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Original Paper

Parental Education and Nucleus Accumbens Response to Reward Anticipation: Minorities' Diminished Returns

Shervin Assari[1,2*]

[1] Department of Family Medicine, Charles Drew University, Los Angeles, CA 90059, USA

[2] Department of Urban Public Health, Charles Drew University, Los Angeles, CA 90059, USA

[*] Shervin Assari, E-mail: assari@umich.edu; Tel.: +1-734-858-8333

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Abstract

Background: *Considerable research has documented the effects of race and Socioeconomic Status (SES) on reward-seeking behaviors; however, less is known about the multiplicative effects of race and family SES on brain response to reward anticipation. Minorities' Diminished Returns (MDRs) suggest that family SES would show weaker effects on brain development of children in non-White families than in White families.* ***Objective:*** *To test race by SES variation in Nucleus Accumbens (NAcc) response to reward anticipation (NAcc-RA) among American children.* ***Methods:*** *For this cross-sectional analysis, data came from the Adolescents Brain Cognitive Development (ABCD) study which included 6,419, 9-10 year old children. The independent variable was parental education. The moderator was race. The primary outcome was the right NAcc-RA. Age, sex, ethnicity, household income, and family structure were the covariates. We used mixed-effect regression models that adjusted for the nested nature of the ABCD data.* ***Results:*** *While high parental education was associated with a higher amount of right NAcc-RA, this effect was stronger for White than non-White children. This finding was evident in the observed interactions between race and parental education on the right NAcc-RA.* ***Discussion:*** *For American children, NAcc-RA is not shaped by race or family SES, but by their intersection. As a result of the interaction between race and SES (diminished return of SES for non-Whites), middle-class racial minority children may remain susceptible to high-risk behaviors. Disparities in high-risk behaviors in children should not be reduced to economic disparities. Structural inequalities may reduce the return of SES resources for non-White families.*

Keywords

socioeconomic status, reward, high risk, reward-seeking, ethnic groups, Nucleus Accumbens

1. Introduction

Marginalization-related Diminished Returns (MDRs) (Assari, Caldwell, & Bazargan, 2019) refer to the weaker effects of SocioEconomic Status (SES) indicators, such as parental education, on outcomes for members of marginalized groups when compared to their non-marginalized peers (Assari, 2017c; Shervin Assari, 2018). As a result of MDRs, racial minority children from high SES families remain at risk of poor developmental outcomes (Spera, Wentzel, & Matto, 2009). For example, relative to Whites, non-White childrenshow weaker effects of parental education on school performance (Spera et al., 2009), health (Goodman, Slap, & Huang, 2003), depression (Assari & Caldwell, 2018a), anxiety (Assari, Caldwell, & Zimmerman, 2018), suicide (Assari, Boyce, Bazargan, & Caldwell, 2020), impulsivity (Morris, Silk, Steinberg, Myers, & Robinson, 2007; Park & Holloway, 2013), reward dependence (Assari, Akhlaghipour, Boyce, Bazargan, & Caldwell, 2020; Assari, Boyce, Akhlaghipour, Bazargan, & Caldwell, 2020), attention (Assari, Boyce, & Bazargan, 2020a), aggression (Pabayo, Molnar, & Kawachi, 2014), problem behaviors (Assari, 2020c; Assari, Boyce, Caldwell, & Bazargan, 2020), and substance use (Goodman et al., 2003; Wills, McNamara, & Vaccaro, 1995). At least some of these effects may be due to MDRs of parental education and income on children's brain development in non-White families (Assari, Boyce, & Bazargan, 2020b).

