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Original Paper

American Indian, Alaska Native, Native Hawaiian, and Pacific Islander Children's Body Mass Index: Diminished Returns of Parental Education and Family Income

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Abstract

Background: *High socioeconomic status (SES) is associated with several health-related outcomes, such as obesity and body mass index (BMI). However, we do not know whether SES is associated differently with children's BMI from American Indian and Alaska Native and Native Hawaiian and Pacific Islander (AIAN/NHPI) families when compared to non-Hispanic White (NHW) families.* ***Aim:*** *To compare AIAN/NHPI and NHW families for associations between parental education, family income, and children's BMI in the United States (U.S).* ***Methods:*** *This cross-sectional study used the Adolescent Brain Cognitive Development (ABCD) study. Participants (n = 8580) included 63 AIAN/NHPI and 8517 NHW children between ages 9 and 10. The independent variables were parental education and family income. The primary outcome was BMI. Race was the moderator. Age, sex, and family structure were covariates. Mixed-effects regression models were used for data analysis.* ***Results:*** *In the pooled sample, higher parental education and family income were associated with lower children's BMI. We found interactions between race and parental education and family income indicating weaker associations between parental education and family income and children's BMI in AIAN/NHPI families than in NHW families.* ***Conclusion:*** *The salience of parental education and family income as social determinants of children's BMI is diminished for AIAN/NHPI families than NHW families. As a result, AIAN/NHPIs children with high SES remain at risk for high BMI, while high-SES NHW children show the lowest BMI. Future research should test if obesogenic environments, food options, and physical activity-friendly neighborhoods can explain higher-than-expected BMI in high-SES AIAN/NHPI children. In other terms, more research is needed to understand if residential segregation, discrimination, and historical trauma*

explain the observed differences in the social patterning of childhood BMI in AIAN/NHPI and NHW communities.

Keywords

social determinants, education, income, obesity, body mass index, population groups

1. Background

Similar to many other parts of the world (Wang & Lim, 2012), the U.S. has recently experienced an increasing trend in childhood body mass index (BMI) (Skinner, Ravanbakht, Skelton, Perrin, & Armstrong, 2018). However high childhood BMI does not affect all the subsections of the U.S. population equally, as childhood obesity is more common in families from racial and ethnic minorities and low socioeconomic status (SES) backgrounds (Ogden, Carroll, Kit, & Flegal, 2014). The racial, ethnic, and SES gaps in childhood BMI are also increasing (Singh, Siahpush, & Kogan, 2010b). High childhood BMI is a risk factor for a wide range of cardiometabolic diseases, such as future diabetes, hypertension, stroke, and heart disease. Childhood obesity also increases the risks of cancer, healthcare costs, and overall mortality (Freedman, Khan, Dietz, Srinivasan, & Berenson, 2001; Jeffreys, McCarron, Gunnell, McEwen, & Smith, 2003; Reilly & Kelly, 2011). In addition to such unfavorable health effects, high childhood BMI is also associated with adverse economic outcomes in the future (Gortmaker, Must, Perrin, Sobol, & Dietz, 1993).

Compared to children with low SES, children with high SES have a lower risk of obesity and BMI (Wang, 2001). This is in part because SES indicators, such as parental education and family income, reflect parenting, living conditions, food habits, exposure to stress, and other risk factors that contribute to the risk of obesity (Fan & Jin, 2014; Rogers et al., 2015; Singh, Siahpush, & Kogan, 2010a). Children from high SES families also have healthier diets and engage in a more active life style (Goyal et al., 2010).

American Indian and Alaska Native and Native Hawaiian and Pacific Islander (AIAN/NHPI) individuals have the highest BMI levels in adults and children when compared to other racial and ethnic groups (Halpern & Regier, 2007; Hodge, Cantrell, & Kim, 2011). However, across various racial and ethnic groups, we know the least about factors that predict childhood BMI in AIAN/NHPIs families. The Department of Health and Human Services (HHS) website lists the current prevalence of childhood obesity in AIAN/NHPI families as unknown (HHS, 2020). We argue that lack of data regarding risk factors of childhood obesity in AIAN/NHPI families may contribute to the excess heart disease, stroke, diabetes, and other cardiometabolic diseases in adults in AIAN/NHPI communities (Bungum, Landers, Azzarelli, & Moonie, 2012; Hawley & McGarvey, 2015; Liu et al., 2009; O'Dea, 2008). Availability of data on SES effects on childhood BMI is extremely important (Karter et al., 2013; Mau et al., 2010) given that such information is essential for the allocation of limited resources in sections of the community that need them most. Such information may also help us tailor our interventions by targeting most-at-risk communities, and better design, implement and evaluate our programs based on groups that need them. Thus, research in this area is needed for us to suggest programs and policies to eliminate racial, ethnic

