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Socioeconomic status and age at menarche: An examination of multiple indicators in an ethnically diverse cohort

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Abstract

Purpose—Ethnic disparities exist in US girls' ages at menarche. Overweight and low socioeconomic status (SES) may contribute to these disparities but past research has been equivocal. We sought to determine which SES indicators were associated uniquely with menarche, for which ethnic groups, and whether associations operated through overweight.

Methods—Using National Longitudinal Study of Youth data, we examined associations between SES indicators and age at menarche. Participants were 4851 girls and their mothers. We used survival analyses to examine whether SES, at various time points, was associated with menarche, whether body mass index (BMI) mediated associations, and whether race/ethnicity modified associations.

Results—Black and Hispanic girls experienced menarche earlier than whites. After adjusting for SES, there was a 50% reduction in the effect estimate for "being Hispanic" and 40% reduction for "being Black" versus "being white" on menarche. SES indicators were associated uniquely with earlier menarche, including mother's unmarried status and lower family income. Associations varied by race/ethnicity. BMI did not mediate associations.

Conclusion—Racial differences in menarche may in large part be due to SES differences. Future experimental or quasi-experimental studies should examine whether intervening on SES factors could have benefits for delaying menarche among Blacks and Hispanics.

Keywords

menarche; socioeconomic factors; ethnic groups; cohort study

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Marked racial/ethnic differences exist in age at menarche in the U.S., with Black and Hispanic girls experiencing menarche significantly earlier than non-Hispanic whites and Asians.[1-3] Understanding these disparities is critical because early menarche has been linked to poor health outcomes across the life course, including behavioral problems in adolescence and reproductive cancers in adulthood.[45] Numerous studies since the 1970s have shown that body weight is highly correlated with menarcheal timing, with heavier girls experiencing menarche at younger ages.[6-10] Research to date suggests that ethnic differences in menarcheal timing appear largely due to differences in overweight across racial/ethnic groups.[7] However, upstream factors that influence prepubertal weight gain, such as socioeconomic status (SES), are understudied and may play a prominent role in explaining why girls from certain ethnic groups are heavier and start menstruating earlier.

Menarche is biologically linked to adequate nutrition and body fat increases, which hormonally signal that a developing girl's body is ready to prepare for reproduction.[1112] As the prevalence of obesity has increased in the U.S., girls' age at pubertal onset has simultaneously declined.[613-15] Girls growing up in low SES environments are at particularly high risk for both obesity and early menarche. Low-income families have less access to healthful foods and fewer opportunities for safe physical activity.[16-19] This may partially explain the racial disparities in menarcheal timing observed in the U.S., given that Black and Hispanic youth are more likely to grow up in lower-income communities and, on average, tend to be more overweight compared to their non-Hispanic white counterparts.[19]

Past research examining associations between SES on menarche has yielded inconsistent results. Some studies have shown that lower SES is associated with earlier menarche,[20] while others have shown no association[21] or mixed results depending on the SES indicator examined.[722] One reason for equivocal findings may be that a variety of SES indicators are utilized across studies (e.g., family income, single parenthood, parental education, parental occupation, income-to-needs ratio and poverty), yet are referred to, collectively, as SES. Studies have found that certain SES indicators, such as single parent status and household income, were associated with earlier menarche, while other indicators were not.[23242422] SES has also been assessed with combinations of indicators. For instance, using longitudinal data from the Collaborative Perinatal Project (n=262), James-Todd et al created an SES index (comprised of income, education, and occupation) and found that a 20-unit decrease in this index at age 7 was associated with a 4-month decrease in age at menarche later in life; however, specific indicators were not examined to assess unique SES effects.[20] Few studies have included multiple indicators concurrently to tease apart unique effects, and of those that have, there appear to be differential associations depending on the indicators used. Moreover, some evidence suggests that the timing of when SES indicators are measured (e.g., at birth versus later in childhood) may influence findings.[25] No known studies have examined whether SES of the previous generation (grandparents' SES) in addition to parents' generation influences a girls' menarcheal timing.