As a result of these MDRs, middle-class racial minority children and adults report worse than expected outcomes across a variety of domains (Assari, Boyce, Bazargan, Mincy, & Caldwell, 2019; Assari et al., 2019; Assari, Caldwell, & Mincy, 2018a; Assari, Caldwell, & Mincy, 2018b; Assari, Thomas, Caldwell, & Mincy, 2018). For example, middle-class racial minority children remain at risk of anxiety (Assari, Caldwell, & Zimmerman, 2018), depression (Assari & Caldwell, 2018a), poor health (Assari, 2018h), and poor school performance (Assari, 2019; Assari & Caldwell, 2019b). With the same pattern, middle-class racial minority children engage in high-risk behaviors (Assari et al., 2019), such as aggression (Assari et al., 2019) and tobacco use (Assari & Mistry, 2018; Assari, Mistry, & Bazargan, 2020), to a level that is unexpected given their high SES. As these patterns are repeatedly documented (S. Assari, 2018f, 2018g, 2018h, 2018i; Assari & Moghani Lankarani, 2018a) across studies, settings, and outcomes (Assari, 2018f, 2018j; Assari & Caldwell, 2019a; Assari & Thomas et al., 2018), they are believed to be robust and to be the result of structural racism and social stratification that influence the daily lives of all people of color, regardless of their race and ethnicity (Assari, 2017c; Shervin Assari, 2018).

A number of studies have investigated societal and structural causes of the observed diminished returns of SES for racial minority families. Racial discrimination is shown to be higher, not lower, in high SES racial minority families (Assari, Lankarani, & Caldwell, 2018). These families are also increasingly vulnerable to racial discrimination (Assari, Preiser, Lankarani, & Caldwell, 2018). This increased exposure and vulnerability to discrimination in middle-class minority families is due in part to middle-class racial minority families living and working at a higher proximity to White families (Assari, 2018b; Assari & Moghani, 2018b), which increases their exposure to discrimination (Assari, 2020b;

Assari, Gibbons, & Simons, 2018a; Assari, Gibbons, & Simons, 2018b). As a result, the health gains that are expected to follow SES are less for middle-class families who are non-White (Assari, 2018b; Assari et al., 2018; Assari & Moghani, 2018b; Hudson et al., 2012; Hudson, Neighbors, Geronimus, & Jackson, 2016; Hudson, Puterman, Bibbins-Domingo, Matthews, & Adler, 2013). Due to systemic societal injustice, neighborhoods (Assari, 2016a) and social contacts (Assari, 2017d) become less protective of children in non-White than in White high SES families.