and economic inequalities in childhood obesity and childhood BMI, particularly for AIAN/NHPI communities (Eisenmann, 2006; Skidmore & Yarnell, 2004). In the absence of detailed data on the association between SES and childhood BMI in AIAN/NHPI populations, we cannot develop an informed response to reduce an additional burden of childhood and adult obesity that the ongoing epidemic is currently imposing on minority populations.

There is at least some evidence that suggests that the SES gradient in childhood BMI may be weaker in AIAN/NHPI populations than the SES effects in NHW families. This is based on the observations that SES effects on obesity (Assari, Chalian, & Bazargan, 2019; Assari, Thomas, Caldwell, & Mincy, 2018), exercise (Assari, 2019), and diet (Assari, Boyce, Bazargan, Caldwell, & Mincy, 2020; Assari & Lankarani, 2018) are weaker in Hispanic and Non-Hispanic Black families than in NHW families, a pattern called Minorities' Diminished Returns (MDRs) (Assari, 2017; Shervin Assari, 2018; S. Assari, 2020e). Such MDRs suggest that SES effects tend to be weaker for any non-White group than for their NHW counterparts (Assari, 2017; Assari, 2018; Assari, 2020e). Exhibiting a wide range of behaviors and health outcomes that are well beyond BMI (Assari, 2020d, 2020e; Assari, Bazargan, & Caldwell, 2019; Assari, Caldwell, & Zimmerman, 2018), MDRs are attributed to structural racism, segregation, and discrimination (Assari, 2018a; Assari & Moghani Lankarani, 2018). For example, it has been shown that non-White people with high SES may remain in poor high-risk neighborhoods (Assari, Boyce, Caldwell, Bazargan, & Mincy, 2020), generate less income (Assari, 2020e; Assari, Preiser, & Kelly, 2018) and wealth (S. Assari, 2020a), experience high levels of discrimination (Assari, F. X. Gibbons, & R. Simons, 2018; Assari, F. X. Gibbons, & R. L. Simons, 2018) and stress (Assari & Bazargan, 2019c), have higher-risk peers and family members (Assari, Caldwell, & Bazargan, 2020), live in high-risk context (Boyce, Bazargan, Caldwell, Zimmerman, & Assari, 2020) and lack access to medical care (Assari, 2020d) and use of healthcare services (Assari & Bazargan, 2019a).

We are, however, not aware of any previous studies that have tested the relevance of MDRs of family SES indicators on AIAN/NHPI children's BMI. There has been one study on MDRs of own educational attainment on tobacco use of AIAN/NHPI adult population, showing that highly-educated AIAN/NHPI adults remain at risk of smoking, a pattern different than for NHWs, due to MDRs of educational attainment (Assari & Bazargan, 2019b). However, there is still a need to expand our knowledge about MDRs and SES on childhood BMI in AIAN/NHPI families.

1.1 Aims

This study aimed to compare AIAN/NHPI and NHW families for the association of families' SES and childhood BMI. We focused on the two most robust SES indicators, namely family income, and parental educational attainment. While higher family SES is expected to be associated with lower BMI (*Hypothesis 1*), we expect the associations between family income and parental education and childhood BMI to be less salient for AIAN/NHPI children than for NHW children (*Hypothesis 2*). The weaker association between family SES and childhood BMI in AIAN/NHPI families rather than NHW families is in line with the previously published work on weaker effects of family SES indicators, such as parental

education and family income on BMI of children and adults in Black and Hispanic than NHW families (Assari, 2020c; Assari, Caldwell, & Mincy, 2018; Assari & Lankarani, 2016).