Another explanation for equivocal results across studies examining SES and menarche is that race/ethnicity may modify these associations. In other words, certain SES indicators may influence menarche differentially depending on ethnicity. In a 2012 study, using data from National Longitudinal Study of Youth, Regan et al found that age of menarche declined with increases in exposure to poverty during early childhood for whites, but there was no effect for African-Americans.[26] Another longitudinal study using National Growth and Health Study data also revealed racial differences in the association between family income and menarche. Black girls from *high* income brackets experienced menarche early, while the reverse was true for whites.[23] In contrast, a study using National Health and Nutrition Examination Survey data found no associations between SES indicators and age at menarche when race was included as a covariate; however, effect modification by race was not tested.[21] Studies that control for race may show no significant association, or an attenuated association, between SES and menarche, while within-ethnic group studies or stratified analyses may yield associations that vary by race.

Finally, a significant gap in the literature is that there has been a dearth of research examining whether BMI operates as a mediator between SES and menarche. This is an important area for investigation given that girls' body weight may present one of the few modifiable targets for intervention to delay puberty. One recent longitudinal study showed that, for African American girls, the availability of more neighborhood recreational facilities delayed girls' breast development; however, this association was not mediated by girls' BMI.[27] Given the paucity of studies that have concurrently examined BMI when studying the effects of SES on menarche, it is unclear whether BMI might operate as a mediator of these effects.

The current study addresses these gaps. We aimed to: (1) assess the unique effects of multiple SES indicators on age at menarche longitudinally, using two prepubertal time points and two generations of SES data; (2) examine whether prepubertal BMI mediated associations between SES indicators and age at menarche; and (3) test whether associations varied by race/ethnicity. Based on the literature, we hypothesized that certain SES factors, particularly family income and father absence, would be more highly correlated with menarcheal timing compared to others. Both father absence and low family income have the potential to disrupt the home environment significantly and lead to poor nutrition and overweight. Single parent and low-income households often have fewer resources available to control the food environment and to promote opportunities for recreation. We anticipated that by examining these and other SES factors together, we could tease apart their potential unique effects and also determine whether they were differentially related to menarche across ethnic groups.

To examine these hypotheses, we used data from a large nationally representative study to examine the relative influence of various SES indicators assessed at birth and at age 7 on age at menarche. The multigenerational nature of these data allowed us to examine parental/family SES during daughters' childhood as well as grandparents' SES. This is a marked strength of the current study given the scarcity of research examining potential intergenerational effects of SES on menarche.

Method

Participants

We used data from the National Longitudinal Survey of Youth 1979 (NLSY79), an ongoing examination of 12686 men and women born between 1957 and 1964.[28] Participants in this cohort were interviewed annually between 1979 and 1994, and biennially thereafter. The children of these adults entered the study in 1986 and ranged from 9 to 16 years old at that time. These children were surveyed biennially from 1986 to present as part of the NLSY Children and Young Adult survey. Participants in the original cohort were sampled using a complex multistage sampling approach. Households in the U.S. were randomly sampled and screened for eligible participants; blacks, Hispanics, economically disadvantaged non-Hispanic non-black youth, and individuals serving in the military were oversampled.[28] Our analyses focused on mothers in the original NLSY79 cohort and their daughters. This included 4851 daughters (9 – 16 years old), assessed from 1986 to 2010, and their mothers (n=3216) who participated in the original NLSY79. Mothers reported retrospectively on their parents (girls' grandparents) to obtain data about the previous generation. Data were completely de-identified and were not subject to human subjects review.

Measures

Age at menarche. Daughter's age at first menstrual period (in years) was assessed using mother's report for girls under age 14y. When the child was 14 years old or older, we used child report. These data were collected at each survey wave (on a biennial basis) since the girls entered the study in 1986. Less than two years of recall were required due to the study design of biennial surveys. Retrospective report of age at menarche is reliable, particularly when length of recall is short.[29,30]

Non-time varying independent variables. Non-time varying independent variables included covariates: year of daughter's birth, family size at daughter's birth, mother's age at menarche in years, and daughter's race/ethnicity, as well as SES indicators: grandfather's and grandmother's highest level of education and maternal prenatal healthcare. Daughter's prepubertal BMI was converted to age (in months) and sex-specific percentiles based on CDC definitions. BMI percentile at ages 8-9y was included to test for mediational effects of body weight. However, to minimize missing data, values for BMI were based on surveys completed within 1 year (before or after) the child was 8-9 years old. This age range (7-10y) was specifically chosen because it generally follows SES assessment at age 7y (to establish temporal precedence in mediational models) and because it typically precedes menarche for most girls in the US.

