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ABSTRACT

Heterogeneity in Peer Effects of Obesity*

Children form social ties along dimensions of gender and race/ethnicity, and thus may differ greatly in exposure to peer health and also in reactivity to peer influence. This paper estimates heterogeneity in the peer effects of obesity along dimensions of gender, race/ethnicity, and socio-economic status for grade-mates within schools. Using data from the New York City (NYC) FITNESSGRAM initiative on over 1.6 million children in grades K-8, we find that males and females are equally responsive to peer effects. We estimate larger differences by race/ethnicity, immigration status and home language, but find no statistically significant differences in peer effects by socio-economic status. Taken together, these findings suggest that policies that reduce obesity could simultaneously widen some existing health disparities due to the heterogeneities in peer effects we uncover. Understanding the dynamics of peer influence is essential for designing policies and programs that seek to leverage social interactions for better health outcomes.

Keywords: peer effects, children, adolescents, obesity, health disparities

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1. INTRODUCTION

The childhood obesity epidemic is one of the fastest growing and most notorious public health issues in the US and worldwide (Ogden, Carroll, Kit, & Flegal, 2014). The rapid rise in childhood obesity is likely the result of multi-factorial changes in technology and environment that are amplified by genetic and social factors (Brownell & Horgen, 2004; Cutler, Glaeser, & Shapiro, 2003; Lakdawalla & Philipson, 2002). A growing literature documents evidence that peer effects may play a role in explaining the magnitude and growth rate of the obesity epidemic. Studies that attempt to estimate causal peer effects find strong, positive relationships between peer body weight and individual child body weight (Asirvatham, Thomsen, Nayga, & Rouse, 2014; Dieye & Fortin, 2016; Renna, Grafova, & Thakur, 2008; Strombotne, Fletcher, & Schlesinger, 2019; Trogdon, Nonnemaker, & Pais, 2008). Quantifying the impact of causal peer effects is important for understanding the drivers of childhood obesity, planning effective school wellness policies, and leveraging spillover effects to increase the reach of interventions.

Students may differ greatly in how they respond to peer influence. This variability may exist across multiple levels of analysis such as individual and familial attributes as well as contextual attributes like school and neighborhood environments. Moreover, students may be likely to self-select friendships within a cohort based on characteristics like gender or race, and peer effects may be stronger within these subgroups (Gaughan, 2006; Mayer & Puller, 2008; Moody, 2001). Additionally, standards of physical appearance and body ideals are powerful drivers of human behavior, and vary along on gender and racial lines (Ali, Rizzo, & Heiland, 2013; Granberg, Simons, & Simons, 2015; Webb, Butler-Ajibade, & Robinson, 2014). Leaving heterogeneity unmodeled may even mask mediating factors and selection bias, and thus lead to biased estimates of treatment effects for certain subgroups of the population (Clark & Lohéac, 2007; Elwert & Winship, 2010; Xie, Brand, & Jann, 2012).

Despite this fact, studies of peer effects on obesity outcomes have only skimmed the surface of heterogeneity in social interactions and have focused primarily on gender. Three studies that examine differential peer effects in youth by gender find that adolescent females are more responsive to changes in peer body weight than their male counterparts (Dieye & Fortin, 2016; Fowler & Christakis, 2008; Renna et al., 2008) or find no statistically significant difference at all (Asirvatham et al, 2018). Only one existing study models heterogeneity by race/ethnicity (Asirvatham et al, 2018). To our knowledge, nothing is known about heterogeneity of peer effects along other dimensions like socio-economic status (SES), language spoken in the home, or country of birth.

Understanding heterogeneity in peer effects has important implications for policy makers, as peer effects imply the existence of social multiplier effects (Charles F Manski, 2009). In resource constrained school-districts where interventions are costly and difficult to implement, quantifying endogenous peer effects can help identify key influential individuals within a network to increase the benefits of an intervention without increasing the costs. If policy makers understand patterns of peer effect heterogeneity, they can more effectively target treatments to influential individuals within a network to reduce disparities in obesity outcomes within a given population. Additionally, the study of heterogeneity across the course of childhood development may shed light on known health disparities between demographic groups later in life (Umberson, Crosnoe, & Reczek, 2010).

