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Journal

Fertility and Sterility, 101(1)

ISSN

0015-0282

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Publication Date

2014

DOI

10.1016/j.fertnstert.2013.09.015

Peer reviewed

Published in final edited form as:
Fertil Steril. 2014 January ; 101(1): 199–207. doi:10.1016/j.fertnstert.2013.09.015.

Race/ethnic disparities in reproductive age: An examination of ovarian reserve estimates across four race/ethnic groups of healthy, regularly-cycling women

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Abstract

Objective—To determine whether reproductive age, indexed by a validated marker of ovarian reserve (antimüllerian hormone [AMH]), varies between women of different race/ethnic backgrounds.

Design—Cross-sectional study.

Setting—Community-based sample.

Patients—Multi-ethnic sample of 947 (277 white, 237 African-American, 220 Latina, and 213 Chinese) healthy and regularly-cycling pre-menopausal women, ages 25-45.

Interventions—None.

Main Outcome Measures(s)—AMH level.

Results—A multivariate model was fit examining race/ethnicity, covariates, non-linear terms for age (age^2, age^3) and BMI (BMI^2, BMI^3), and 2-way interactions between race/ethnicity and each other predictor variable in relation to AMH. Following backward elimination, significant effects included race/ethnicity (F=8.45), age (F=349.94), race/ethnicity-by-linear age interaction (F=4.67), age^2 (F=31.61), and BMI (F=10.69). Inspection of the significant race/ethnicity-by-linear age interaction showed AMH levels were consistently lower in the Latina vs. white women across all ages, whereas AMH levels were lower in the African-American and Chinese women vs. white women at younger and middle ages, respectively, and AMH levels were higher in the African-American vs. Latina and Chinese women at older ages.

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The authors have nothing to disclose.

Conclusions—Although results must be considered preliminary, findings are two-fold, suggesting 1) African-American women may have lower AMH levels at younger ages but experience less of a reduction in AMH with advancing age; and 2) Latina and Chinese women, compared to white women, may have lower AMH levels, marking a lower ovarian reserve and possible increased risk for earlier menopause.

Keywords

race/ethnicity; antimüllerian hormone (AMH); ovarian reserve; menopause; reproductive aging

The timing of menopause has important implications for a woman's reproductive status as well as her health more generally. Earlier age at menopause is related to an increase in risk for cardiovascular disease (1-17) and osteoporosis (18-21) but also to a decrease in risk for breast, endometrial, and ovarian cancers (22-27). Studies examining factors affecting menopausal timing suggest that among US women the timing of natural menopause differs between race/ethnic groups. Compared to white women, findings show menopausal onset is earlier in African-American (28) and Latina women (29-30), later in Japanese women (29-30), and not significantly different in Chinese women (29). Study findings are not entirely consistent, however, especially with respect to African-American women in whom the median age at menopause was similar to that of white women in several studies (29-31).

Race/ethnic differences in the timing of menopause suggest that trajectories of reproductive aging over the life course may vary between women of different race/ethnic backgrounds. Recently, methods have been validated that enable the estimation of a woman's total ovarian reserve or “reproductive age” in the pre-menopausal period. In particular, antimüllerian hormone (AMH) has emerged as a biochemical marker of ovarian reserve; its validity is supported by its correlation with the primordial follicle pool (32), inverse relation to chronological age (33-34), prediction of ovarian response in assisted reproductive technologies (35-36), and prospective relation to menopausal timing (37-39). A primary limitation of studies of AMH to date is the inclusion of samples that are predominately comprised of white women. In one multi-ethnic study in which changes in ovarian reserve between race/ethnic groups were examined in a sample of HIV-infected and non-infected but high-risk women, average declines in AMH over a median follow-up period of 5.3 years were greater among African-American and Latina women compared to white women (40). These findings are notable in suggesting that differences in ovarian reserve may be present between race/ethnic groups which by extension may underlie observed race/ethnic disparities in menopausal timing and subsequent variations in risk for disease in the post-menopausal period.

In the present study, we utilized a community-based, multi-ethnic sample of 947 healthy and regularly-cycling pre-menopausal women to examine the cross-sectional association between race/ethnicity and reproductive age, indexed by AMH. Women who self-identified as belonging to one of four race/ethnic groups, including white (n=277), African-American (n=237), Latina (n=220), and Chinese (n=213), were compared to determine whether estimates of ovarian reserve differed between the groups.