Time varying independent variables. Time varying independent variables included SES indicators: family income, family wealth, household size, mother's education, mother's employment, and mother's marital status. Family income was total family income in the past year from all sources. Family wealth was calculated based on subtracting total debt from all sources from total assets from all sources. Family income and family wealth were standardized to year 2000 dollars. Family income was also adjusted for family size and economies of scale as described in Rehkopf et al.[31] Because family wealth was not collected in 1979-1982 or 1984, we used the 1985 values for these years.

Analyses

Analyses were conducted using SAS 9.3. All analyses were weighted using the custom survey weights obtained from the weight generator developed by the National Longitudinal Survey. Of the 3216 mothers, 1216 (38%) had more than one female child. We accounted for potential clustering among sisters by basing our inferences on the robust sandwich estimates of Lin and Wei (1989), available in SAS options.[32]

A number of girls (N=935) had not experienced menarche by the time of the last survey, therefore we used survival analysis with Cox-proportional hazards to estimate associations. Survival analysis allowed us to examine time to age at menarche and account for censored data for those who had yet to achieve menarche. Hazard ratios (HR) can be interpreted similarly to relative risk estimates. For categorical exposures, the HR can be interpreted as the instantaneous probability of menarche for girls with as compared to without each exposure, adjusting for covariates. The proportional hazards model assumes that this ratio of probabilities is the same for any age, given that menarche has not yet occurred.

Time-varying covariates were entered into the models in two ways: values at birth and values at 7 years. Values of the time-varying variables at 7 years were based on surveys completed within 1 year (before or after) the child was 7. If more than one survey occurred within this window, the one closest to the 7 years was used. Children who had no surveys within this window, or were censored before the age of 6, had missing values for this time point, as did girls who were born prior to the first survey in 1979 (n= 515) and therefore were missing assessment “at birth.” To minimize list-wise deletion, “missing” categories were included for all categorical variables in our models (descriptives in Table 1).

First, we examined univariate statistics for the variables of interest. Second, we examined bivariate (unadjusted) and multivariate (adjusted) associations between the time varying and non-time varying variables and daughter's age at menarche. In the multivariate analyses, we included all covariates and SES indicators simultaneously to determine which indicators uniquely predicted age at menarche. Third, we followed Baron and Kenny's approach to test for mediation by BMI.[33] We also used Sobel tests to determine whether mediation was statistically significant.[34,35] Last, we examined SES by race interactions for all indicators, and when there were significant interactions, we then repeated our multivariate analyses stratified by race/ethnicity. For all analyses, we included a “missing” category to account for missing data for each independent variable (not shown in results tables).

Results

Sample characteristics

A total of 4851 female children born to 3216 mothers were included in these analyses. The ethnic breakdown of the sample in weighted percentages was: 17% non-Hispanic Black; 7% Hispanic; 75% White; and less than 1% Asian. Baseline characteristics of the 4851 female children are presented in Table 1, along with information about missing data. There were racial/ethnic differences across SES indicators, with Whites and Asians generally faring better economically compared to Blacks and Hispanics. Unmarried status (at both child's birth and at age 7y) was much higher among Black families (34.0%) compared to Asian (2.9%), Hispanic (14.5%) and white (7.2%) families. Regardless of race, mothers were more highly educated than the grandmothers of the children, with more mothers having college educations.

Associations between covariates, SES indicators and age at menarche

Results from primary analyses are presented in Table 2. The first column shows bivariate associations between independent variables and age at menarche; the second column presents associations adjusted for all indicators (covariates and SES indicators); the third column presents results when BMI was examined as a mediator.

A number of covariates were associated with earlier menarche in adjusted analysis (Table 2, column 2), including daughter's later birth year, younger maternal age at menarche, being Black or Hispanic, and having a higher BMI percentile. It should be noted that including mother's age at menarche in models did not attenuate findings. Although we did not have the power to test for differences, point estimates were reduced for Black and Hispanic when adjusting for SES indicators. The HR for Hispanic was reduced from 1.34 to 1.18, and for Black, 1.33 to 1.20 (column 1 versus 2).

Several SES indicators were uniquely associated with menarcheal timing in adjusted analyses (Table 2, column 2). Daughters with mothers who were not married at birth *and* at age 7 experienced menarche significantly earlier than those with mothers who were married at both time points. Lower family income and larger family size at birth were associated with daughter's earlier menarche; while mother's unemployment at age 7 was related to later menarche.