Across various brain regions, the nucleus accumbens (NAcc) is most central to Pavlovian learning (Carr, 2020; Dingess et al., 2017; Gugusheff, Ong, & Muhlhausler, 2014; Olivo, Caba, Gonzalez-Lima, Rodriguez-Landa, & Corona-Morales, 2017; Romani-Perez et al., 2017; Saul'skaya & Mikhailova, 2004), meaning that the NAcc regulates incentive salience, pleasure-seeking, reward dependence, and positive reinforcement (Deshmukh & Sharma, 2012; Kask & Schioth, 2000; Pan, Berman, Haberny, Meller, & Carr, 2006; Pan, Siregar, & Carr, 2006; Salamone, Mahan, & Rogers, 1993; Whishaw & Kornelsen, 1993). The NAcc mediates cue-triggered reward-seeking behaviors (Gomez, Shnitko, Caref, Nicola, & Robinson, 2020; Grottick, Fletcher, & Higgins, 2000; Kask & Schioth, 2000; Tricomi & Lempert, 2015; Uribe-Cerda, Morselli, & Perez-Leighton, 2018). By regulating food cues' response, the NAcc also plays a unique role in addiction pathogenesis (Casquero-Veiga, Garcia-Garcia, Pascau, Desco, & Soto-Montenegro, 2018; Dingess et al., 2017; Uribe-Cerda et al., 2018; van de Giessen, de Bruin, la Fleur, van den Brink, & Booij, 2012) and in issues such as obesity (Aitken, Greenfield, & Wassum, 2016). Alteration of the NAcc function is shown to be associated with changes in seeking food and drugs (Carr, Cabeza de Vaca, Sun, & Chau, 2009; Naef, Moquin, Gratton, & Walker, 2013; Nakazato, 2005; Singer et al., 2016; Vollbrecht, Nobile, Chadderdon, Jutkiewicz, & Ferrario, 2015). In animal models (Derman & Ferrario, 2018) and humans (Alsio et al., 2010; Azzout-Marniche et al., 2016; Brown et al., 2017; Crespo, Stockl, Zorn, Saria, & Zernig, 2008; Durst, Konczol, Balazsa, Eyre, & Toth, 2019; Oginsky & Ferrario, 2019), NAcc activity is linked to the expression of behaviors secondary to various cues (Derman & Ferrario, 2018). Inputs and cues related to drugs, sex, and food can elicit a robust NAcc dopamine response that results in seeking these behaviors (Aitken et al., 2016). Thus, the NAcc is a part of the brain reward system and, through dopamine release, alters how an individual seeks drugs, food, and sex (Alonso-Caraballo et al., 2020; Oginsky & Ferrario, 2019; Oginsky, Maust, Corthell, & Ferrario, 2016; Ong & Muhlhausler, 2011; Vollbrecht et al., 2015). Activity in the NAcc also predicts addiction susceptibility (Derman & Ferrario, 2018). Although we know that the NAcc has a prominent role in these behaviors, most of the existing evidence is limited to animal studies performed in highly-controlled laboratory settings (Alsio et al., 2010; Azzout-Marniche et al., 2016; Brown et al., 2017; Crespo et al., 2008; Durst et al., 2019; Oginsky & Ferrario, 2019). The NAcc response to reward anticipation (NAcc-RA) is one of the functions of the NAcc that reflects how the individual responds to cues that signal a potential reward. NAcc-RA and other proxies of reward responsiveness have predicted several risk behaviors, obesity, and drug use (Alonso-Caraballo et al., 2020; Oginsky & Ferrario, 2019; Oginsky et al., 2016; Ong & Muhlhausler, 2011; Vollbrecht et al., 2015).

1.1 Aims

There is a need to study brain areas that reflect similar MDRs in mechanisms that are involved in reward processing (e.g., NAcc). To extend the existing knowledge on the relevance of MDRs to brain development of children of color in middle-class families, we used a national sample to explore race by family SES variation in right NAcc-RA among 9-10 year old American children. We expected to observe weaker SES effects on the right NAcc-RA for non-White than White children (Assari, 2017c; Shervin Assari, 2018; Assari et al., 2019). This hypothesis is based on our expectation that right NAcc-RA may carry some of the effects of social injustice on children's brain development and risk-taking behaviors.

2. Methods

We conducted a secondary analysis of the previous ABCD study data (Alcohol Research: Current Reviews Editorial, 2018; Casey et al., 2018; Karcher, O'Brien, Kandala, & Barch, 2019; Lisdahl et al., 2018; Luciana et al., 2018). Using a cross-sectional design, we applied data from wave 1 of the ABCD study; our analysis included a total number of 6,419, 9-10 children who had participated previously in the ABCD study. The ABCD participants are nested to MRI devices and the families are nested to 21 sites across the nation. The ABCD sample was primarily recruited through school systems with sampling (school selection) informed by demographic factors (Garavan et al., 2018). Eligibility criteria for this analysis were having complete data for our study variables, regardless of race, ethnicity, or sex, and having a recommended (to use) MID fMRI.

The study variables included race, ethnicity, age, sex, parental education, household income, family structure, and NAcc-RA. The primary outcome was right NAcc-RA, measured using task-based fMRI. In the data set, this variable is tfmri_mid_run1_antic.large.vs.small.reward_beta_subcort.aseg_accumbens. area.rh. Race was a nominal variable: Black, Asian, Other/Mixed, and White (reference). Ethnicity was coded as 1 for Latino and 0 for non-Latino. Parents reported their years of schooling, which was operational zed as a categorical variable: 1) Less than high school diploma, 2) high school diploma, 3) some college, 4) college graduation, and 5) graduate-level education. Household income was a three-level categorical variable: Income > 100,000 USD, Income 50,000 -100,000 USD, and Income Less than 50,000 USD (reference). Children's age, in months, was a continuous measure and was reported by parents. Sex was reported as 1 for males and 0 for females. Parental marital status was reported as 1 for married and 0 for any other condition (reference).