Materials and Methods

Participants

Women in the current sample were participants in the Ovarian Aging (OVA) Study, an investigation of reproductive aging and its correlates. OVA Study participants were recruited through Kaiser Permanente (KP) of Northern California, a large, integrated health care delivery system that provides medical care to approximately one-third of the population

of Northern California. The KP membership compared to the population of Northern California is generally representative in its socio-demographic and health-related characteristics, especially when the comparison is limited to those with health insurance (41). Inclusion criteria for the OVA Study were age between 25-45 years; regular menses (i.e., able to predict the start of menses within 5 days); intact uterus and both ovaries; self-identification as white, African-American, Latina, Chinese, or Filipina and having both biological parents be from the same self-identified race/ethnic group as the participant; and able to speak/read English, Spanish, or Cantonese. Exclusions were the self-report of major medical illnesses (cardiovascular diseases, chronic kidney or liver disease, diabetes, invasive cancer, chemotherapy or radiation therapy, epilepsy, systemic lupus erythematosus, HIV positive status); use of medications affecting the menstrual cycle in the 3 months prior to study participation; and current pregnancy/breastfeeding. The OVA Study protocol included an in-person medical history interview, trans-vaginal ultrasound, anthropometric assessment, blood draw, and self-report questionnaires. Of 1019 total participants, 947 women were included in the current analysis. Of the 72 women who were excluded, 41 Filipina women were excluded due to their small numbers and 31 women were excluded due to missing data on a variable of primary interest. Institutional Review Board approval was obtained both from KP and the University of California San Francisco and all subjects provided informed, written consent.

Measures

Race/ethnicity—A requirement for inclusion in the current study was that all women self-identify as belonging to one of four race/ethnic groups categorized as white (including self-identification as white non-Hispanic); African-American (including self-identification as African-American or black non-Hispanic); Latina (including self-identification as white or black Hispanic of Mexican or Central American origin); or Chinese (including self-identification as Chinese or Chinese-American). An additional requirement was having both biological parents be from the same self-identified race/ethnic group as the participant so that no women were included that were “mixed” race.

Reproductive Age

Antimüllerian hormone (AMH): Blood was drawn from each study participant between menstrual cycle days 2-4. AMH (ng/mL) was assayed using two commercially available ELISAs from Beckman Coulter (Marseille, France) both of which use a two-site sandwich immunoassay. The majority of the samples (85%) were assayed using the Immunotech assay until this assay was retired and the remainder of the samples were assayed using the second generation assay (Gen II). In a subset of 44 women in whom both assays were performed, regression analyses showed excellent correspondence between the assays (R^2=0.94) which has also been demonstrated in prior studies (35-36). AMH values based on the Immunotech assay were adjusted using the equation of the line with Immunotech predicting Gen II. Gen II assay sensitivity was 0.16 ng/mL, the intra-assay coefficient of variation (CV) was 1.4%, and the inter-assay CV was 12.5%.

Covariates

Medical history interview: An in-person medical history interview was administered by a trained research associate from which variables related to cigarette smoking, parity, contraception, menarcheal age, psychological stress, and socioeconomic status were derived. Cigarette smoking was coded as current or past smoking (coded 1) versus no history of smoking (coded 0). Parity was coded as having had at least one live birth (coded 1) versus having no live births (coded 0). All hormonal methods of contraception (e.g., pills, patch, shot, ring) were assessed and coded as a positive history of use (coded 1) versus no use

(coded 0). Menarcheal age was assessed by asking women to report the age of their first menstrual period; retrospective reports of menarcheal age have been shown to be highly reliable even over lengthy recall intervals (42). Psychological stress was assessed using the 4-item version of the Perceived Stress Scale (PSS) which evaluates appraisals of stress experienced over the past month; the PSS is widely used and has adequate psychometric properties (43-45). Socioeconomic status was assessed by self-report of education and income levels. Education was assessed at the individual level and coded into categories: 1=<high school (HS)/some HS; 2=HS diploma/GED; 3=some college/Associate's degree/ vocational school; 4=college graduate; 5=graduate/professional degree (MS, PhD, MD, JD, DDS, MBA). Income was assessed including all sources of income for the household and was coded into categories: 1=<$25,000; 2=$25,000-$34,999; 3=$35,000-$49,999; 4= $50,000-$74,999; 5=$75,000-$99,999; 6=≥$100,000.

Anthropometric evaluation: BMI, calculated as weight (kg) / height (m^2), was derived from a standardized anthropometric assessment performed by a study nurse.