BMI as a mediator of SES effects

After including BMI in models (Table 2, column 3), the point estimates for the SES variables and menarche remained largely unchanged, indicating that BMI did not act as a mediator. Results from Sobel tests (column 4) confirmed that BMI did not mediate associations between SES variables and menarche.

Racial/ethnic differences

A number of SES variables significantly interacted with race to predict age at menarche, including grandmother's education, mother's education at child's birth and age 7y, mother's marital status, family income at birth, and family size at birth. Table 3 presents results from adjusted analyses stratified by race for these SES variables. Three sets of findings stood out. One, grandmother's lower education was related to later menarche for Black girls. Two, mother's unmarried status (at birth and age 7) was associated with earlier menarche for Hispanics and Whites, but not for Blacks. Three, family income at child's birth was related to earlier menarche for Blacks and Hispanics, but not Whites. In stratified analyses, we also examined whether BMI mediated the effects of SES indictors on menarche, but there was no evidence for mediation.

Discussion

This is one of few existing longitudinal studies to estimate associations between multiple SES indicators and age at menarche. Our study is unique in that we examined SES measures at several time points and across two generations. As expected, girls who were overweight, those who were Black or Hispanic, and those whose mothers had earlier menarche tended to experience menarche earlier on average. Several SES indicators were associated with age at menarche in adjusted models, including maternal marital status and family income, which we hypothesized would be the most salient exposures and might operate through prepubertal BMI. However, findings suggested no mediating effect of BMI. A notable strength was the sample's ethnic diversity, which allowed us to examine effect modification by race. Associations between key SES indicators and menarche varied considerably depending on racial/ethnic group.

Generally, findings from our unadjusted analyses showed that lower SES was associated with earlier menarche, lending support to the notion that growing up in low SES contexts is bad for one's health. Girls from low SES environments are more likely to be exposed to cumulative risk factors – both in utero and during childhood – that are believed to contribute to early puberty, including chemicals that act as endocrine disruptors, lifestyle factors that promote obesity, family and neighborhood stressors, and other prepubertal risk factors.[36] One exception in our findings was maternal employment. We found that mother's unemployment (when daughters were age 7) was associated with *later*, as opposed to *earlier*, menarche. If replicated in future research, this finding deserves closer examination into the quality of parent-child relationships prepubertally and stressors related to working and raising a family, which may influence girls' menarcheal timing. Alternatively, women who are not working may hail from higher resource households and therefore choose not to work. Thus, rather than indicating low income, maternal unemployment may be a proxy for financial stability.

Results from our adjusted model showed there were marked reductions in the estimated effect of Black and Hispanic race on menarche when SES indicators were included. Although we did not have the power to test for differences formally, point estimates suggest that racial differences in menarche may be largely attributed to disparities in socioeconomic status. Moreover, it is arguable that remaining racial/ethnic differences may be in part due to residual confounding.[37] While we were able to deal with several issues that influence residual confounding, measurement error exists in the factors we examined, and thus a greater extent of racial/ethnic differences may remain to be explained by SES factors.

A primary aim of the current study was to determine which SES variables might be most salient in predicting menarche; thus, we included multiple indicators and key covariates in adjusted models. Based on past studies, we hypothesized that family income and maternal marital status would be the most robust SES indicators and would operate through BMI to influence menarche. These factors initially stood out in terms of direct effects but there was no mediation by BMI. Moreover, moderating analyses (tests of interaction) revealed that associations differed depending on race. Lower family income at birth was associated with earlier menarche for Blacks (and to some extent for Hispanics), but not for white girls. This pattern is inconsistent with previous work that showed no effects, or opposite effects, of poverty/low income on Black girls' menarcheal timing.[23,38] In particular, a 2010 study by Reagan et al. using NLSY data showed that girl's menarche declined with increases in poverty during early childhood (0-5y) for whites, but there was no effect for African-Americans.[26] The Reagan study and ours differ in a number of ways, which may account for the contrasting results. First, Reagan et al. focused on one particular SES measure (percent time in poverty from 0-5y), whereas our study aimed to test the unique effects of a number of SES indicators, while adjusting for others, to determine which were most robust. Second, the Reagan study excluded girls who had not reached menarche yet, limiting their sample size. In contrast, we used survival analyses and included participants who had not yet reached menarche, which might have resulted in better estimates. Third, we accounted for clustering among sisters, and there is no indication that this was done in the Reagan study. Nonetheless, these differing results call for future research in this area.