2.1 Data Analysis

We used the Data Analysis and Exploration Portal (DEAP) for data analysis. DEAP uses R package **(R version 4.0)** for fitting the models. Frequencies (n and %) and mean [standard deviations (SDs)] were reported to describe the variables in the pooled sample and across racial groups. To estimate vicariate analyses between the study variables, we used an ANOVA and Chi-square test. To perform our multivariable analyses, we performed mixed-effect regression models that adjusted for the data's nested nature. **Appendix 1** shows our modeling strategy. **Appendix 2** shows the distribution of our independent variable, dependent variable, and the test of assumption for our regression model. We also ruled out co linearity between study variables. The independent variable was parental education, and the dependent variable was NAcc-RA. Our models controlled for ethnicity, age, sex, family income, and family structure. All models were performed in the pooled sample. *Model 1* did not have any interaction terms. *Model 2* did include interaction terms between parental education and racial group membership. Unstandardized regression coefficient (b), SE, and p-values were reported for each model. A p-value that was equal to or less than 0.05 was significant.

2.2 Ethical Aspect

Our analysis was exempt from a full review. The ABCD study protocol, however, was approved by the University of California, San Diego (UCSD) Institutional Review Board (IRB) (Auchter et al., 2018).

3. Results

3.1 Descriptives

The sample included 6,419, 9-10 year-old children. Table 1 presents the descriptive statistics of the pooled sample and across racial groups. White children came from families who had the highest income and level of parental education, and Black children came from families who had the lowest level of parental education and income.

Table 1. Descriptive Data Overall (*n* = 6419)

Level	Overall	All	White	Black	Asian	Other/Mixed	p
N		6419	4431	814	132	1042	
		n (%)	n (%)	n (%)	n (%)	n (%)	
Hispanic	No	5189 (80.8)	3674 (82.9)	768 (94.3)	121 (91.7)	626 (60.1)	< 0.001
	Yes	1230 (19.2)	757 (17.1)	46 (5.7)	11 (8.3)	416(39.9)	
Sex	Female	3174 (49.4)	2136 (48.2)	421 (51.7)	73(55.3)	544(52.2)	0.024
	Male	3245 (50.6)	2295 (51.8)	393 (48.3)	59(44.7)	498(47.8)	
Married Family	No	1783 (27.8)	850 (19.2)	567 (69.7)	18(13.6)	348(33.4)	< 0.001
	Yes	4636 (72.2)	3581 (80.8)	247 (30.3)	114 (86.4)	694 (66.6)	
Household Income	< 50K	1700 (26.5)	782 (17.6)	543 (66.7)	13 (9.8)	362 (34.7)	< 0.001
	50-100K	2849 (44.4)	2289 (51.7)	98 (12.0)	89 (67.4)	373 (35.8)	
	> =100K	1870 (29.1)	1360 (30.7)	173 (21.3)	30 (22.7)	307 (29.5)	
Parental Education	< High school Diploma	193 (3.0)	73 (1.6)	70 (8.6)	2 (1.5)	48 (4.6)	< 0.001
	HS Diploma/GED	469 (7.3)	191 (4.3)	176 (21.6)	1 (0.8)	101 (9.7)	
	Some College	1623 (25.3)	947 (21.4)	314 (38.6)	12 (9.1)	350 (33.6)	
	Bachelor	1792 (27.9)	1385 (31.3)	120 (14.7)	33 (25.0)	254 (24.4)	
	Post Graduate Degree	2342 (36.5)	1835 (41.4)	134 (16.5)	84 (63.6)	289 (27.7)	