Analytical plan

Due to its non-normal distribution, the AMH variable was logarithmically transformed. In addition, polynomial regression models were fit to accommodate potential non-linear associations between respondent age and BMI variables and the dependent variable AMH. In a single adjusted, multivariate model, all specified predictors were examined simultaneously in relation to AMH, including race/ethnicity, all of the covariates of interest (age, BMI, cigarette smoking, parity, hormonal contraception, menarcheal age, psychological stress, educational attainment, and income level), non-linear terms for age (age^2, age^3) and BMI (BMI^2, BMI^3), and 2-way interactions between race/ethnicity and each other predictor variable. The final multivariate model reflects the variables remaining following backward elimination of main effects with p-values >.10 and interaction effects with p-values >.05. Separate unadjusted, bivariate models were also evaluated. To simplify presentation of results, non-significant polynomial and interaction effects are not reported. Analyses were performed using SAS statistical software version 9.3.

Results

Sample characteristics

Descriptive information for the full sample as well as for women in each race/ethnic group is reported in Table 1. The sample (N = 947), including 277 (29.3%) white, 237 (25.0%) African-American, 220 (23.2%) Latina, and 213 (22.5%) Chinese women, had a mean age of 35.3 (5.5) years, women were overweight on average (BMI = 27.2 [7.1]), and 23.8% smoked cigarettes currently or in the past. Additionally, 32.7% had one or more live birth, the majority (70.0%) used a hormonal method of contraception in the past, and 57.2% held a college or graduate-level degree. With the exception of age, race/ethnic differences were evident for all of the variables of interest. Specifically, with respect to AMH, differences were significant between the white and African-American women as well as the white and Latina women. Other differences that were especially prominent included significant differences between all race/ethnic groups on BMI, parity, and educational attainment. African-American women had the highest BMI on average (32.3 [8.1]) followed by the Latina (29.4 [6.2]), white (24.5 [5.5]), and Chinese (22.9 [3.3]) women. More Latina women had had one or more live births (70.5%) followed by the African-American (52.7%), Chinese (39.9%), and white (14.1%) women. Lastly, more white women held a college or graduate-level degree (85.2%) followed by the Chinese (70.4%), African-American (41.4%), and Latina (26.4%) women.

Race/ethnicity and AMH

Results of unadjusted bivariate and adjusted multivariate models performed to examine the specified predictors in relation to AMH are reported in Table 2.

Bivariate models—In bivariate models, effects of race/ethnicity ($F = 12.05$, $p < .0001$), linear age ($F = 340.39$, $p < .0001$), race/ethnicity-by-linear age interaction ($F = 4.66$, $p = .0031$) (examined simultaneously), as well as non-linear age^2 ($F = 15.44$, $p < .0001$), BMI ($F = 29.85$, $p < .0001$), parity ($F = 31.91$, $p < .0001$), menarcheal age ($F = 5.54$, $p = .0188$), and educational attainment ($F = 5.00$, $p = .0005$) (examined separately) were significant. (Because the interaction effects observed in the bivariate analyses were similar to those observed in the multivariate analyses, to avoid redundancy, a detailed description of the interaction effects is provided below in the multivariate model section only; and, here, the remaining significant bivariate effects are described.) Examination of factor-change coefficients showed every 1-unit increase in BMI was associated with a 2.5% (95% CI: 1.6%, 3.3%) reduction in AMH; having had one or more live births vs. being nulliparous was associated with a 31.1% (95% CI: 21.6%, 39.5%) reduction in AMH; and every one-year increase in age at menarche was associated with 4.8% (95% CI: 0.8%, 8.5%) reduction in AMH. Lastly, with respect to educational attainment, having some college vs. <high school was associated with a 33.7% (95% CI: 2.7%, 74.0%) increase in AMH; having a college degree vs. <high school was associated with a 64.2% (95% CI: 27.5%, 111.4%) increase in AMH; and having a graduate degree vs. <high school was associated with a 57.8% (95% CI: 20.6%, 106.4%) increase in AMH.

Multivariate model—In the multivariate model, following backward elimination of main effects ($p > .10$) and interaction effects ($p > .05$), the retained effects included race/ethnicity ($F = 8.45$, $p < .0001$), linear age ($F = 349.94$, $p < .0001$), and race/ethnicity-by-linear age interaction terms ($F = 4.67$, $p < .01$), as well as non-linear age^2 ($F = 31.61$, $p < .0001$) and BMI ($F = 10.69$, $p < .01$). Previously significant effects of parity, menarcheal age, and educational attainment on AMH were not retained in the multivariate model.