In this paper, we use data from the New York City (NYC) FITNESSGRAM initiative to model the impact of changes in cohort body mass index (BMI) on students of different gender, race/ethnicity, SES, home language and country of birth. The NYC public school system is the largest in the nation, serving 1.1 million children in 1,700 schools. Although recent data show a 6% decline in the overall prevalence of obesity, this decline has been accompanied by widening disparities for black and low SES youths (CDC, 2011; Day et al., 2020). In the analyses that follow, we estimate the impact of changes in the overall cohort BMI, as well as within subgroups of these populations. The remainder of the paper is organized as follows: Section 2 provides an overview of the relevant literature on heterogeneity in peer effects. Section 3 explains the empirical model. Results are presented in Section 4 and are discussed in Section 5. Section 6 provides conclusions and implications for researchers and policymakers.

2. PREVIOUS LITERATURE

Standards of physical appearance and body ideals are powerful drivers of human behavior, and the foundations of those ideals may be laid in childhood (Smolak, 2004). For children and adolescents especially, these standards vary along on demographic lines (Ali et al., 2013; Granberg et al., 2015; Webb et al., 2014). Body image in particular is a strongly gendered phenomenon. Social norms regarding body shape have a significant effect on perceptions of ideal BMI for women (Etile, 2007) and influence the likelihood that women suffer from eating disorders (Costa-Font & Jofre-Bonet, 2013).

Although children may differ substantially in how they respond to peer effects, little is known empirically about the heterogeneity of these effects on obesity outcomes. A handful of studies document heterogeneity of peer effects along gender and race/ethnicity dimensions—at least in teenagers and young adults—and show that adolescent females are more responsive than males to changes in overall peer obesity prevalence and are also more responsive to changes in female-specific obesity prevalence. We review these studies below.

Two of the aforementioned studies use Wave I of Add Health data to model the effects of average peer BMI z-score on individual BMI z-score for males and females in grades 7-12. Trogdon and colleagues (2008) use school-fixed effects models and find that females are more responsive than males to changes in the overall group averages in cohort-level peers and self-selected friendship networks. Their findings are supported by the instrumental variable analyses by Renna and colleagues (2008), who find that the effect is only statistically significant for females. Using data from school children in Arkansas, Asirvatham and colleagues (2018) find no statistically significant differences in peer effects by gender. While these are important findings for adolescent populations, more research is needed to understand how females and males respond to influence in the earliest ages of schooling.

Students may be likely to choose peers within a cohort along demographic dimensions, and peer effects may be stronger within these subgroups (Moody, 2001). There is research to suggest that children create friendships in direct relationship to the demographic and behavioral attributes they share (Kupersmidt, DeRosier, & Patterson, 1995; Smith & Christakis, 2008). In this vein of thought, Renna and colleagues (2008) examine the intra-gender dynamics of peer effects on obesity. They find that teenagers are more responsive to changes in the weight of same-gender friends than changes in the weight of everyone measured together. The peer effects of male-male relationships were not statistically indistinguishable from female-female relationships. Using the same data, Dieye and Fortin (2016) find that female-female peer effects are slightly higher than male-male peer effects. The difference in their findings may owe in part to using a different wave of Add Health data and in part to non-linear-in-means methodology. In a study of college-aged students, Yakusheva and colleagues (2014) use data from random roommate assignments to show that peer effects of weight gain are positive and significant for female roommate pairs, but not for male roommate pairs.

These gender-specific findings are consistent with evidence of heterogeneity of the peer effects of other risky health behaviors like alcohol consumption and substance use (Card & Giuliano, 2012; Clark & Lohéac, 2007). These studies represent an important first step in understanding same-gender effects, yet little is known about how those effects may operate in younger children. The present study will contribute to the existing literature by estimating overall gender and intra-gender peer effects using a within-school, across cohort identification strategy and data on young children, about whom less is known.

There is considerable consensus that ethnicity and culture are key predictors of body ideals and social norms regarding weight (Cachelin, Rebeck, Chung, & Pelayo, 2002; Grogan, 2007). In particular, being overweight or obese is more strongly associated with perceived unattractiveness among whites than blacks (Richmond, Austin, Walls, & Subramanian, 2012). Research suggests that black female adolescents above the normal-weight range are perceived as more attractive than white female adolescents above the normal weight range, suggesting that there is a wider range of socially acceptable body shapes along racial dimensions, especially for females (Ali et al., 2013). Studies that focus on racial and ethnic differences have found that black females are also less likely to judge *themselves* or *others* as unattractive when overweight (Hebl, King, & Perkins, 2009). Despite the importance of race/ethnicity in determining social norms, estimates of heterogeneity with respect to race/ethnicity are largely absent in the peer effects literature. Only one study that we are aware of attempts to model race/ethnicity in peer effects of obesity (Asirvatham et al, 2018). In the previously described of Arkansas public schools, the authors find that African American students are the most responsive to the body weight of obese or overweight peers followed by Hispanics, and then, Caucasians. The present study will estimate the impact of cohort obesity separately for white non-Hispanic, black non-Hispanic, Hispanic, and students of other racial/ethnic groups in a diverse, urban environment. In addition, we will model heterogeneity by socio-economic status (free or reduced price lunch eligibility), home language, and immigration status.

