/pages/mmm.html. Accessed May 4, 2016.

29. Health Resources and Services Administration. Maternal mortality. 2010. Available at: http://mchb.hrsa.gov/whusa10/hstat/mh/pages/237mm.html. Accessed May 4, 2016.

30. Jaffe DH, Neumark YD, Eisenbach Z, Manor O. Parity-related mortality: shape of association among middle-aged and elderly men and women. *Eur J Epidemiol*. 2009;24(1):9–16.

31. Grundy E, Kravdal O. Reproductive history and mortality in late middle age among Norwegian men and women. *Am J Epidemiol*. 2008;167(3):271–279.

32. Grundy E, Tomassini C. Fertility history and health in later life: a record linkage study in England and Wales. *Soc Sci Med*. 2005;61(1):217–228.

33. Lawlor DA, Emberson JR, Ebrahim S, et al. Is the association between parity and coronary heart disease due to biological effects of pregnancy or adverse lifestyle factors associated with child-rearing? Findings from the British Women's Heart and Health Study and the British Regional Heart Study. *Circulation*. 2003;107(9):1260–1264.

34. Abrams B, Heggeseth B, Rehkopf D, Davis E. Parity and body mass index in US women: a prospective 25-year study. *Obesity (Silver Spring)*. 2013;21(8):1514–1518.