Obesity prevalence in large US cities: association with socioeconomic indicators, race/ethnicity and physical activity

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ABSTRACT

Background Obesity has a complex association with socioeconomic factors. Further clarification of this association could guide population interventions.

Methods To determine the relationship between obesity prevalence, socioeconomic indicators, race/ethnicity, and physical activity, we performed a cross-sectional, multivariable linear regression, with data from large US cities participating in the Big Cities Health Inventory.

Results Increased household income was significantly associated with decreased obesity prevalence, for White (−1.97% per 10,000USD), and Black (−3.02% per 10,000USD) populations, but not Hispanic. These associations remained significant when controlling for the proportion of the population meeting physical activity guidelines. Educational attainment had a co-linear relationship with income, and only a bachelor’s degree or higher was associated with a lower prevalence of obesity in White (−0.30% per percentage) and Black (−0.69% per percentage) populations. No association was found between obesity prevalence and the proportion of the population meeting physical activity guidelines for any race/ethnicity grouping.

Conclusion At the population level of large US cities, obesity prevalence is inversely associated with median household income in White and Black populations. Strategies to increase socioeconomic status may also decrease obesity. Targeting attainment of physical activity guidelines as an obesity intervention needs further appraisal.

Keywords obesity, race, socioeconomic factors

Introduction

Over a third of American adults are obese.¹ This high prevalence is a public health concern, as obesity is associated with a multitude of co-morbidities including type-2 diabetes, cancer, cardiovascular disease,²,³ diminished quality of life,⁴ and higher all-cause mortality.⁵ For these reasons, obesity accounts for nearly $150 billion of direct medical spending annually.⁶

Obesity is commonly targeted as a public health intervention. Many interventions focus on inappropriate nutrition and low physical activity,⁷ both known to be risk factors,⁸ and are two of the three ‘proven strategies’ promoted by the Centers for Disease Control and Prevention for obesity prevention campaigns.⁹

Socioeconomic status (SES) plays an important and complex role, as both a risk factor and a consideration for designing interventions.¹⁰ In high-income countries, lower household income is associated with a higher prevalence of obesity.¹¹ Within the United States, this association has been observed in women, and select racial/ethnic categories of men.¹² Attainment of a college degree is correlated with decreased obesity in women, while in men there is not a clear trend relating educational attainment to obesity prevalence.¹³

At all ages, most minority groups are disproportionately affected compared to Whites, with a higher prevalence of obesity in Black, Hispanic, and Native American populations, but a lower prevalence in Asians.¹⁰ While there are correlations between race/ethnicity and low SES, higher
obesity among most minority groups is not solely due to lower SES.\textsuperscript{10} There is conflicting evidence on whether race/ethnicity or socioeconomic status play a more significant role in the higher obesity prevalence in these groups.\textsuperscript{14}

Local health departments can play a crucial and unique role in the prevention of obesity. Staff possess a depth of knowledge of the community, and operate closely with other local agencies and organizations whose collective efforts can impact obesity.\textsuperscript{15} Obesity prevention programs have been implemented in more than half of US local health departments,\textsuperscript{16} and are typically considered high priority.\textsuperscript{17} These programs are associated with a reduction in the risk of obesity, particularly among low-income populations.\textsuperscript{15} More than half of US local health departments are active in policy issues related to obesity, more than 80\% when considering only large US cities.\textsuperscript{18}

Local health departments are often in a position to influence policies that can improve the diet and physical activity of a population.\textsuperscript{19} In addition, policies that can decrease socioeconomic disparities, such as increased minimum wage or decreased barriers to higher education, can be enacted by local governments and local health departments can play a role in advocating to their municipal partners. Given the relationship between increased SES and decreased obesity prevalence, this may present an avenue to impact obesity indirectly.