2. Materials and Methods

2.1 Design and Setting

For this cross-sectional study, we conducted a secondary analysis of existing data. We borrowed data from the Adolescent Brain Cognitive Development (ABCD) study (Alcohol Research: Current Reviews Editorial, 2018; Casey et al., 2018; Karcher, O'Brien, Kandala, & Barch, 2019; Lisdahl et al., 2018; Luciana et al., 2018). The ABCD is a national study of children's brain development in the US (Alcohol Research: Current Reviews Editorial, 2018; Auchter et al., 2018).

2.2 Sample and Sampling

Participants in the ABCD study are diverse and represent race, ethnicity, sex, and SES of the U.S. population. ABCD participants were recruited across 21 participating sites that encompass over $1/5^{th}$ of the U.S. population of 9-10-year-old children. The sampling and recruitment to the ABCD study are described elsewhere (ABCD; Alcohol Research: Current Reviews Editorial, 2018; Asaad & Bjarkam, 2019; Auchter et al., 2018; Beauchaine, 2020; Buscemi et al., 2018; Casey et al., 2018; Dick et al., 2019a, 2019b, 2019c; Exuperio et al., 2019; Feldstein Ewing et al., 2018; Fine et al., 2019; Garavan et al., 2018; Gray, Schvey, & Tanofsky-Kraff, 2019; Hoffman, Howlett, Breslin, & Dowling, 2018; Lisdahl et al., 2018; Lynch et al., 2019; Michelini et al., 2019; Werneck et al., 2018). The ABCD efforts in sampling yielded a final sample that approximates the national composition of race and ethnicity, age, sex, SES, and urbanicity for 9-10-year-old children. The current analysis included 11590 9-10- year-old children who had data on our study variables, including baseline BMI and positive urgency. Children were included regardless of their race or ethnicity. No additional eligibility was considered for this analysis.

2.3 Measures and Measurements

Our study's variables were race, parental education, family income, age, sex, marital status of the family, and BMI. Race, a self-identified variable, was a categorical variable: 1 for AIAN/NHPI and 0 for NHW (reference group). Age was a continuous measure in months. Sex, 1 for males and 0 for females, was a dichotomous variable. Parents reported their marital status, the highest level of educational attainment, and family income. The family structure was 1 for married and 0 for unmarried. Parental education was a five-level nominal variable with less than high school, high school diploma / General Education Development (GED), some college, bachelor's degree, and graduate studies. Family income was a three-level nominal variable: less than 50K, 50-100K, and 100K+. The child's BMI was measured up-to two times. BMI was calculated based on measured height and weight. Appendix 1 shows the distribution of the predictors and outcomes.

2.4 Data Analysis

This analysis was performed in the Data Analysis and Exploration Portal (DEAP), National Data Archive (NDA), National Institutes of Health (NIH). We reported an unweighted mean (SD) and frequencies (%) for our continuous and categorical variables in the pooled sample and by race. We used Chi-square and independent sample t-test for comparison of racial groups. We applied mixed (random)-effects models. These models address the ABCD data's nested nature. As BMI observations were nested to individuals who were nested within families who themselves were nested within 21 sites, we corrected for non-independence of our sample. Three mixed-effects models were performed. In our models, parental education and family income were the predictors, BMI was the outcome, the race was the moderator, and covariates included sex, age, and marital status of the family. *Model 1* (no interaction) was our model in the absence of any interaction terms. *Model 2* (the interaction model) included interaction terms between race and parental education. *Model 2* (the interaction model) included interaction terms between race and family income. Appendix 1 shows the result of our attempts to explore the regression assumptions. Appendix 2 shows the formula used for *Model 1, Model 2, and Model 3* in the DEAP system. Regression coefficient (b), standard error (SE), and p-values were reported for our parameters.

2.5 Ethical Aspects

Our analysis was exempt from a full review from the Institutional Review Board (IRB). The main ABCD study protocol was approved by the University of California, San Diego (UCSD) IRB. The ABCD participants signed consent or assent, depending on their age (Auchter et al., 2018).

3. Results

Table 1 shows the summary statistics of the pooled sample and by race. The current analysis was performed on 8580 BMI observations that were for participants who AIAN/NHPI (n = 63) or NHW (n = 8517) children between the ages 9 and 10.