The significant race/ethnicity-by-linear age interaction suggests that differences in AMH levels across race/ethnic groups varied as a function of age. Reported in Table 2, comparisons between race/ethnic groups (holding age constant at the sample mean) showed AMH was 24.4% (95% CI: 12.2%, 35.0%) lower in the African-American versus white women; 37.0% (95% CI: 26.5%, 45.9%) lower in the Latina versus white women; 22.0% (95% CI: 8.9%, 33.2%) lower in the Chinese versus white women; 19.9% (95% CI: 2.3%, 40.6%) higher in the African-American versus Latina women; and 19.2% (95% CI: 4.9%, 31.4%) lower in the Latina versus Chinese women. AMH was not significantly different between the African-American versus Chinese women (factor-change score=3.1%; 95% CI: -13.7%, 17.5%). This pattern of results was similar in the multivariate model with the exception that differences between the African-American versus white women (factor-change score=9.1%; 95% CI: -7.3%, 22.9%) as well as differences between the Latina versus Chinese women (factor-change score=12.8%; 95% CI: -3.5%, 26.5%) attenuated when *both* age and BMI were held constant at their sample means. Regarding BMI, with every 1-unit increase in BMI, AMH decreased by 1.5% (95% CI: 0.6%, 2.4%).

To aid in the interpretation of the significant race/ethnicity-by-linear age effect, although age effects on AMH were not entirely linear as evidenced by the significant non-linear age^2 term, linear effects of age on AMH within each race/ethnic group were examined. In these analyses, effects of age were highly significant (p's $< .0001$) within each race/ethnic group as expected; however, the association between age and AMH was weaker among the African-American women relative to the other race/ethnic groups. That is, among the white,

Latina, and Chinese women, with every 1-year increase in age, AMH decreased by 9.9%, 9.9%, and 10.2% respectively, whereas among the African-American women, with every 1-year increase in age, AMH decreased by 6.3%.

Depicted in Figure 1, predicted geometric mean AMH values in each race/ethnic group were calculated across the sample age range, holding BMI constant at the sample mean. To identify at what ages differences in AMH values between race/ethnic groups were statistically significant, mean AMH values across race/ethnic groups at preselected ages (i.e., 25, 30, 35, 40, and 45) and the statistical significance of each contrast are reported in Table 3. Results showed differences in AMH between the African-American versus white women were significant at younger ages (i.e., 25, 30) with the African-American women having lower levels of AMH; differences in AMH between the Latina versus white women were significant across all ages with the Latina women having lower levels of AMH; differences in AMH between the Chinese versus white women were significant at the middle ages (i.e., 30, 35, 40) with the Chinese women having lower levels of AMH; and differences in AMH between the African-American versus Latina women were significant at older ages (i.e., 35, 40, 45) as were differences between the African-American versus Chinese women (i.e., 40, 45) with the African-American women having *higher* levels of AMH. There were no statistically significant differences in AMH levels between the Latina and Chinese women at any of the preselected ages.

Discussion

Based on previous studies suggesting menopausal timing varies between women of different race/ethnic backgrounds, we examined the association between race/ethnicity and AMH, a biochemical marker of ovarian reserve, in a community-based, multi-ethnic sample of healthy and regularly-cycling pre-menopausal women. Findings showed that, in covariate-adjusted multivariate analyses, there was a significant race/ethnicity-by-linear age interaction, indicating that differences in AMH levels between race/ethnic groups varied as a function of age. Specifically, AMH levels were consistently lower in the Latina versus white women across all examined ages, whereas AMH levels were lower in the African-American and Chinese women versus white women only at the younger (i.e., 25, 30) and middle (i.e., 30, 35, 40) ages, respectively. In addition, AMH levels were higher in the African-American versus Latina and Chinese women at the older ages, (i.e., 35, 40, 45) and (i.e., 40, 45), respectively. In other words, although these data are cross-sectional, findings are suggestive that African-American women may have lower AMH levels at younger ages relative to the other race/ethnic groups but experience less of a reduction in AMH with advancing age, resulting in having higher AMH levels at older ages relative to the other race/ethnic groups (see Figure 1). Although, again, this pattern of results must be considered preliminary until replicated in longitudinal studies examining changes in AMH levels between race/ethnic groups *over time*.