	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	
Age (Months)	119.29 (7.49)	119.33 (7.49)	119.42 (7.32)	119.89 (8.05)	118.94 (7.56)	0.321
NAcc-RA	0.07 (0.56)	0.06 (0.55)	0.09 (0.43)	0.10 (0.33)	0.05 (0.69)	0.423

NAcc-RA= Nucleus Accumbens (NAc) response to reward anticipation Main Effect of Parental Education Table 2 reports the results of a pooled sample regression model. *Model 1*, which only included the main effects, showed that high parental education was associated with higher NAcc-RA levels (Figure 1).

Table 2. Mixed Effect Regressions on the Effects of Parental Education and Race on Childhood Body Mass Index (NAcc-RA)

	Estimate	Std. Error	Pr(> | t|)
High School Diploma/GED	0.14976**	0.04966	0.00257
Some College	0.15093***	0.04523	0.00085
Bachelor	0.15765***	0.0475	0.00091
Graduate Degree	0.15725**	0.04797	0.00105

**p<0.01, ***p<0.001.

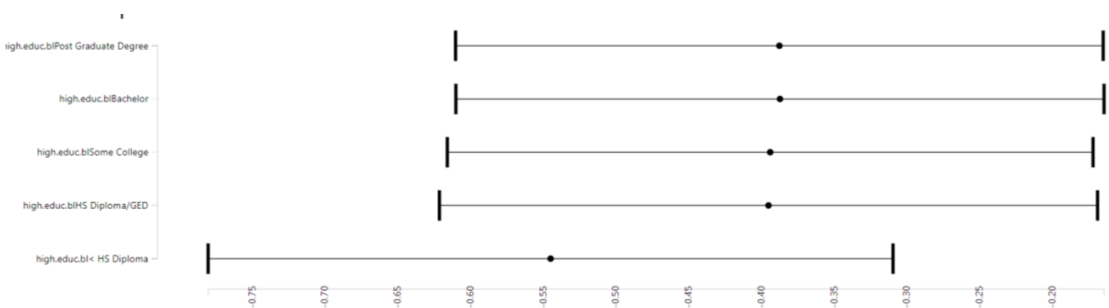

Figure 1. Association between Parental Education and Nucleus Accumbens (NAcc) Response to Reward Anticipation (NAcc-RA)

3.2 Interactional Effects

Table 3 reports the results of *Model 2*. This model showed an interaction between parental education and race, meaning that the effects of high parental education on reducing NAcc-RA were less pronounced for non-White than White children (Figure 2).

Table 3. Mixed Effect Regressions on the Intersectional Effects of Parental Education and Race on Childhood Nucleus Accumbens (NAcc) Response to Reward Anticipation (NAcc-RA)

	Estimate	Std. Error	Pr(> | t|)
High School Diploma/GED	0.32380***	0.07934	<0.001
Some College	0.36495***	0.07096	<0.001
Bachelor	0.36718***	0.07177	<0.001
Graduate Degree	0.37239***	0.07189	<0.001
Race (Black)	0.33161***	0.09851	0.001
Race (Asian)	1.24788**	0.40346	0.002
Race (Mixed/Other)	0.37506***	0.10655	<0.001
Black × High School Diploma/GED	-0.19795#	0.11431	0.083
Black × Some College	-0.29367**	0.10467	0.005
Black × Bachelor	-0.34115**	0.11226	0.002
Black × Graduate Degree	-0.27358*	0.11094	0.014
Asian × High School Diploma/GED	-1.03902	0.69382	0.134
Asian × Some College	-1.26526**	0.43526	0.004
Asian × Bachelor	-1.18399**	0.41550	0.004
Asian × Graduate Degree	-1.25593**	0.40845	0.002
Mixed/Other Race × High School Diploma/GED	-0.36484**	0.12788	0.004
Mixed/Other Race × Some College	-0.39214***	0.11248	<0.001
Mixed/Other Race × Bachelor	-0.36010**	0.11371	0.001
Mixed/Other Race × Graduate Degree	-0.42035***	0.11273	<0.001