3. METHODS

The data, conceptual framework, and empirical models follow from Strombotne et al., 2019. We use the FITNESSGRAM analytic sample to implement a within-school, across-cohort empirical design to estimate causal peer effects of average cohort BMI z-score and percentage cohort obesity (Hoxby, 2000; Charles F. Manski, 1993). Specifically we estimate a reduced-form ordinary least squares equation with fixed effects where the BMI z-score (y) of an individual student (i) in school (s), grade (g), and academic year (t) is:

$$y_{igst} = \lambda P_{-igst} + \mathbf{x'}_{igst}\eta_k + \mathbf{m'}_{-igst}\theta_n + \alpha_g + \beta_s + \gamma_t + \delta_{st} + \zeta_{sg} + \pi_{gt}\,\varepsilon_{igst}. \qquad (1)$$

where P_{-igst} is a measure of peer body weight composition (excluding student *i*); $\mathbf{x'}_{igst}$ is a vector of *k* individual-level, student characteristics including gender, race/ethnicity, immigration status, meal-plan type, and days absent in a school-year; $\mathbf{m'}_{-igst}$ is a vector of *n* peer-level characteristics (excluding student *i*) which measure the average characteristics of peers in the cohort; α_g, β_s, and γ_t are fixed effects for grades, schools and school-years, respectively; δ_{st}, ζ_{sg}, and π_{gt} are a set of interacted fixed effects between year, grade and school dummies.

We model two types of heterogeneity: (1) the impact of the overall average cohort BMI z-score on different subgroups (e.g., the impact of the full cohort average BMI z-score on males only) and (2) the impact of intra-group peer effects (e.g., the impact of average male BMI z-score on males only). For the first aim, we estimate equation one separately for students of different gender, race/ethnicity, free lunch status, home language, and immigration status. For the second aim, we recalculate the average BMI z-score (with individual removed) within sub-groups, and regress individual student BMI z-score on the intra-group measures.

4. RESULTS

4.1 Summary Statistics

Table 1 presents the summary statistics for the pooled analytic FITNESSGRAM sample of 6,926,500 person-year observations. The sample includes 1,658,404 unique students in 66,455 unique cohorts in 1,252 schools across 12 years of observation. Each student appears an average of 5.76 years in the dataset. The sample is similar to the NYC public school children population as a whole. The majority of students come from non-white (black, Hispanic, and other race) backgrounds. A relatively high proportion are foreign-born (13%) and qualify for free or reduced price lunch (78%). In addition, this sample includes representation from vulnerable populations: students with a disability IEP plan (17%) and students for whom English is a second language (16%). In the full sample, the average BMI z-score is 0.57, and 21% of students are obese.

Table 1. Summary statistics for the analytic FITNESSGRAM sample.

Variable	Mean	Std. Dev.	Min	Max
Grade	3.88	(2.56)	0	8
Year	2011.77	(3.33)	2006	2017
Cohort size	158.76	(120.7)	11	768
No. of panels per *i*	5.76	(2.41)	1	12
BMI z-score	0.57	(1.23)	-6.56	4.31
Obese	0.21	(.41)	0	1
Age (months)	113.72	(31.98)	56.25	236.09
Female	0.49	(.5)	0	1
Black	0.25	(.43)	0	1
White	0.16	(.37)	0	1
Hispanic	0.41	(.49)	0	1
Other race	0.18	(.38)	0	1
Qualifies for FRP lunch	0.78	(.41)	0	1
Foreign born	0.13	(.34)	0	1
NYC born	0.80	(.4)	0	1
US born	0.07	(.25)	0	1
Home language: English	0.58	(.49)	0	1
Home language: Spanish	0.18	(.39)	0	1
Home language: Other	0.24	(.43)	0	1
English Language Learner	0.16	(.37)	0	1
Disability (IEP plan)	0.17	(.37)	0	1
Days Absent	11.3	(11.65)	0	185
Cohort descriptors				
Avg. cohort BMI z-score	0.57	(.33)	-3.62	2.53
Proportion female	0.49	(.06)	0	1
Proportion black	0.25	(.28)	0	1
Proportion white	0.16	(.22)	0	1
Proportion Hispanic	0.41	(.27)	0	1
Proportion FRP lunch	0.78	(.23)	0	1
Proportion foreign born	0.13	(.09)	0	1
Avg. days absent	11.3	(4.28)	0	59.42