Interestingly, mothers' unmarried status was a risk factor for earlier menarche among Hispanic and white girls, but not among Black girls. These differences warrant further examination of cultural norms and family support structures that may ameliorate risk within certain ethnic groups, yet confer risk for others. It is possible that lower-income African American families have stronger, extended kinship networks compared to other ethnic groups and that these networks help support unmarried mothers and therefore protect against the negative effects of single parenthood on pubertal timing.[39] These culturally-grounded networks may be responsive to the high prevalence of single parenting among African American mothers in the US. However, results require confirmation and replication.

Finally, among African American girls, our results indicated that lower education of grandmothers was associated with delayed menarche for their granddaughters. While this finding runs counter to most current observations of education differences in age at menarche, prior work has demonstrated that education has had markedly different associations with health outcomes over different cohorts for different racial/ethnic groups.[40] This association should be investigated in future studies, preferably using data that allows for historical examination into the health effects of changes in educational attainment over time.

Limitations

Our study has limitations worth noting. Some girls had not experienced menarche by the last available year of assessment, therefore results must be viewed in light of those missing data. However, we used survival analyses rather than logistic regression in order to estimate effects better. We were unable to include Asian participants in our stratified analyses given small numbers (n=34). Further, the Hispanic group included girls from various Latino backgrounds and we were not able to tease apart these subgroups given that sample sizes were too small to allow robust analyses. Future research should focus on specific Latino and Asian subgroups to determine if SES is differentially associated with menarche depending on a child's ethnic heritage or country of origin.

Public health and policy implications

We emphasize that our findings are not causal, but should be interpreted as associations that are suggestive of what types of policies and interventions may prove beneficial for slowing or even reversing the trend of increasingly early menarche. True experiments or quasi-experiments based on retrospective or prospective policy changes should be the next step. Our findings suggest that these types of studies should be pursued to determine whether intervening on factors associated with family income, or related factors, could have benefits for delaying menarche, particularly among Hispanics and Blacks. Given that these populations are at increased risk of experiencing menarche early, this would be particularly advantageous for not only raising the overall age at menarche in the population as a whole, but also for reducing racial disparities. For example, income distributions in the United States have changed dramatically over time as a direct result of tax policy.[41] More specifically, the single policy of the Earned Income Tax Credit creates dramatically different income levels for working families, and changes in this policy over time have been shown to have impacts on child health and development.[42] This suggests that social determinants of health can be intervened upon, and that these interventions may in turn have beneficial impacts on child development.

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Table 1

Sample Characteristics.

Variable	ALL N	ALL %	Asian n	Asian %	Black n	Black %	Hispanic n	Hispanic %	White n	White %
Grandfather's education										
Missing	840	17.3	11	32.4	426	30.6	163	20.0	240	9.2
Less than High school	1218	25.1	7	20.6	331	23.7	403	49.4	477	18.3
High School	2021	41.7	8	23.5	521	37.4	197	24.2	1295	49.7
College or higher	772	15.9	8	23.5	116	8.3	52	6.4	596	22.9
Grandmother's education										
Missing	304	6.3	4	11.8	103	7.4	71	8.7	126	4.8
Less than High school	1088	22.4	3	8.8	272	19.5	489	60.0	324	12.4
High School	2860	59.0	20	58.8	896	64.3	235	28.8	1709	65.5
College or higher	599	12.3	7	20.6	123	8.8	20	2.5	449	17.2
Mother's education at child's birth										
Missing	515	10.6	2	5.9	198	14.2	74	9.1	241	9.2
Less than High school	228	4.7	0	0.0	38	2.7	111	13.6	79	3.0
High School	2669	55.0	21	61.8	784	56.2	442	54.2	1422	54.5
College or higher	1439	29.7	11	32.4	374	26.8	188	23.1	866	33.2
Mother's marital status at child's birth										
Missing	515	10.6	2	5.9	198	14.2	74	9.1	241	9.2
Not married	1541	31.8	7	20.6	780	56.0	250	30.7	504	19.3
Married	2795	57.6	25	73.5	416	29.8	491	60.2	1863	71.4
Mother's employment at child's birth										
Missing	2529	52.1	18	52.9	797	57.2	418	51.3	1296	49.7
Unemployed/part time	920	19.0	5	14.7	272	19.5	172	21.1	471	18.1
Half/Full time	1402	28.9	11	32.4	325	23.3	225	27.6	841	32.2
Mother's employment when child was 7y										
Missing	1161	23.9	8	23.5	313	22.5	171	21.0	669	25.7
Unemployed/part time	1780	36.7	10	29.4	492	35.3	326	40.0	952	36.5
Half/Full time	1910	39.4	16	47.1	589	42.3	318	39.0	987	37.8