The finding that the African-American women were not significantly different from the white women at the sample mean age of 35 years or older contrasts with one study of menopausal timing in which African-American women experienced menopause earlier than white women (28) but is consistent with several other studies showing the median age at menopause was not different between African-American and white women (29-31). Additionally, that differences were especially pronounced among the Latina women who had markedly lower levels of AMH compared to the white women at all the examined ages is also consistent with studies showing Latina women experienced menopause earlier than white women (29-30). Lastly, the finding that Chinese women had lower levels of AMH compared to the white women at the examined middle ages (i.e., 30, 35, 40) but not at younger (i.e., 25) or older (i.e., 45) ages contributes to a limited literature in which one study

found the median age at menopause was not different between Chinese and white women (29), but because Chinese women have been understudied, more research is needed.

In a previous study of race/ethnicity in relation to AMH (40), results showed mean decreases in AMH *over time* were greater in African-American and Latina women compared to white women, following adjustment for age, BMI, cigarette smoking, and HIV status; no differences in *levels* of AMH between the race/ethnic groups were observed in this study at the baseline or follow-up time points, however, which contrasts with findings in the current study showing there was a significant cross-sectional relation between race/ethnicity and AMH. Additionally, this previous study included a sample comprised of women of whom 78% were HIV positive and the remainder were at high-risk for HIV infection (40) compared to women in the current study who were selected to be free from major medical illnesses, have regular menses, and be off medications affecting the menstrual cycle in the three months prior to study participation. Thus, the current study extends what was previously reported by suggesting there is also a cross-sectional relation between race/ethnicity and AMH and that this relation is similarly present in a community-based sample of healthy women. Lastly, while findings in the current study are not directly comparable to this previous study due to the above-mentioned differences in design between the studies, taken together, both studies are suggestive that Latina women may be at risk for having a lower ovarian reserve, and, therefore, possible earlier entry into menopause.

In the current study, the significant interaction of race/ethnicity-by-linear age described above necessitated the examination of age in relation to AMH within each race/ethnic group separately. For the white, Latina, and Chinese women, every 1-year increase in age was associated with a 9.9%, 9.9%, and 10.2% decrease in AMH, respectively, whereas among the African-American women, this decrease was only 6.3%. Effects of age on AMH were not entirely linear, however, as was evidenced by the significant association between the non-linear quadratic age term and AMH. With respect to BMI, a one-unit increase in BMI was associated with a 1.5% decrease in AMH. The significant inverse relation between BMI and AMH reported here is generally consistent with previous studies showing AMH is lower in obese women (46-48) although not all studies have found a correlation between BMI and AMH (40, 49-52). In multivariate analyses, none of the other covariates (cigarette smoking, past use of hormonal methods of contraception, menarcheal age, psychological stress, and socioeconomic status) included as potential explanatory factors were significantly related to AMH. This was unexpected insofar as studies of menopausal timing show current cigarette smoking, non-use of oral contraceptives, nulliparity, and increased socioeconomic disadvantage reliably predict earlier menopausal onset (for review see (53)). However, there are few studies that have examined these same factors in relation to AMH with the exception of cigarette smoking which has been shown to be related to lower AMH in some studies (54-58) but to have no relation to AMH in several others (40, 51-52, 59). It is possible that effects of these factors on AMH are truly weaker at this earlier point in reproductive aging compared to the examination of menopausal timing or perhaps there is something unique about the current sample that these associations were not observed, especially because the current sample was healthy (e.g., only 7.9% of women reported current smoking).

The primary weakness of the current study was its cross-sectional design which precludes the examination of trajectories of reproductive aging, indexed by changes in AMH over time, as well as how such trajectories may vary by race/ethnicity. Secondly, because the women were recruited to be healthy and regularly-cycling, the sample is not population-based and, therefore, the generalizability of the current findings may be limited. Thirdly, although the current study included a relatively large sample of approximately equal numbers of women from four race/ethnic groups, the number of women in a given race/ethnic group at a given age is quite small. Therefore, while the overall pattern of results

showing race/ethnic differences in AMH is likely robust, the precise nature of the distribution of AMH values within these race/ethnic groups across the sample age range (depicted in Figure 1) should be interpreted cautiously. Fourth, the adjustment of AMH values necessitated by the use of two different AMH assays during the study period might not have produced entirely accurate imputations especially at the ends of the distribution. Lastly, the current study reflects a snapshot of AMH values across a relatively short age interval without any information regarding potential race/ethnic differences in the initial endowment of ovarian follicles. Moreover, there may be additional variables, not considered here (e.g., toxicant exposures), that may be relevant to understanding race/ethnic differences in AMH. Strengths of the current study included an analytical approach in which contrasts were performed between all combinations of race/ethnic groups rather than using white women as the reference group which is more typical. Additionally, the sample was generally well-characterized in terms of its overall health and reproductive history, allowing for thorough consideration of possible confounding and/or explanatory variables that might have accounted for effects of race/ethnicity on AMH. Accordingly, future studies should be longitudinal in design with the objective of tracking changes in AMH across race/groups over time and how such changes may ultimately predict race/ethnic differences in the timing of menopause and subsequent risk for diseases associated with menopausal onset.