Table 1. Descriptive Data Overall and by Race

	level	All	White	AIAN/NHPI
N		8580	8517	63
		Mean (SD)	Mean (SD)	Mean (SD)
Age (Month)*		123.29 (9.68)	123.31 (9.69)	120.60 (8.66)
Body Mass Index (BMI)*		18.13 (3.41)	18.12 (3.39)	20.24 (5.04)
		n(%)	n(%)	n(%)
Family Income*	<50K	1083 (12.6)	1052 (12.4)	31 (49.2)
	>=50K&<100K	2647 (30.9)	2623 (30.8)	24 (38.1)
	>=100K	4850 (56.5)	4842 (56.9)	8 (12.7)

Parental Education*	<HS Diploma	41 (0.5)	36 (0.4)	5 (7.9)
	HS Diploma/GED	256 (3.0)	244 (2.9)	12 (19.0)
	Some College	1609 (18.8)	1576 (18.5)	33 (52.4)
	Bachelor	2740 (31.9)	2731 (32.1)	9 (14.3)
	Post Graduate Degree	3934 (45.9)	3930 (46.1)	4 (6.3)
Sex*	Female	4069 (47.4)	4029 (47.3)	40 (63.5)
	Male	4511 (52.6)	4488 (52.7)	23 (36.5)
Married Family*	No	1501 (17.5)	1481 (17.4)	20 (31.7)
	Yes	7079 (82.5)	7036 (82.6)	43 (68.3)

*P < 0.05

American Indian/Alaskan Native (AIAN) Native Hawaiian Pacific Islander (NHPI)

BMI: Body Mass Index

Table 2 summarizes the fit statistics for our three mixed-effects regression models in the overall (pooled) sample. *Model 1* tested the additive effects of race, family income, and parental education against childhood BMI in the pooled sample. *Model 2* (Interaction Model) tested significant interactions between race and parental education on childhood BMI in the pooled sample. *Model 3* (Interaction Model) tested significant interactions between race and family income on childhood BMI in the pooled sample.

Table 2. The Fit of Three Mixed-effects Models

	Model 1	*Model 2*	*Model 3*
	Effect Size	Effect Size	Effect Size
N	8580	8580	8580
R-squared	0.10202	0.10303	0.10242
ΔR-squared	0.00123 (0.12%)	0.00879 (0.88%)	0.0024 (0.24%)

Table 3 summarizes results for each parameter in each of our mixed-effects regression models that were performed in the overall sample. While *Model 1* showed significant effects of race, family income, and parental education on childhood BMI, *Model 2* showed significant interactions between race and parental education, and *Model 3* documented a significant interaction between race and family income on childhood BMI.

Table 3. Parameters in Our Three Mixed-effects Models

	Model 1			*Model 2*			*Model 3*		
	df	F	p-value	df	F	p-value	df	F	p-value
Family Income	2**	5.28	0.005	4***	14.47	< 0.001	2**	5.79	0.003
Race (AIAN/NHPI)	1*	5.60	0.018	1*	4.01	0.045	1	0.47	0.494
Parental Education	4***	14.23	< 0.001	2**	5.21	0.005	4***	14.27	< 0.001
Age	1***	818.08	< 0.001	1***	818.75	< 0.001	1***	819.42	< 0.001
Sex	1	2.69	0.101	1	2.61	0.106	1	2.66	0.103
Married Family	1***	12.89	< 0.001	1***	13.26	< 0.001	1***	12.56	< 0.001
Parental Education × Race (AIAN/NHPI)	-	-	-	4*	2.41	0.047	2	1.93	0.146
Family Income × Race (AIAN/NHPI)	-	-	-	-	-	-	2	1.93	0.146

American Indian/Alaskan Native (AIAN) Native Hawaiian Pacific Islander (NHPI)

*P < 0.05 **P < 0.01 ***P < 0.001

Table 4 shows the beta coefficients of our parameters of interest for each of our three mixed-effects regression models, all performed in the pooled sample. *Model 1* showed inverse (negative) associations between family income and parental education with childhood BMI in the pooled sample. This model also showed a positive association between AIAN/NHPI racial and ethnic status and childhood BMI. *Model 2* showed positive and significant interactions between race and three levels of parental education: HS diploma/GED, some college, and bachelor's degree. *Model 3* documented a significant interaction between race and family income of more than 100K on childhood BMI. These interactions were suggestive of smaller SES effects for AIAN/NHPI than for NHW families.