Variable	ALL N	%	Asian n	%	Black n	%	Hispanic n	%	White n	%
Family income quartile at child's birth										
Missing	515	10.6	2	5.9	198	14.2	74	9.1	241	9.2
1	1084	22.3	5	14.7	499	35.8	192	23.6	388	14.9
2	1084	22.3	6	17.6	390	28.0	246	30.2	442	16.9
3	1084	22.3	10	29.4	199	14.3	191	23.4	684	26.2
4	1084	22.3	11	32.4	108	7.7	112	13.7	853	32.7
Family wealth quartile at child's birth										
Missing	1023	21.1	3	8.8	352	25.3	168	20.6	500	19.2
1	956	19.7	5	14.7	487	34.9	194	23.8	270	10.4
2	958	19.7	4	11.8	307	22.0	204	25.0	443	17.0
3	957	19.7	12	35.3	180	12.9	149	18.3	616	23.6
4	957	19.7	10	29.4	68	4.9	100	12.3	779	29.9
Family size at child's birth										
Missing	515	10.6	2	5.9	198	14.2	74	9.1	241	9.2
5+	996	20.5	6	17.6	421	30.2	229	28.1	340	13.0
1-4	3340	68.9	26	76.5	775	55.6	512	62.8	2027	77.7
Mother had prenatal visits during pregnancy										
Missing	384	7.9	3	8.8	114	8.2	93	11.4	174	6.7
No	62	1.3	0	0.0	22	1.6	17	2.1	23	0.9
Yes	4405	90.8	31	91.2	1258	90.2	705	86.5	2411	92.4
Mother's marital status at child's birth and 7y										
Missing, Missing	389	8.0	1	2.9	149	10.7	57	7.0	182	7.0
Missing, Not married	62	1.3	0	0.0	31	2.2	9	1.1	22	0.8
Not married, Missing	367	7.6	2	5.9	154	11.0	60	7.4	151	5.8
Not married, Not married	785	16.2	1	2.9	477	34.2	118	14.5	189	7.2
Missing, Married	64	1.3	1	2.9	18	1.3	8	1.0	37	1.4
Not married, Married	389	8.0	4	11.8	149	10.7	72	8.8	164	6.3
Married, Missing	662	13.6	6	17.6	84	6.0	115	14.1	457	17.5
Married, Not married	394	8.1	4	11.8	106	7.6	71	8.7	213	8.2
Married, Married	1739	35.8	15	44.1	226	16.2	305	37.4	1193	45.7

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Variable	ALL N	%	Asian n	%	Black n	%	Hispanic n	%	White n	%
Child's BMI at 8-9 years										
Missing	961	19.8	6	17.6	220	15.8	156	19.1	579	22.2
<5	369	7.6	3	8.8	121	8.7	58	7.1	187	7.2
5 – 85	2350	48.4	19	55.9	635	45.6	387	47.5	1309	50.2
>85	1171	24.1	6	17.6	418	30.0	214	26.3	533	20.4
Mother's age at menarche										
Missing	88	1.8	3	8.8	11	0.8	22	2.7	52	2.0
5 - 8	8	0.2	0	0.0	2	0.1	1	0.1	5	0.2
9 – 12	2162	44.6	13	38.2	635	45.6	403	49.4	1111	42.6
13 – 16	2531	52.2	18	52.9	722	51.8	380	46.6	1411	54.1
>16	62	1.3	0	0.0	24	1.7	9	1.1	29	1.1

Note: all p-values were significant at the p<0.001 for chi-square tests of association.

Table 2

Results from survival analyses examining associations between SES factors and daughter's age at menarche, before adding interaction terms, and tests of BMI mediation.