Note: Summary statistics are calculated for the pooled sample of 6,926,500 person-year observations. The sample includes 1,658,404 unique students in 66,455 unique cohorts in 1,252 schools across 12 years of observation.

4.2 Heterogeneity of Findings: Stratified Regressions by Subgroup

The full sample models show that an increase in the average cohort BMI z-score and/or the percentage of obesity in a cohort has a positive and statistically significant impact on individual BMI z-score outcomes (Table 2, row 1). The overall impact of cohort BMI z-score on individual z-score is 0.400. The interpretation of this effect is that a one-point standard deviation change in the average BMI of the peer group leads to a 0.4 standard deviation change in individual student BMI.

However, students may differ based on observable characteristics in how they respond to peer influence. In Table 2, we stratify the analyses separately by gender, race/ethnicity, socio-economic status (as measured by free or reduced price lunch qualification), home language, and immigration status. The results of these twelve regressions are also presented graphically in Figure 1.

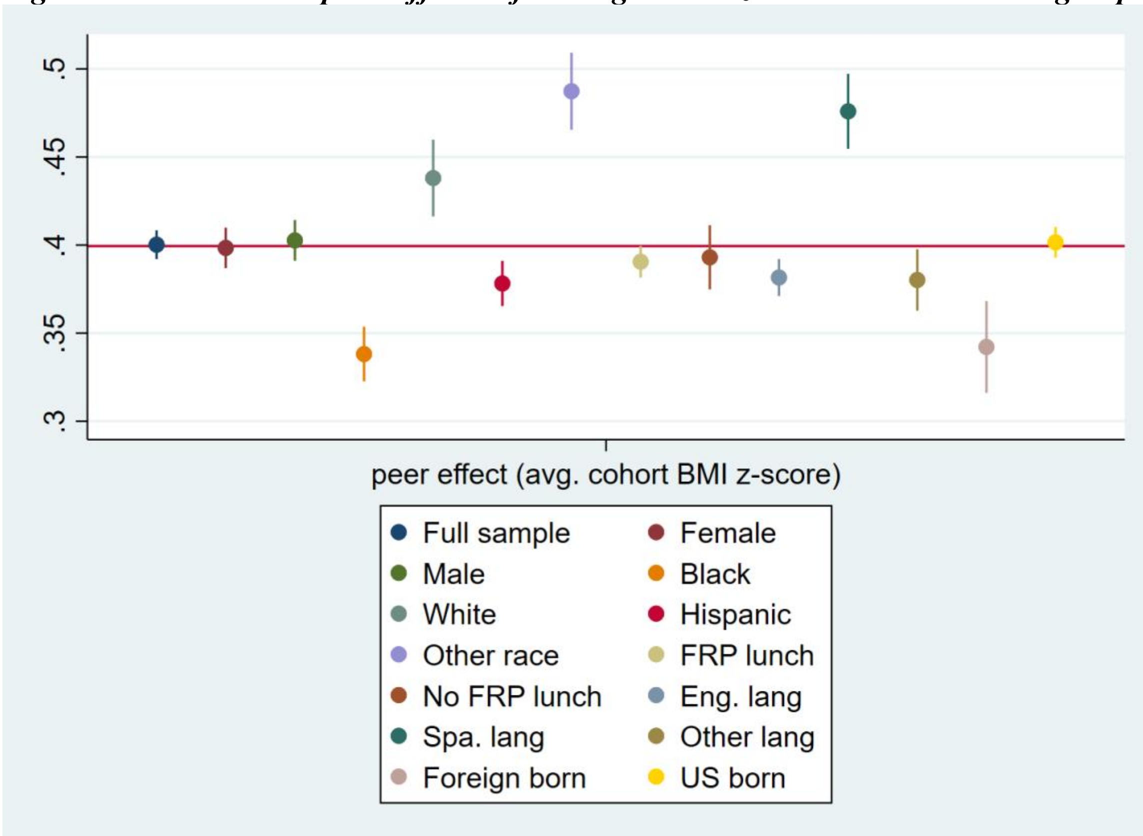
We detect significant differences in response to peer BMI by race/ethnicity and immigration groups such that an increase in overall peer BMI z-score has a larger effect on white (0.438) and other race students (0.487) compared to black (0.338) and Hispanic students (0.378). Peer effects were lower for foreign-born students (0.342) compared to US-born students (0.402). We do not detect significant differences between students who qualified for free or reduced price lunch (0.391) and students who did not (0.393). The effect of a one-point change in average cohort BMI z-scores is nearly identical for females (0.398) and males (0.403).