Table 4. The Results of Mixed-effects Regression Models without and with the Interaction Terms

	b	SE	p
Model 1			
Family Income (> =50K& < 100K)	-0.28#	0.17	0.090
Family Income (> =100K)	-0.53*	0.17	0.002
Race (AIAN/NHPI)	1.23*	0.52	0.018
Parental Education (HS Diploma/GED)	-0.27	0.70	0.696
Parental Education (Some College)	-0.73	0.66	0.269
Parental Education (Bachelor)	-1.53*	0.67	0.022
Parental Education (Post Graduate Degree)	-1.62*	0.67	0.016
Age (Month)	0.07***	0.00	< 0.001
Sex (Male)	-0.14	0.08	0.101

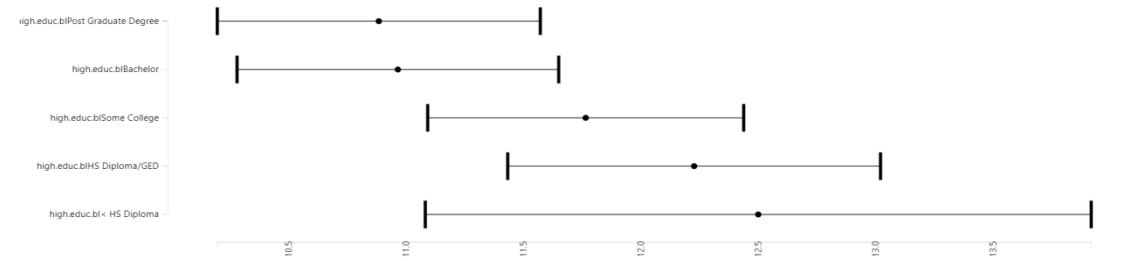
Model 2			
Parental Education (HS Diploma/GED)	-0.98	0.74	0.186
Parental Education (Some College)	-1.42*	0.71	0.045
Parental Education (Bachelor)	-2.21**	0.71	0.002
Parental Education (Post Graduate Degree)	-2.29**	0.71	0.001
Race (AIAN/NHPI)	-3.84*	1.92	0.045
Family Income (> =50K& < 100K)	-0.27#	0.17	0.099
Family Income (> =100K)	-0.52**	0.17	0.003
Age (Month)	0.07***	0.00	< 0.001
Sex (Male)	-0.14	0.08	0.106
Parental Education (HS Diploma/GED) × Race (AIAN/NHPI)	5.89**	2.25	0.009
Parental Education (Some College) × Race (AIAN/NHPI)	5.76**	2.05	0.005
Parental Education (Bachelor) × Race (AIAN/NHPI)	5.06*	2.28	0.027
Parental Education (Post Graduate Degree) × Race (AIAN/NHPI)	2.57	2.96	0.385
Model 3			
Family Income (> =50K& < 100K)	-0.31#	0.17	0.065
Family Income (> =100K)	-0.56**	0.17	0.001
Race (AIAN/NHPI)	0.49	0.72	0.494
Parental Education (HS Diploma/GED)	-0.33	0.70	0.636
Parental Education (Some College)	-0.82	0.67	0.219
Parental Education (Bachelor)	-1.61*	0.67	0.016
Parental Education (Post Graduate Degree)	-1.69*	0.67	0.012
Age (Month)	0.07***	0.00	< 0.001
Sex (Male)	-0.14	0.08	0.103
Family Income (> =50K& < 100K) × Race (AIAN/NHPI)	0.99	1.12	0.379
Family Income (> =100K) × Race (AIAN/NHPI)	3.11*	1.61	0.050

American Indian/Alaskan Native (AIAN) Native Hawaiian Pacific Islander (NHPI)