# p<0.1, *p<0.05, **p<0.01, ***p<0.001

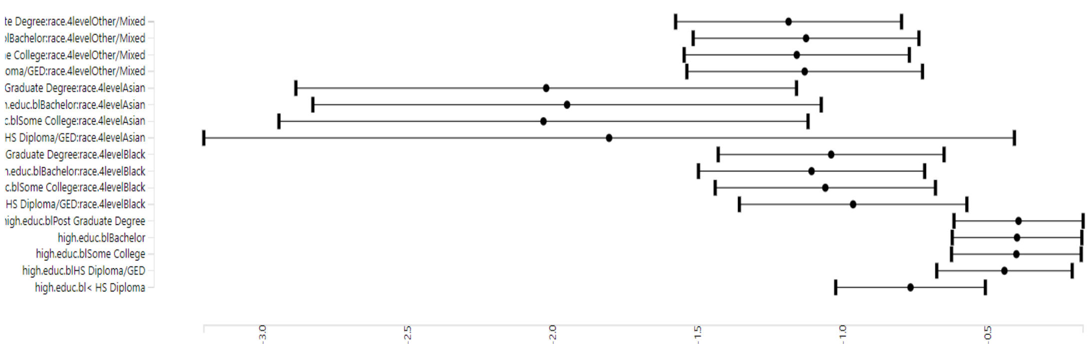

Figure 2. Association between Parental Education and Nucleus Accumbens (NAc) Response to Reward Anticipation (NAcc-RA) by Race

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4. Discussion

Although higher parental education was associated with a higher level of NAcc-RA in children (1st finding), parental education showed weaker effects for non-White and White children (2nd finding).

Our 1st result is in-line with what we know about parental education's role as a social determinant of health in general (Cuevas et al., 2020; Williams, 1999) and brain development in particular (Brody et al., 2017; Farah, 2018; Hackman et al., 2013; Hackman & Farah, 2009; Hackman, Farah, & Meaney, 2010; Hanson, Chandra, Wolfe, & Pollak, 2011; "Poverty and brain development", 2015). Marmot (2005; Singh-Manoux, Richards, & Marmot, 2005; Stringhini et al., 2018), Link and Phelan (1995, 2009; Phelan, Link, Diez-Roux, Kawachi, & Levin, 2004), Mirowsky and Ross (2015; Ross & Mirowsky, 2011), and many other investigators (Cuevas et al., 2020; Williams, 1999) have previously theorized and discussed the health effects of SES indicators such as parental education across age groups. An extensive body of research also link slow SES to high-risk behaviors, impulsivity, and sensation seeking (Assari, 2020a; Assari, Caldwell, & Mincy, 2018a).

