

Associations of Fruit and Vegetable Consumption and Sugar-Sweetened Beverage Intake with Current Depression Among New York City Adults

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Abstract

Depression is a leading cause of disease burden in the United States, yet associations between dietary behaviors and depression remain understudied in diverse urban populations. This cross-sectional study examined associations between fruit and vegetable consumption (FVC), sugar-sweetened beverage (SSB) intake, and current depression among 24,526 adult participants in the New York City Community Health Survey (CHS), 2016–2018. Survey-weighted logistic regression estimated associations using continuous and categorical dietary exposure variables, with adjustment for demographic, socioeconomic, and lifestyle covariates. Each additional daily serving of FVC was associated with a 9% lower odds (aOR = 0.91, 95% CI: 0.87–0.96) of current depression; FVC was associated with lower odds of depression across all consumption categories (1–2, 3–4, and ≥ 5 servings compared to none). Consuming each additional daily serving of SSB was associated with a 7% higher odds of depression (aOR = 1.07, 95% CI: 1.03–1.11); consuming ≥ 1 SSB serving per day was associated with a 21% higher odds of depression (aOR = 1.21, 95% CI: 1.03–1.41) compared to < 1 serving per day. Associations were broadly consistent across subgroups and remained largely unchanged after additionally adjusting for health-related variables. Findings suggest that policies and programs promoting FVC and limiting SSB intake may benefit mental health in urban populations.

Introduction

Depression affects an estimated 8.2% of adults in the United States (US) [1], and along with anxiety disorders, accounts for the greatest share of disease burden among mental and behavioral disorders [2]. Its economic burden has grown substantially, reaching an estimated \$382.4 billion in 2019 [3, 4]. Depression is a complex condition driven by a convergence of environmental, genetic, biological, and lifestyle determinants [5]. Among modifiable risk factors, diet has received increasing attention in recent years, particularly fruit and vegetable consumption (FVC) and sugar-sweetened beverage (SSB) intake.

High FVC is a key component of traditional dietary patterns such as the Mediterranean diet, which has been associated with lower depression risk and reduced depressive symptoms in randomized controlled trials [6–9]. Higher FVC specifically has been inversely associated with depression across cross-sectional and cohort studies [10, 11]. Fruits and vegetables are rich in antioxidants and anti-inflammatory phytochemicals that may reduce systemic inflammation [12], a biological pathway implicated in depression [13]. Conversely, SSBs are a major source of added sugars in the American diet, accounting for approximately 40% of added sugar intake [14]. Higher SSB intake has been associated with greater odds of depression [15, 16]. This relationship is hypothesized to operate through hypothalamic-pituitary-adrenal axis dysregulation and heightened low-grade systemic inflammation [17, 18].

Despite growing evidence linking diet to depression, these associations have not been examined exclusively among diverse urban populations, like those in New York City (NYC). In 2022, approximately 13% of NYC adults had current depression, affecting an estimated 845,000 individuals [19]. This burden

was not distributed evenly; depression rates were substantially higher among disadvantaged NYC adults, including those experiencing food insecurity and financial stress [19]. Dietary intakes follow similar socioeconomic gradients in NYC, with residents with lower socioeconomic status consuming more SSBs and fewer fruits and vegetables [20, 21]. These parallel patterns suggest that diet and depression co-cluster along socioeconomic lines, underscoring the need for population-specific evidence to inform targeted public health responses. This current analysis examined associations between FVC, SSB intake, and current depression among NYC adults.

Methods

Data were from the NYC Community Health Survey, an annual cross-sectional telephone survey conducted by the NYC Department of Health and Mental Hygiene since 2002 to monitor the health of NYC residents and inform public health policy. The survey uses stratified random sampling to collect data from approximately 10,000 adults (≥ 18 years) across all five NYC boroughs annually. Data collection employs computer-assisted telephone interviewing via landline (since 2002) and cellular phones (since 2009), with interviews conducted in English, Spanish, Russian, Mandarin, and Cantonese. For the current analysis, data were from the 2016, 2017, and 2018 surveys, which had consistent measures for depression, FVC, and SSB intake. Analyses accounted for the CHS complex survey design using a stratum variable and a multi-year combined survey weight (2016–2018), which was obtained from the New York City Department of Health and Mental Hygiene. Of the total 30,081 respondents, 1,928 were missing current depression, 1,078 were missing FVC and/or SSB intake, and 3,650 were missing covariate data. The final analytic sample was 24,526 (81.5%) respondents.