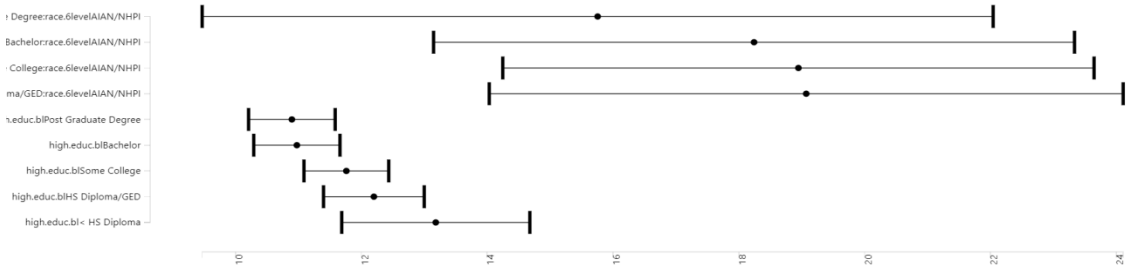
*P < 0.05 **P < 0.01 ***P < 0.001

#P < 0.1

Figure 1 shows the overall effect, as well as the interaction between race and parental education on childhood BMI in the pooled sample. This figure shows an inverse association between parental education on childhood BMI in NHW families, but a weaker inverse association between parental education and childhood BMI in AIAN/NHPI families.



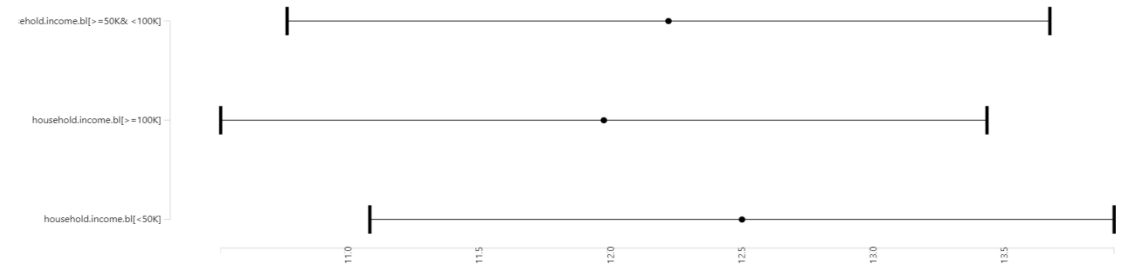
(a) overall



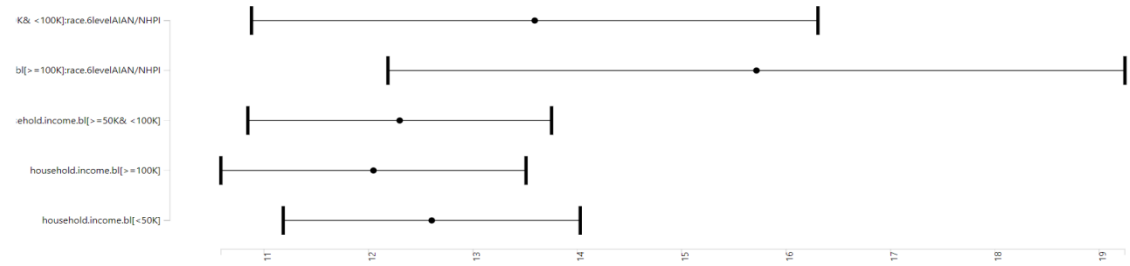
(b) by race

Figure 1. Association between Parental Education and Body Mass Index (BMI) Overall and by Race

Figure 2 shows the overall effect of family income, as well as interaction effects between race and family income on childhood BMI in the pooled sample. This figure shows an inverse association between family income and children BMI in NHW families, but a weaker inverse association between family income and childhood BMI in AIAN/NHPI families.



(a) overall



(b) by race

Figure 2. Association between Family Income and Body Mass Index (BMI) Overall and by Race

4. Discussion

Our findings showed the protective effects of high parental education and family income against high BMI in children. While both SES indicators seemed to be protective against high BMI levels of children, high family SES indicators were less relevant to the BMI levels of AIAN/NHPI children. As a result, AIAN/NHPI children remained with high BMI, across all SES levels, a pattern which could not be seen in NHW families. For NHW families, children had low BMI if they had high SES.