In conclusion, findings from the current study suggest that, in healthy, pre-menopausal women, there are race/ethnic disparities in reproductive age as indexed by AMH, a biochemical marker of ovarian reserve. A significant race/ethnicity-by-linear age interaction emerged, indicating that race/ethnic differences in AMH levels vary by age. That is, while AMH levels were consistently lower in the Latina versus white women across all examined ages, AMH levels were lower in the African-American and Chinese women versus white women only at the examined younger and middle ages, respectively; and AMH levels were higher in the African-American versus Latina and Chinese women at the examined older ages. This pattern of results, although based on cross-sectional data, is suggestive that African-American may have lower AMH levels at younger ages but experience less of a reduction in AMH with advancing age. These effects were not attributable to confounding/explanatory factors, including BMI, cigarette smoking, past use of hormonal methods of contraception, menarcheal age, psychological stress, and socioeconomic status. Although these findings must be considered preliminary due to the cross-sectional design of the study, implications are that the Latina women and possibly the Chinese women may have a lower ovarian reserve. Additional implications are that the characterization of trajectories of reproductive aging associated with particular race/ethnic groups may aid in pointing to novel intervention opportunities in these groups to lessen risk for diseases associated with menopausal timing, including diseases that are associated with accelerated reproductive aging and earlier menopausal onset (e.g., cardiovascular disease (1-17, 60)) as well as those associated with a slower trajectory of reproductive aging and later menopausal onset (e.g., breast cancer (24-25)).

Acknowledgments

Funding: Preparation of this manuscript and the research described here were supported by NIH/NICHD and NIH/NIA (R01 HD044876); NIH/NIA (K08 AG03575); and NIH/UCSF-CTSI (UL1 RR024131).

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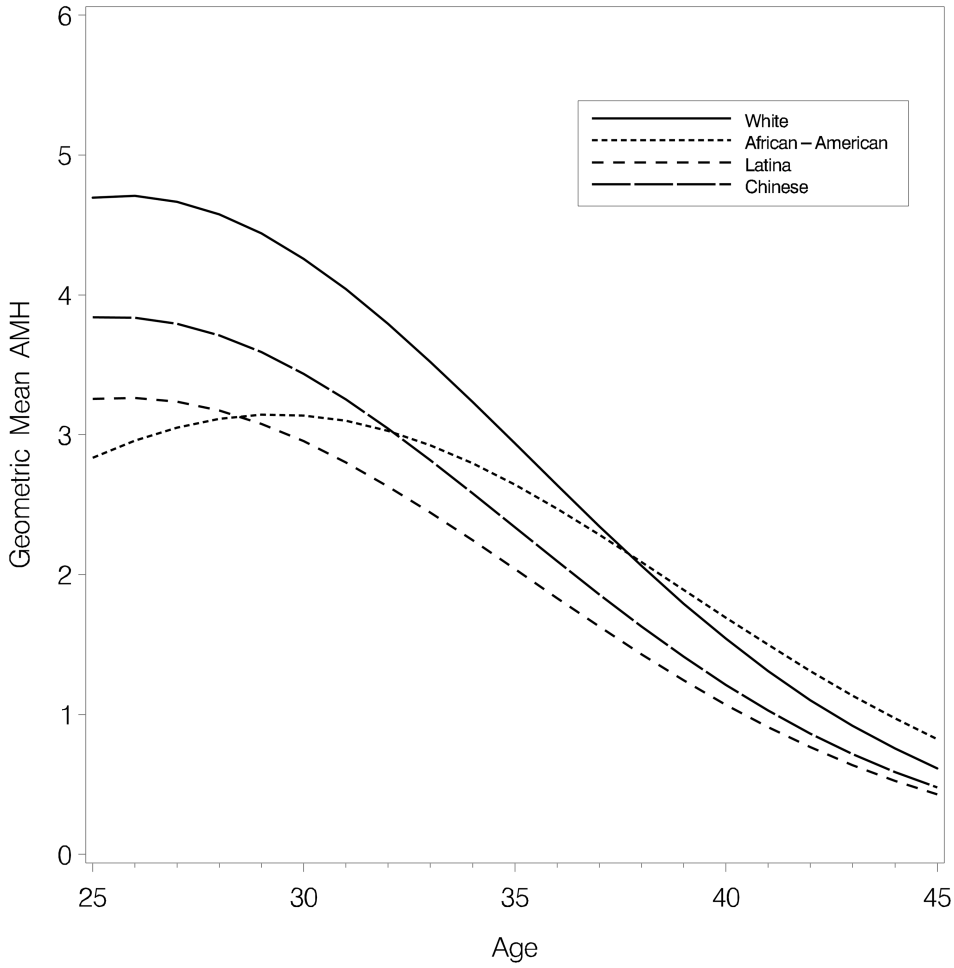