Table 2. Estimated effects of full cohort peer body composition measures on individual student BMI z-score, stratified by gender and race/ethnicity.

Sample	Avg. Cohort BMI z-score	Observations
Full Sample	0.400*** (0.004)	6,926,500
Females	0.398*** (0.006)	3,386,409
Males	0.403*** (0.006)	3,539,720
Black	0.338*** (0.008)	1,704,100
White	0.438*** (0.011)	1,072,024
Hispanic	0.378*** (0.007)	2,812,420
Other Race	0.487*** (0.011)	1,205,107
Qualifies for FRP lunch	0.391*** (0.005)	5,425,892
Does not qualify for FRP lunch	0.393*** (0.009)	1,470,892
Home language: English	0.382*** (0.005)	4,028,135
Home language: Spanish	0.476*** (0.011)	1,205,510
Home language: Other	0.380*** (0.009)	1,606,848
Foreign born	0.342*** (0.013)	866,078
US born	0.402*** (0.004)	6,015,060

Note: Each row contains the coefficient of the estimate of average (full) cohort BMI z-score on individual BMI z-scores for specific subgroups in 14 separate regressions All specifications include individual controls, cohort controls, and main and interacted school, year and grade fixed effects (S, Y, G, SY, SG, YG). Standard errors are in parentheses, clustered at the school level. *** p<0.001, ** p<0.01, * p<0.05.

Figure 1. Full cohort peer effects of average BMI z-score on student subgroups.



Note: Each data point represents the coefficient of the estimate of average (full) cohort BMI z-score on individual BMI z-scores for specific subgroups in 14 separate regressions. Each estimate can be found in Table 1. All regressions include individual controls, cohort controls, and main and interacted school, year and grade fixed effects (S, Y, G, SY, SG, YG). The full analytic sample contains n=6,926,500 student-year observations.

4.2 Intra-Group Peer Effects

The preceding analyses focused on the peer effects of the *entire* cohort on *sub-populations* of students. Those findings are relevant for understanding how interventions that change the weight of the entire cohort may have different effects on sub-populations of students. It is probable, however, that students are more likely to self-select friendships among demographic dimensions, and that peer influence regarding weight-related behaviors may be stronger within these sub-groups. It may also be true that interventions can have different effects on certain subpopulations of students, and that these subpopulations will have different effects on individual peers.

To examine this possibility, we re-calculate the peer composition measures *within* gender and race/ethnicity subgroups, and regress individual BMI z-scores from that sub-group on the peer composition of the group (with individual measures removed). Table 3 presents the results from these analyses. Estimates from row 1 show the impact of a one-point increase in female BMI z-score on other females in the cohort, estimates in row 2 show the impact of a change in male BMI z-score on other males in the cohort, and so forth. Overall, the estimates for intra-group peer effects are smaller in magnitude than the overall estimates presented earlier in Table 2. We find that males (0.188) and females (0.184) are, again, equally responsive to intra-group peer effects. In race/ethnicity models, Hispanic students (0.115) are more responsive to intra-group weight changes compared to black (0.299), white (0.042) and other race students (0.299).

Table 3. Intra-group peer effects of peer body composition measures on individual student BMI z-scores

Sample	Avg. Cohort BMI z-score	Observations
Females	0.184***	
	(0.005)	3,386,409
Males	0.188***	
	(0.005)	3,539,720
Black	0.0299***	
	(0.006)	1,704,100
White	0.0420***	
	(0.008)	1,072,024
Hispanic	0.115***	
	(0.00537)	2,812,420
Other race	0.0299***	
	(0.008)	1,205,107

Note: Each row contains the coefficient of the estimate of sub-group BMI z-score on individual BMI z-scores for the same subgroups in 7 separate regressions All specifications include individual controls, cohort controls, and main and interacted school, year and grade fixed effects (S, Y, G, SY, SG, YG). These regressions are restricted to cohorts with at least 5 students within any subgroup. Standard errors are in parentheses, clustered at the school level. *** p<0.001, ** p<0.01, * p<0.05.