Our study is not the first study to show weaker effects of economic and psychological risk factors on BMI of a racial and ethnic minority group, however, it is the first study to document this pattern in AIAN/NHPI families. This pattern is best described for high SES Black children (Assari, 2018b; Assari, Caldwell, & Bazargan, 2019; Assari, Thomas, et al., 2018) and adults (Assari, 2016; Assari, Nikahd, Malekahmadi, Lankarani, & Zamanian, 2016). In some studies, high SES showed a stronger association with BMI for White children than for Black children (Assari, 2018b; Assari, Caldwell, et al., 2019; Assari, Thomas, et al., 2018) and adults (Assari, Bazargan, & Chalian, 2020). Any source of social marginalization, as well as race and ethnicity, may reduce the protective effect of SES for BMI and obesity (Assari, 2019b). In a study, SES showed weaker protective effects against obesity and high BMI in Lesbian, Gay, Bisexual (LGB) people than in non-LGB people (Assari, 2019b). Thus, although previous work has documented differential correlates of BMI in marginalized people defined by race (Black and Latino) and LGB status, this is one of the first studies to document a similar pattern in 9-10-year-old AIAN/NHPI children.

A wide range of structural and environmental risk factors may contribute to the excess risk of obesity in AIAN/NHPI communities. Such structural factors may hinder the protective effect of education and income, so all individuals would be at risk of obesity, regardless of their individual-level risk factors and protective factors. Due to racial and residential segregation, food options are fried chicken and apples for non-White and White children, respectively (Kwate, 2008). The high density of fast food stores and low availability of healthy food choices may increase the risk of obesity for AIAN/NHPI communities, regardless of their individual-level risk factors and SES (Fleischhacker, Evenson, Rodriguez, & Ammerman, 2011). Thus, some of the BMI inequalities are due to societal and structural inequalities that force unhealthy food options (Black, Moon, & Baird, 2014). The same inequalities exist for exercise options (Lopez & Hynes, 2006; McNeill, Kreuter, & Subramanian, 2006), as opportunities and space are limited for pro-health behaviors, such as exercise and walking in communities of color (Connor, 2006).

As such, the diminished return of SES on BMI in people of color may be due to a unique set of social factors. In such contexts, even psychological risk factors may lose some of their relevance as risk factors of obesity in communities of color. While racial discrimination is a significant predictor of BMI in racial minority population (Hunte & Williams, 2009; Johnson, Risica, Gans, Kirtania, & Kumanyika, 2012; Schmengler, Ikram, Snijder, Kunst, & Agyemang, 2017), racial discrimination does not seem to play a major role as a cause of obesity for White children. Similarly, environmental influences may be a larger contributor to obesity in communities of color, when compared to White communities (Assari, 2020a;

Assari, 2020). In various studies, depression has shown weaker effects on BMI for people of color than White children and adults (Assari, 2014; Assari, 2019a, 2020b; Assari & Caldwell, 2015; Carter & Assari, 2016). The association between sustained obesity and depression was found to be a White females' phenomenon, as these women did not expect and accept obesity (Carter & Assari, 2016). Similarly, emotion regulation may be of the highest salience as a predictor of obesity for White females than for other races by sex groups (Carter & Assari, 2016). Some degrees of privilege is needed for the population if obesity generates depression (Carter & Assari, 2016). If the social group is not privileged, and obesity becomes a norm, then it is tolerated and does not generate depression (Carter & Assari, 2016).

Our study had several limitations. We did not measure a wide range of confounding factors that could impact the family SES – childhood BMI association. These include access to food, diet, neighborhood, family habits, exercise, and health. The sample was not entirely random. Besides, this was a national sample, but the results are not generalizable to the U.S. children. We also did not measure parents' BMI or eating feeding habits. Our sample size was very imbalanced; our n was much larger in NHWs than in was in AIAN/NHPIs. Despite these limitations, the results reported here are among the first to explore the variation of the link between SES and childhood between AIAN/NHPIs and NHWs. Research is extremely limited on AIAN/NHPIs.

Our results may have implications for public health interventions and programs that aim to prevent obesity among racial minority children in the U.S. The results also have clinical implications for working with AIAN/NHPI children at risk of obesity. We argue that high SES and low SES in AIAN/NHPI families have the same risk on childhood BMI, a pattern that is similar to Black and Latino (Cummins et al., 2020; Frisco, Quiros, & Van Hook, 2016), but different than in NHW families. Family SES indicators may have fewer salient effects for a high BMI of AIAN/NHPI children than for NHW children. Investing in and addressing obesity prevention of children should be done regardless of the family's SES, and all AIAN/NHPI families should be regarded as similarly at risk.