This study examined the relationship between obesity prevalence and household income in large US cities, to determine if an income gradient of obesity exists, one that could potentially be influenced by local governments or health departments. Large US cities were chosen to study because their size permits subset analyses of race/ethnicity, they represent one-in-six Americans, and they present a degree of similarity in terms of structure and goals of their local health departments.\textsuperscript{19} Secondary variables of adult physical activity and educational attainment were included in the analysis to determine if these factors influence obesity prevalence and/or the relationship between income and obesity.

The Big Cities Health Inventory (BCHI) is a database of demographic and health indicators created by the Big Cities Health Coalition, a project of the National Association of County and City Health Officials.\textsuperscript{20} Membership consists of the 30 largest urban areas, as defined by the U.S. Census Bureau, with a population of at least 400,000, and a locally controlled health department. The specificity of the BCHI database permits an analysis of the relationships between obesity, income, race/ethnicity, educational attainment, and physical activity among populations within large US cities.

\section*{Methods}

\subsection*{Indicators}

BCHI data is primarily sourced directly from the member health agencies, with supplementation from publicly-available federal datasets.\textsuperscript{21} Member health agency data is for the years 2012–2014, and is publicly accessible at www.bigcitieshealth.org/city-data/. Each observation in this study represents a racial/ethnic population in a specific city.

The primary indicators in this study are adult obesity prevalence and median household income. Adult obesity prevalence is defined as the percentage of the population 18 and over with a body mass index (BMI) of 30 kg/m\textsuperscript{2} or above. This is compiled from the Behavioral Risk Factor Surveillance System, a cross-sectional, self-reported periodic nationwide telephone survey operated by the Centers for Disease Control and Prevention (CDC), which has been externally validated.\textsuperscript{22} Household income is defined as the income of the householder and all other people 15 years and older in the household. This is compiled through the American Community Survey, a continuous self-reporting periodic survey operated by the US Census Bureau, and provided as the median household income for the population of interest.\textsuperscript{23}

Secondary indicators include race/ethnicity, adult physical activity levels, and educational attainment. Racial grouping in the BCHI is as follows: American Indian or Alaska Native, Asian or Pacific Islander, Black, Hispanic, Multiracial, Other, or White. Adult physical activity data is sourced again from the Behavioral Risk Factor Surveillance System, and is defined as the prevalence of those over 18 years of age who self-report meeting CDC-recommended weekly activity levels of 150 minutes of moderate-intensity aerobic activity or 75 minutes of vigorous-intensity aerobic activity, or an equivalent mixture of both.\textsuperscript{21} Educational attainment within the BCHI is provided as the proportion of adults who are high school graduates, using American Community Survey data.\textsuperscript{21}

The entirety of the BCHI database was downloaded and the variables of interest isolated. Due to median household income being defined for a household, and not by gender, this limited the analysis to a gender-aggregated basis. For each variable, a number of observations were present for a location based on yearly estimates. These were aggregated and averaged to allow for comparison. For median household income, the BCHI data was limited to observations for an entire city population. To perform a subset analysis based on race/ethnicity, supplemental data was extracted from the American Community Survey (ACS) based on the same methodology used by the BCHI to determine geographic
As other observations have been transformed into an average of yearly observations, the 2012–2016 5-year ACS estimates were used and merged into the BCHI dataset. This strategy was also used to refine the indicator of educational attainment. The BCHI dataset provides only one indicator of educational attainment: the proportion of adults who are high school graduates. To increase the categories of educational attainment, data was added from the ACS, by 2012–16 5-year estimates, of the proportion of each population 25 years and older with the highest attainment of less than high school diploma, high school graduate (includes equivalency), some college or associate’s degree, or bachelor’s degree or higher.

Statistical analyses
Data were analyzed using Stata statistical software, version 15.0 (StataCorp, College Station, TX). Simple linear regressions were performed for each variable in relation to the outcome variable of obesity prevalence. Multiple linear regression models were generated with the addition of variables to the regression of obesity prevalence on median household income. Akaike information criterion (AIC) was compared between candidate models to determine relative quality. The model of highest quality was further analyzed with diagnostics of linearity, normality, homogeneity of variance, and collinearity. Subset analyses were also performed, with multivariable linear regressions for each race/ethnic grouping.