Our 2nd result may have three explanations. The first explanation is the MDRs phenomenon. A high number of investigations have shown weaker effects of SES for Black than White American children (S. Assari, 2018c, 2018g, 2018h). Household SES indicators, such as parental education, show diminished effects on aggression (Assari et al., 2019), tobacco dependence (Assari et al., 2019), suicide (Shervin Assari, Shanika Boyce, Mohsen Bazargan, et al., 2020), school bonding (Assari, 2019b), school performance (Assari, 2019c; Assari & Caldwell, 2019b), ADHD (Assari & Caldwell, 2019a), anxiety (Assari, Caldwell, & Zimmerman, 2018), obesity (Assari, Thomas, et al., 2018), and health (Assari, Caldwell, & Mincy, 2018b) for Black than White American children. Family SES plays a more robust determinant effect on impulse control (Shervin, 2020; Assari, Caldwell, & Mincy, 2018a) and attention (Shervin Assari, Shanika Boyce, & Mohsen Bazargan, 2020a) of White than Black American children. Risk of poor mental and physical health outcomes, such as depression, anxiety, suicide, chronic disease, and obesity, also remains high in high SES Black American children (Assari, 2018f; Assari & Caldwell, 2019a; Assari et al., 2018). Similar MDRs (Assari, 2017c) are shown for children (S. Assari, 2018d; Assari & Moghani Lankarani, 2018a), adolescents (Assari, Gibbons, et al., 2018a), adults (S. Assari, 2018a), and older adults (Assari & Lankarani, 2016b; Assari, Moghani Lankarani, Caldwell, & Zimmerman, 2016). Under racism, parental education (S. Assari et al., 2019), own educational attainment (S. Assari, 2018j; Assari, 2019a; Assari & Mistry, 2018), and other SES resources (Assari & Caldwell, 2018b; S. Assari, 2018i), and even non-economic assets (Assari, 2017a; Assari & Lankarani, 2016c), generate fewer outcomes for non-Whites and Whites. This pattern, however, is best descried for comparison of Blacks and Whites (Bailey et al., 2017; Bassett, Krieger, & Bailey, 2017; Krieger, 2000, 2003, 2008, 2016; Krieger, Smith, Naishadham, Hartman, & Barbeau, 2005; Krieger, Williams, & Zierler, 1999; Parrott et al., 2005; Rich-Edwards et al., 2001).

The third explanation for our finding is the high level of general, economic, and racial stress experienced in middle-class Black families' daily lives. As racial and ethnic discrimination affects various aspects of health (Chekroud, Everett, Bridge, & Hewstone, 2014; Clark, Miller, & Hegde, 2018; Fourie, Stein, Solms, Gobodo-Madikizela, & Decety, 2019; Han et al., 2020; Phelps et al., 2000; Wheeler & Fiske, 2005), and as high SES is a proxy of higher, not lower discrimination for non-White families (S. Assari, 2018b; Assari & Caldwell, 2018b; Assari, Gibbons, et al., 2018b; Assari, Lankarani, et al., 2018; Assari & Moghani Lankarani, 2018b; Assari, Preiser, et al., 2018; Hudson et al., 2012; Hudson et al., 2016; Hudson et al., 2013), middle-class racial minority Americans still report higher than an expected health risk.

These findings can be understood through an intersectional perspective (Bowleg, 2008; Carbado, Crenshaw, Mays, & Tomlinson, 2013; Cole, 2009; Strompolis, Tucker, Crouch, & Radcliff, 2019; Viruell-Fuentes, Miranda, & Abdulrahim, 2012). According to an intersectionality framework, social identities such as race, ethnicity, SES, and sex do not have additive, but multiplicative effects. History, life experiences, exposures, and vulnerabilities are distinct across groups defined by more than one social identity (Bowleg, 2008; Carbado et al., 2013; Cole, 2009; Strompolis et al., 2019; Viruell-Fuentes et al., 2012). As a result, the intersection of race, SES, and sex shape health through variation in risk factors and vulnerabilities (Assari, 2016b, 2017b; S. Assari, 2018e; Assari & Caldwell, 2018b; Assari & Lankarani, 2016a).

Our paper also showed some negative results. These findings included that there is no significant interaction between Asian or Black race with high school diploma. In other terms, while higher education better served Whites than non-Whites, this difference could not be detected for Asian and Black children if their parents only had a high school diploma/GED. Thus, the effects of high parental education on the outcome tended to be smaller for racial and ethnic minorities, though some irregularities and inconsistencies exist. That is, not every education level interacts with every racial/ethnic minority group; however, the general trend is clear and indicates that MDRs exist.