	Unadjusted associations		Adjusted associations		After including BMI percent		
Variable	**Hazard Ratio(CI)**	**p**	**Hazard Ratio(CI)**	**p**	**Hazard Ratio(CI)**	**p**	**Sobel test p**
Child's birth year	1.02(1.01-1.03)	0.00	1.05(1.03-1.07)	0.00	1.04(1.02-1.06)	0.00	0.03
Grandfather's education (Ref=College+)							
Less than High school	1.19(1.05-1.34)	0.01	1.09(0.94-1.27)	0.25	1.12(0.95-1.31)	0.17	0.45
High School	1.12(1.02-1.24)	0.02	1.06(0.94-1.19)	0.36	1.08(0.95-1.23)	0.24	0.70
Grandmother's education (Ref=College+)							
Less than High school	1.18(1.02-1.37)	0.02	1.04(0.87-1.24)	0.65	1.04(0.86-1.24)	0.70	0.88
High School	1.10(0.98-1.23)	0.09	1.05(0.92-1.19)	0.47	1.06(0.92-1.21)	0.41	0.69
Mother's education at child's birth (Ref=College+)							
Less than High school	1.34(1.01-1.78)	0.04	1.29(0.83-2.01)	0.25	1.71(1.17-2.49)	0.01	0.31
High School	1.05(0.96-1.14)	0.29	1.10(0.93-1.29)	0.26	1.11(0.93-1.32)	0.23	0.49
Mother's education when child was 7y (Ref=College+)							
Less than High school	1.25(0.93-1.69)	0.14	0.84(0.53-1.35)	0.48	0.78(0.51-1.18)	0.24	0.62
High School	1.03(0.94-1.13)	0.48	0.91(0.78-1.06)	0.21	0.91(0.77-1.07)	0.23	0.46
Mother's marital status at birth and 7y (Ref=Married, Married)							
Not married, Not married	1.46(1.31-1.62)	0.00	1.18(1.01-1.37)	0.03	1.17(1.00-1.37)	0.05	0.81
Not married, Married	1.22(1.06-1.39)	0.00	1.10(0.94-1.29)	0.23	1.08(0.91-1.27)	0.37	0.70
Married, Not married	1.12(0.97-1.29)	0.12	0.99(0.85-1.15)	0.91	1.06(0.91-1.23)	0.47	0.95
Mother's employment at child's birth (Ref=Half/Full time)							
Unemployed/part time	1.06(0.95-1.19)	0.30	1.04(0.92-1.17)	0.53	1.02(0.90-1.15)	0.81	0.90
Mother's employment when child was 7y (Ref=Half/Full time)							
Unemployed/part time	0.92(0.84-1.00)	0.05	0.91(0.83-1.00)	0.04	0.92(0.84-1.01)	0.08	0.21
Family income quartile at child's birth (Ref = 4)							
1	1.28(1.15-1.43)	0.00	1.18(1.01-1.38)	0.04	1.15(0.97-1.36)	0.10	0.23
2	1.22(1.09-1.36)	0.00	1.12(0.97-1.29)	0.13	1.07(0.92-1.25)	0.40	0.52
3	1.09(0.98-1.20)	0.11	1.13(1.00-1.27)	0.04	1.13(1.00-1.27)	0.05	0.19
Family income quartile when child was 7y (Ref = 4)							