Results
A total of 46 observations were found that had a value for obesity prevalence, median household income, and physical activity attainment. Only five observations were found for the category of Asian / Pacific Islander, three observations for multiracial, and only one for American Indian / Alaska Native. Due to the low number of observations for these three subsets, they were omitted from further analyses. The remaining observations are summarized in Table 1. Compared to White populations, there was a significantly higher obesity prevalence, lower median household income, and lower educational attainment among Black and Hispanic populations. The proportion of the population attaining physical activity guidelines was similar for all race/ethnicity groups.

A scatter matrix showed a linear relationship between obesity prevalence and both median household income and educational attainment, and the association between median household income and educational attainment appeared linear as well. This was further explored with simple linear regressions of median household income on educational attainment, which showed that median household income was significantly decreased with an increase in the proportion of less than high school (−929.53 USD per percentage, 95% CI: −1337.16, −521.91) and high school attainment (−2286.12 USD per percentage, 95% CI: −2759.57, −1812.67), and median household income was significantly increased with an increasing proportion attaining a bachelor’s or higher (947.66 USD per percentage, 95% CI: 765.97, 1129.35). When inputted into a multiple linear regression model, variance inflation factors were above 2.5. Due to the substantial collinearity between the indicators of median household income and educational attainment, educational attainment was not included in the multiple linear regression model.

Amongst different multivariable linear regression candidate models, the one with the lowest AIC is summarized in Table 2. Obesity prevalence significantly decreased with
increased median household income (−1.92% per 10 000USD, 95% CI: −3.20, −0.64), adjusted for adult physical activity attainment and race/ethnicity. Black (β=5.28, 95% CI: −0.65, 11.20) and Hispanic (β=3.48, 95% CI: −1.93, 8.90) populations do not differ in obesity prevalence compared to White populations when income and physical activity attainment are controlled for. There is no significant correlation between physical activity attainment and obesity prevalence when median household income and race/ethnicity is controlled (−0.02% per percentage, 95% CI: −0.13, 0.08). Only with an increase in the proportion with a bachelor's degree or higher was there a significant decrease in obesity prevalence (−0.32% per percentage, 95% CI: −0.39, −0.24).

As a subset analysis, Table 3 displays multivariable linear regressions for each race/ethnicity grouping. A significant decrease in obesity prevalence with increasing median household income was seen for White (−1.97% per 10 000USD, 95% CI: −3.57, −0.36), and Black (−3.02% per 10 000USD, 95% CI: −5.25, −0.79) populations. This relationship was not seen for Hispanic populations (−1.29% per 10 000USD, 95% CI: −5.36, 2.78). Increases in the proportion with a bachelor’s degree or higher was associated with a lower prevalence of obesity in White (−0.30% per percentage, 95% CI: −0.48, −0.11) and Black (−0.69% per percentage, 95% CI: −0.90, −0.48) populations. In none of the race/ethnicity categories was adult physical activity attainment significantly correlated with obesity prevalence.

**Discussion**

**Main finding of this study**
The main finding of this study is that in large US city populations, increased median household income is significantly associated with a lower prevalence of obesity. This association was found for White and Black populations; however, it was not seen for Hispanic populations. No correlation was observed between the proportion of people meeting physical activity guidelines and obesity prevalence. When this parameter was controlled for along with income, the prevalence of obesity in Black or Hispanic populations was not found to be significantly different than that in White populations. This suggests that neither Black nor Hispanic populations would be more likely to be obese than White populations if they had similarly high income and/or educational attainment.