The racial differences that were observed here also have research implications. Research tends to conceptualize race as a control variable in BMI research (Quinto et al., 2011). We should not assume that BMI and obesity have similar correlates across racial and ethnic groups (Norman, Nyberg, Elinder, & Berlin, 2015). One size never fits all (Field, Camargo, & Ogino, 2013). Although race and ethnicity also have a direct effect on BMI, some of the effects of race and ethnicity are through altering the correlates of SES and BMI. Thus, as a simple rule, race should never be reduced to a control variable (covariate). Race is a proxy of social context, habits, vulnerabilities, beliefs, and many more sociological factors that may indirectly influence how a group reacts when faced with a challenge.

5. Conclusions

Racial/ethnic groups of children are not similar in how family SES indicators contribute to high BMI. As our results showed, family SES seems to be a less salient social determinant of BMI for AIAN/NHPI children, compared to NHW children.

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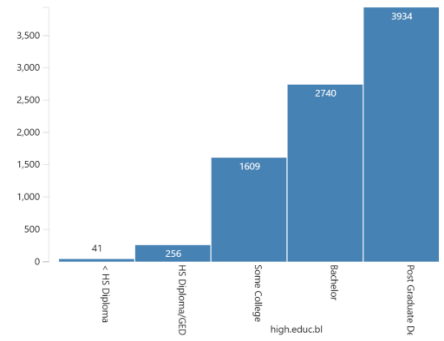
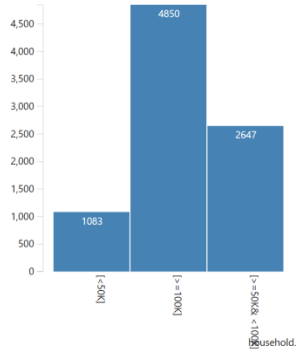
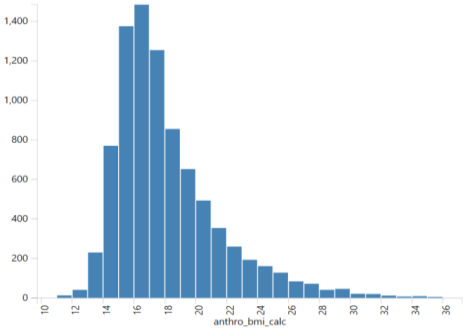
Appendix 1. Distribution of the Predictors (a and b), Outcome (c), Residuals (d), and Quantiles (e)



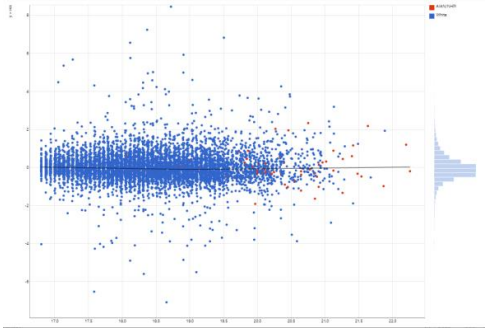
(a) Parental education



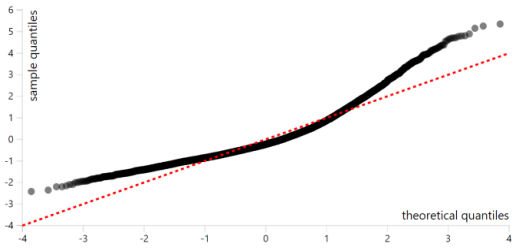
(b) Household income



(c) Body mass index (BMI)



(d) Model residuals



(e) Quantiles

Appendix 2. Model Formula

Model 1

anthro_bmi_calc ~ high.educ.bl + race.6level + household.income.bl + age + sex + married.bl

Random: ~(1|abcd_site)+(1|rel_family_id)+(1|src_subject_id)

Model 2

anthro_bmi_calc ~ high.educ.bl + race.6level + household.income.bl + age + sex + married.bl + high.educ.bl * race.6level

Random: ~(1|abcd_site)+(1|rel_family_id)+(1|src_subject_id)

Model 3

anthro_bmi_calc ~ high.educ.bl + race.6level + household.income.bl + age + sex + married.bl + household.income.bl * race.6level

Random: ~(1|abcd site)+(1|rel_family_id)+(1|src_subject_id)