Variable	Unadjusted associations Hazard Ratio(CI)	p	Adjusted associations Hazard Ratio(CI)	p	After including BMI percent Hazard Ratio(CI)	p	Sobel test p
1	1.21(1.07-1.37)	0.00	1.06(0.90-1.24)	0.48	1.03(0.88-1.21)	0.69	0.83
2	1.17(1.04-1.32)	0.01	1.09(0.94-1.27)	0.27	1.05(0.90-1.23)	0.54	0.68
3	0.93(0.83-1.05)	0.24	0.94(0.83-1.06)	0.28	0.91(0.81-1.04)	0.17	0.65
Family wealth quartile at child's birth (Ref = 4)							
1	1.26(1.11-1.44)	0.00	0.93(0.77-1.12)	0.45	0.97(0.80-1.17)	0.74	0.85
2	1.09(0.97-1.22)	0.15	0.91(0.78-1.07)	0.25	0.93(0.79-1.11)	0.43	0.71
3	1.03(0.93-1.15)	0.57	1.00(0.89-1.12)	0.96	0.99(0.88-1.12)	0.92	1.00
Family wealth quartile when child was 7y (Ref = 4)							
1	1.29(1.15-1.45)	0.00	1.06(0.88-1.28)	0.54	1.07(0.88-1.30)	0.51	0.76
2	1.16(1.03-1.30)	0.01	1.05(0.90-1.23)	0.52	1.10(0.93-1.30)	0.27	0.66
3	0.97(0.86-1.09)	0.56	0.99(0.87-1.13)	0.91	0.99(0.86-1.14)	0.88	0.99
Family size at birth (Ref= 1-4)							
5+	1.22(1.11-1.35)	0.00	1.12(1.00-1.24)	0.04	1.10(0.99-1.24)	0.08	0.22
Family size when child was 7y (Ref= 1-4)							
5+	0.99(0.90-1.08)	0.77	0.96(0.87-1.05)	0.34	0.96(0.87-1.06)	0.38	0.60
Age of mother at birth of child	1.01(1.01-1.02)	0.00	1.00(0.99-1.02)	0.62	1.00(0.98-1.02)	0.89	0.95
Mother's age at menarche	0.89(0.87-0.92)	0.00	0.89(0.86-0.91)	0.00	0.89(0.86-0.92)	0.00	<.01
Child's race (Ref=White)							
Asian	1.14(0.75-1.73)	0.54	1.09(0.74-1.60)	0.66	1.17(0.80-1.72)	0.42	0.79
Black	1.33(1.22-1.45)	0.00	1.20(1.08-1.33)	0.00	1.16(1.03-1.29)	0.01	0.05
Hispanic	1.34(1.21-1.48)	0.00	1.18(1.04-1.34)	0.01	1.12(0.97-1.29)	0.12	0.21
Child's BMI percent at 8-9y	1.01(1.01-1.01)	0.00			1.01(1.00-1.01)		

Note: Missing categories were included in all analyses; results not shown.

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Table 3

Results from adjusted analyses examining SES factors and timing of menarche stratified by race.

	Black		Hispanic		White	
Variable	**Hazard Ratio(CI)**	**p**	**Hazard Ratio(CI)**	**p**	**Hazard Ratio(CI)**	**p**
Grandmother's education (Ref=College+)						
Less than High school	0.79(0.62-1.01)	0.06	1.05(0.62-1.78)	0.85	1.14(0.91-1.44)	0.24
High School	0.80(0.65-0.98)	0.03	1.03(0.60-1.78)	0.92	1.09(0.95-1.24)	0.21
Mother's education at child's birth (Ref=College+)						
Less than High school	1.20(0.72-2.00)	0.48	1.31(0.78-2.20)	0.31	1.29(0.59-2.80)	0.52
High School	0.92(0.75-1.13)	0.44	1.10(0.76-1.60)	0.61	1.17(0.95-1.44)	0.14
Mother's education when child was 7y(Ref=College+)						
Less than High school	0.84(0.42-1.68)	0.62	0.77(0.43-1.37)	0.37	0.91(0.45-1.87)	0.80
High School	1.10(0.90-1.35)	0.34	0.75(0.53-1.07)	0.11	0.89(0.73-1.09)	0.25
Mother's marital status at birth and 7y (Ref=Married, Married)						
Not married, Not married	1.01(0.85-1.19)	0.94	1.50(1.13-1.99)	0.01	1.42(1.17-1.72)	0.00
Not married, Married	0.93(0.76-1.15)	0.51	1.10(0.83-1.46)	0.51	1.18(0.95-1.46)	0.13
Married, Not married	1.23(0.98-1.55)	0.08	1.06(0.76-1.49)	0.72	1.04(0.88-1.23)	0.65
Family income quartile at child's birth(Ref = 4)						
1	1.48(1.12-1.95)	0.01	1.23(0.92-1.65)	0.17	1.13(0.92-1.38)	0.24
2	1.42(1.09-1.84)	0.01	1.40(1.07-1.84)	0.02	0.99(0.83-1.18)	0.94
3	1.76(1.37-2.26)	0.00	0.94(0.74-1.19)	0.59	1.06(0.93-1.20)	0.40
Family size at birth (Ref= 1-4)						
5+	1.09(0.94-1.26)	0.24	0.99(0.82-1.20)	0.94	1.15(0.99-1.34)	0.07

Note: Analyses are adjusted for all SES indicators and covariates and included missing categories; results not shown. Asians were not included in tests of interaction and subgroup analyses because of the small sample size (n=34).