Figure 1.
Predicted geometric mean AMH values in each race/ethnic group calculated across the sample age range (holding BMI constant at the sample mean) among 947 pre-menopausal women.

Table 1

Descriptive statistics examining AMH and the covariates in the full sample as well as in the four race/ethnic groups.

	Total (n = 947)	**White (n = 277)**	**AA (n = 237)**	**Latina (n = 220)**	**Chinese (n = 213)**	**Test Statistic**	***p***
AMH (ng/mL), median (range)	2.44 (0.16-19.28)	2.82 (0.24-15.59)	2.18 (0.16-19.28)	1.96 (0.16-10.18)	2.35 (0.16-17.10)		
	Mean (SD) or %	**Mean (SD) or %**	**Mean (SD) or %**	**Mean (SD) or %**	**Mean (SD) or %**		
AMH (ng/mL)	3.18 (2.84)	3.69 (2.96)	3.05 (3.04)	2.62 (2.26)	3.23 (2.86)	F = 6.1	<.001[a,b]
Age	35.3 (5.5)	35.4 (5.0)	35.6 (6.1)	35.0 (5.4)	34.9 (5.7)	F = 0.8	.490
BMI	27.2 (7.1)	24.5 (5.5)	32.3 (8.1)	29.4 (6.2)	22.9 (3.3)	F = 121.2	<.001[a,b,c,d,e,f]
Smoking (% current/past)	23.8%	43.7%	21.5%	18.2%	6.1%	$\chi 2$ = 101.8	<.001[a,b,c,e,f]
Parity (% ≥1 live birth)	32.7%	14.1%	52.7%	70.5%	39.9%	$\chi 2$ = 172.5	<.001[a,b,c,d,e,f]
Hormonal BC (% past use)	70.0%	81.2%	76.4%	75.0%	43.2%	$\chi 2$ = 96.7	<.001[c,e,f]
Menarcheal age (in years)	12.6 (1.6)	12.9 (1.5)	12.2 (1.7)	12.5 (1.6)	12.7 (1.5)	F = 8.0	<.001[a,e]
Psychological stress	4.3 (2.8)	3.8 (2.6)	4.6 (3.1)	4.5 (2.8)	4.3 (2.6)	F = 4.4	.005[a,b]
Education (% ≥college degree)	57.2%	85.2%	41.4%	26.4%	70.4%	$\chi 2$ = 213.7	<.001[a,b,c,d,e,f]
Household income (% ≥$75,000)	31.2%	43.7%	25.3%	16.8%	36.2%	$\chi 2$ = 47.6	<.001[a,b,f]

AMH=antimüllerian hormone; BMI=body mass index; BC=birth control; AA=African-American

[a]=Significant differences were between AA and white women

[b]=Significant differences were between Latina and white women

[c]=Significant differences were between Chinese and white women

[d]=Significant differences were between AA and Latina women

[e]=Significant differences were between AA and Chinese women

[f]=Significant differences were between Latina and Chinese women

Table 2

Results of polynomial regression analyses examining race/ethnicity in relation to AMH in a sample of 947 pre-menopausal women.