5. Conclusions

In summary, higher parental education is associated with a higher level of NAcc-RA in American children; however, this boosting effect is weaker for non-White than White children. This means middle-class racial minority children show NAcc-RA that is similar to NAcc-RA of low SES minority children. In other terms, NAcc-RA is not a strong SES gradient for non-White children. This indicates that children's NAcc-RA is not shaped by race or parental education, but by their intersection. Therefore, eliminating the racial and economic disparities in children's high-risk behaviors may benefit from an intersectional approach that acknowledges the complexities and interdependent effects of race, SES, and social context. Societal barriers that reduce the health return of middle-class status for non-White families should be addressed by multi-level policies that go beyond health policies. The solutions seem to be public and economic rather than health policies. Health and developmental inequalities due to race/ethnicity should not be reduced to economic inequalities in health. The effects of race/ethnicity are beyond economic effects.

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Conflicts of Interest

The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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Appendix 1

Model Formula

Model 1

tfmri_mid_run1_antic.large.vs.small.reward_beta_subcort.aseg_accumbens.area.rh ~ high.educ.bl + race.4level + sex + married.bl + age + household.income.bl + hisp

Random: ~(1|rel_family_id)

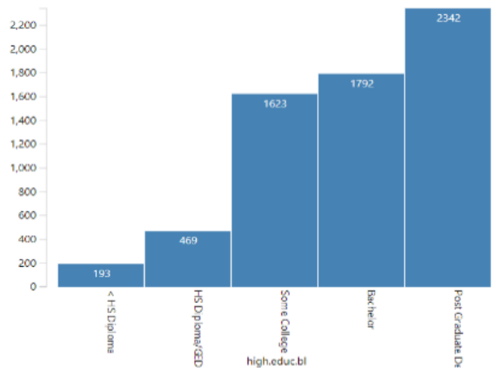
Model 2

tfmri_mid_run1_antic.large.vs.small.reward_beta_subcort.aseg_accumbens.area.rh ~ high.educ.bl + race.4level + sex + married.bl + age + household.income.bl + hisp + high.educ.bl * race.4level

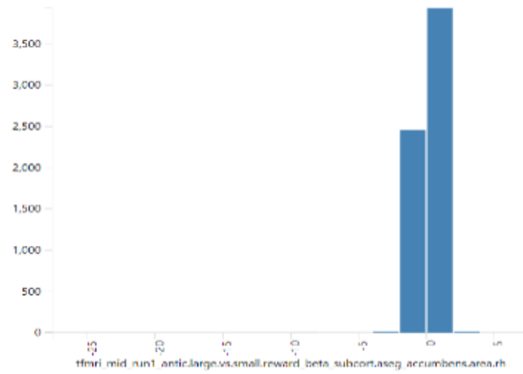
Random: ~(1|rel_family_id)

Appendix 2

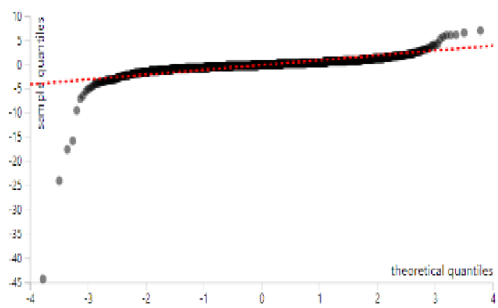
Distribution of our Independent Variable (a), Dependent Variable (b), Quantiles (c), and (d) Model Residuals



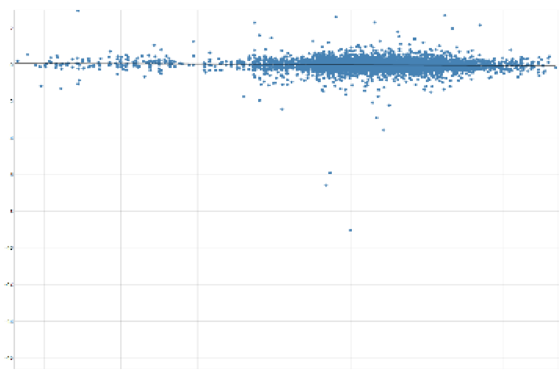
(a)



(b)



(c)



(d)