**What is already known on this topic**
The correlation between income and obesity is likely attributable to numerous mechanisms. Increasing income makes healthier foods more affordable. The odds of consuming whole grains, lean proteins, and fruits and vegetables is known to be higher with increasing SES, and energy-dense, nutrient-poor diets are more common with lower SES. The food environment is also typically superior in high-SES neighborhoods, with improved access, quality, and selection of foods. Increased income has also been associated with increased physical activity, however this was not seen within our analysis. Improved access to health care may also contribute to the relationship, as primary care-based childhood prevention and intervention strategies have been shown to decrease the BMI of patients. Within this study, there was a strong relationship between a lower obesity prevalence and attainment of a bachelor’s degree or higher. This could stem from increased education influencing behaviors that decrease obesity risk, or could merely be due to populations with a higher median household income.
having a higher prevalence of high educational attainment, which was also seen in a co-linear relationship.

**What this study adds**

The findings of this study have implications for practice, particularly at the level of government and local health departments. First, knowing that this relationship exists is a reminder that when planning interventions, one must be cognizant of economic considerations. For instance, a media campaign encouraging increased consumption of fruits and vegetables may not have an impact on a community or population where fruits and vegetables are too costly or not widely available.

Secondly, the lack of correlation between attainment of physical activity guidelines and obesity prevalence suggests that this indicator may not be a useful target for obesity campaigns. As this indicator is self-reported, this raises concerns of reliability and validity. However, a systematic review assessing the reliability and validity of the Behavioral Risk Factor Surveillance System suggested that self-reports of physical activity were ‘substantially reliable’ and validity when compared to physical measures was moderate. An alternative explanation for the lack of association is that physical activity may indeed not be correlated with obesity. The association between physical activity and obesity is contentious in the literature, from both an observational and physiological perspective. Other research suggests that the minimum physical activity guidelines are insufficient to result in weight loss in overweight and obese people without concurrent dietary changes. It is important to note, however, that there are positive effects from physical activity that are separate from a relationship with obesity, such as reduced risk of coronary artery disease and type-2 diabetes mellitus. Lastly, the inverse correlation between income and obesity observed may present an avenue for intervention. Longitudinal studies have shown that increasing household income in childhood is associated with lower rates of obesity compared to households who remained low-income. Interventions that increase SES may, among other positive benefits, decrease obesity and the mortality and morbidity associated with it. SES enhancement could be fostered by policies of increased minimum wage, guaranteed income, and reducing barriers to higher education.
Limitations of this study

There are several limitations to this study. The data are at the population level, not individual. This was intentional, as this is the data monitored by health agencies, and therefore the conclusions reached with these indicators will be relevant to those same agencies. However, this may result in masking groups of individuals within the population who may be influencing the data. Median household income was used because of its availability, and the status of recent family income as an optimal indicator of SES.\(^3\)\(^9\)\(^{12}\)\(^{13}\) This is an important area that requires further research. As a cross-sectional analysis, no conclusions about causation can be made. Most of the variables relied on self-reported survey data, which may lead to reporting bias. Multiple different variables of physical activity exist,\(^1\)\(^4\) and this study utilized only one. Not all of the BCHI member cities were able to be included in the analysis due to lack of complete data. Lastly, the intention of this analysis was to perform a subset analysis of all racial/ethnic categories, but a lack of data for all but White, Black, and Hispanic populations prevented this.

Conclusion

This study provides support for the existence of a correlation in large US cities between increasing income and/or higher educational attainment and decreasing obesity prevalence among White and Black populations, but not Hispanic populations. An inequity in obesity prevalence is suggested, as when income and adult physical activity attainment are controlled, obesity prevalence among Black and Hispanic populations is similar to White populations.

Lastly, the findings in this data source suggest that attainment of physical activity guidelines is not correlated with obesity rates. Considering this, a critical appraisal of local prevention and intervention programs related to obesity is warranted, to determine the impact of existing activity-based programs, and to consider more strongly interventions that would positively impact socioeconomic status of vulnerable populations in US cities.

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References