		Bivariate Models†		Multivariate Model‡	
Model†	**Predictor**	**Factor-change (95% CI)**	***p***	**Factor change (95% CI)**	***p***
1	**Race/ethnicity**		<.0001		<.0001
	• AA vs. White @ mean age	0.756 (0.650, 0.878)	0.0003	0.909 (0.771, 1.073)	0.2587
	• Latina vs. White @ mean age	0.630 (0.541, 0.735)	<.0001	0.694 (0.593, 0.812)	<.0001
	• Chinese vs. White @ mean age	0.780 (0.668, 0.911)	0.0017	0.796 (0.683, 0.927)	0.0035
	• AA vs. Latina @ mean age	1.199 (1.023, 1.406)	0.0255	1.310 (1.118, 1.536)	0.0009
	• AA vs. Chinese @ mean age	0.969 (0.825, 1.137)	0.6968	1.143 (0.956, 1.367)	0.1433
	• Latina vs. Chinese @ mean age	0.808 (0.686, 0.951)	0.0106	0.872 (0.735, 1.035)	0.1163
	Linear age averaged across R/E	0.909 (0.900, 0.919)	<.0001	0.909 (0.900, 0.918)	<.0001
	Race/ethnicity-by-linear age		0.0031		0.0030
	• Linear age among White	0.899 (0.881, 0.918)	<.0001	0.901 (0.883, 0.919)	<.0001
	• Linear age among AA	0.938 (0.921, 0.955)	<.0001	0.937 (0.921, 0.954)	<.0001
	• Linear age among Latina	0.901 (0.882, 0.921)	<.0001	0.901 (0.882, 0.920)	<.0001
	• Linear age among Chinese	0.899 (0.881, 0.918)	<.0001	0.898 (0.881, 0.917)	<.0001
2	**Quadratic age** *	0.994 (0.992, 0.996)	<.0001	0.995 (0.993, 0.996)	<.0001
3	**BMI**	0.975 (0.967, 0.984)	<.0001	0.985 (0.976, 0.994)	0.0011
4	**Smoking** (current/past=1, never=0)	1.139 (0.978, 1.327)	0.0938	-	-
5	**Parity** (parous=1, nu1liparous=0)	0.689 (0.605, 0.784)	<.0001	-	-
6	**Hormonal BC** (positive hx=1, no hx=0)	0.974 (0.845, 1.123)	0.7161	-	-
7	**Menarcheal age** (in years)	0.952 (0.915, 0.992)	0.0188	-	-
8	**Psychological stress**	0.994 (0.971, 1.017)	0.6206	-	-
9	**Education**	-	0.0005	-	-
	• High school (HS) vs. <HS	1.264 (0.933, 1.713)	0.1299	-	-
	• Some college vs. <HS	1.337 (1.027, 1.740)	0.0310	-	-
	• College degree vs. <HS	1.642 (1.275, 2.114)	0.0001	-	-
	• Graduate degree vs. <HS	1.578 (1.206, 2.064)	0.0009	-	-

		Bivariate Models†		Multivariate Model‡	
Model†	**Predictor**	**Factor-change (95% CI)**	***p***	**Factor change (95% CI)**	***p***
10	**Household income**		0.1529		
	• $25,000-$34,999 vs. <$25,000	1.251 (0.963, 1.627)	0.0937	-	-
	• $35,000-$49,999 vs. <$25,000	1.345 (1.065, 1.698)	0.0129	-	-
	• $50,000-$74,999 vs. <$25,000	1.267 (1.005, 1.597)	0.0453	-	-
	• $75,000-$99,999 vs. <$25,000	1.091 (0.836, 1.424)	0.5215	-	-
	• $100,000+ vs. <$25,000	1.256 (0.990, 1.594)	0.0605	-	-

AMH=antimüllerian hormone; BMI=body mass index; BC=birth control

*conditional on the linear effect of age

†In 10 separate models, unadjusted, bivariate associations were estimated; non-significant polynomial and interaction effects are not reported.

‡In a single adjusted, multivariate model, all specified predictors included the covariates of interest (age, BMI, smoking, parity, birth control, menarcheal age, stress, education, income), non-linear terms for age (age^2, age^3) and BMI (BMI^2, BMI^3), and 2-way interactions between race/ethnicity and each other predictor variable. Displayed results show effects of variables remaining in the model following backward elimination of main effects ($p > .10$) and interaction effects ($p > .05$).

Table 3

Contrasts between predicted geometric mean AMH (ng/mL) values by race/ethnic at five preselected ages.

Age	White	AA	Latina	Chinese	Sig.
25	4.70	2.84	3.26	3.84	*a*, *b*
30	4.26	3.14	2.95	3.44	*a*, *b*, *c*
35	2.94	2.64	2.04	2.34	*b*, *c*, *d*
40	1.54	1.69	1.07	1.21	*b*, *c*, *d*, *e*
45	0.62	0.82	0.43	0.48	*b*, *d*, *e*

AMH=antimüllerian hormone; AA=African-American

a=Significant differences were between AA and white women

b=Significant differences were between Latina and white women

c=Significant differences were between Chinese and white women

d=Significant differences were between AA and Latina women

e=Significant differences were between AA and Chinese women

f=Significant differences were between Latina and Chinese women