5. DISCUSSION

The preceding analyses show that—in the full sample—females and males are equally responsive to changes in group average BMI z-score. This is contrary to findings by Renna and colleagues (2008) and Trogdon and colleagues (2008) who find that females are more responsive to changes overall average BMI z-score than their male counterparts. A potential explanation for the differences in our findings lies in the different ages in the populations under consideration: Renna et al and Trogdon et al examine older adolescents, while the present study examines children and younger adolescents.

We find differential impacts of overall cohort composition on race and ethnicity subgroups. In particular, we find that white non-Hispanic and other race students are more responsive to changes in the group average compared to black non-Hispanic and Hispanic students. This finding is in contrast to a recent study from Arkansas, which shows the opposite relationships (Asirvatham, et al. 2018). It is important to note that the racial and ethnic composition of NYC and Arkansas schools are very different, and the mechanisms of peer effects may also be distinct. In our intra-group peer analyses, Hispanic students were far more responsive to changes in the composition of other Hispanic students in comparison to other race/ethnicity subgroups.

The construct of race/ethnicity has both cultural and economic structural connotations, and in this study, we begin to examine both of those elements by looking at differences in response to peer effects by free- and reduced-price lunch eligibility, immigration status, and language spoken in the home. We find no statistically significant differences by lunch status—a proxy for socio-economic status—and detect larger differences by immigration status and home language. Taken together with the results from race/ethnicity, these findings suggest that the peer effects of obesity in children and young adolescents may operate through a cultural channel, rather than through an economic channel.

Understanding the differential response of peer effects is important from a standpoint of understanding drivers of existing health disparities between race/ethnicities. In the NYC sample, black and Hispanic students have 1.7 and 2.1 times the prevalence of obesity compared to white students, respectively. How much of this disparity is driven by differential obesity *exposure*, and how much is driven by differential *response* to obesity exposure? Our results can begin to shed a light on this question. If we use rudimentary calculations to imagine hypothetical scenarios where black and Hispanic students are exposed to the mean peer obesity levels of white students, and visa versa, we can decompose the race/ethnicity disparity into an explained portion, driven by initial differences in peer obesity levels between race/ethnicities, and an unexplained portion, driven by the differences in the estimated coefficients, which can be interpreted as the differential response to peer obesity by each ethnic group. Using the estimates in Table 3, we find that, for the black-white disparity, the explained portion is 3% and the unexplained portion is -1.8%. For the Hispanic-white disparity, the explained portion is 11.6% and the unexplained portion is 6.7%.

As with any analysis of peer effects, this study is subject to limitations. We examine peer effects at the cohort level. Students may self-select into smaller friendship circles, and those friends may represent a more proximal measure of peers—especially as children enter into adolescence. While grade-level peers represent an exogenous and policy-relevant group of study, the mechanisms by which females at the cohort level impact individual female BMI z-score may be quite different from the mechanism by which endogenously selected (self-reported) female friends influence BMI z-score. To the extent that cohort-level peers do not capture all friends and are thus mis-measured, the peer effects estimates may be subject to measurement error, and thus bias the OLS estimates towards zero.

6. CONCLUSIONS

Recent data show that a 6% decline in the overall prevalence of obesity in NYC was accompanied by widening disparities for black and low SES youths (Day et al., 2020). The existence of causal peer effects along the dimensions of race/ethnicity documented in the present study raises the possibility of spillover effects—that students treated by an intervention may spillover the effects of a program onto untreated students. That these effects are heterogeneous show that peer influence and social norms may spillover differentially along sociodemographic dimensions. These differential social patterns in early childhood may even explain observed health disparities later in life.

If researchers can identify the mechanisms of peer effect heterogeneity, policy makers can more effectively target treatments to influential individuals within a network to reduce disparities in obesity outcomes within a given population. The results of this study show that investigations that fail to model heterogeneity in gender and ethnicity may miss important dynamics of social networks. Future studies should seek to understand the mechanisms of peer influence, which is important for designing policies and programs that can leverage social interactions within a network for better health outcomes.

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