Current depression was assessed using the Patient Health Questionnaire-8 (PHQ-8), an 8-item self-report instrument measuring the frequency of depressive symptoms during the previous two weeks. Each item was rated on a four-point scale: not at all (0), several days (1), more than half the days (2), and nearly every day (3). Responses were summed to create a total score ranging from 0 to 24. A binary variable was created using a cutoff of ≥ 10 , validated for identifying clinically significant depressive symptoms in the general population [22].

FVC was assessed based on reported intakes during the previous day. For the 2016 survey, respondents were asked: "Thinking about nutrition, how many total servings of fruit and/or vegetables did you eat yesterday?" with standardized serving references (e.g., one medium apple, a handful of broccoli, or a cup of carrots). For 2017 and 2018 surveys, FVC was assessed separately using two questions: "About how many cups of fruit did you eat yesterday?" and "About how many cups of vegetables did you eat yesterday?" with standardized serving references (e.g., one cup of fruit equals one large orange, eight large strawberries, or one medium pear; one cup of vegetables equals 12 baby carrots, one large raw tomato, or one large ear of corn). Each serving was approximately 160 grams based on US Food and Drug Administration standards [23]. Reported intakes for fruits and vegetables were summed for 2017 and 2018 to create a comparable measure to 2016. Total FVC was examined continuously (number of

servings on the previous day) and categorized as 0, 1–2, 3–4, and ≥ 5 servings on the previous day, with the highest category adhering to the Dietary Guidelines for Americans' recommended daily intake [24].

SSB intake was assessed using two survey items, consistent across 2016–2018 surveys. Respondents reported how often they consumed one serving (defined as a 12-ounce can, bottle, or glass) of sugar-sweetened soda and other sweetened beverages such as iced tea, sports drinks, and fruit punch, with response options of number of times per day, per week, or per month. Weekly and monthly responses were converted to daily equivalents by dividing by 7 and 30, respectively, and then summed to derive total average daily SSB intake. SSB intake was examined continuously (number of servings per day) and dichotomized as ≥ 1 and < 1 serving per day.

Several demographic, socioeconomic, lifestyle, and health-related variables were considered as covariates. Demographic variables were sex (male, female); sexual identity (gay/lesbian, straight, bisexual, something else); age (18–24, 25–44, 45–64, ≥ 65 years); race and ethnicity (White non-Hispanic, Black non-Hispanic, Hispanic, Asian/Pacific Islander non-Hispanic, Other non-Hispanic); and nativity (reported place of birth: US born, including Puerto Rico and US territories, and foreign born). Socioeconomic variables were marital status (married or common-law, divorced/separated/widowed, never married); presence of children in household (yes, no); annual household income relative to the federal poverty level (FPL) ($< 100\%$, $100\text{--}<200\%$, $200\text{--}<400\%$, $400\text{--}<600\%$, $\geq 600\%$ FPL); educational attainment (less than high school, high school graduate, some college, college graduate); employment status (employed, unemployed, not in labor force); and neighborhood poverty. Neighborhood poverty was defined as the percentage of the zip code population living below 100% FPL, derived from the American Community Survey (2011–2015, 2012–2016, and 2013–2017 waves matched to corresponding survey years), and categorized as low poverty ($0\text{--}<10\%$), moderate poverty ($10\text{--}<20\%$), high poverty ($20\text{--}<30\%$), or very high poverty ($\geq 30\%$). Lifestyle variables were smoking status (never, current, former); alcohol consumption (consumed at least one alcoholic drink in past 30 days: yes, no); and physical activity (participated in any physical activities or exercises during the past 30 days, other than regular job: yes, no). Health-related variables were body mass index (BMI, calculated from self-reported height and weight), history of diabetes (yes, no), history of hypertension (yes, no), and self-rated general health (excellent, very good, good, fair, poor).

Statistical Analysis

Analyses were conducted using SAS 9.4. Descriptive statistics were used to characterize the analytic sample, with frequencies and weighted proportions reported for categorical variables. Survey-weighted multivariable logistic regression estimated associations of FVC and SSB intake, separately, with current depression. Primary models were adjusted for demographic, socioeconomic, and lifestyle variables; secondary models also included health-related variables. Stratified analyses were performed by sex and US nativity. Both crude and adjusted odds ratios (ORs) with 95% CIs were reported.

Results

Characteristics of the analytic sample are presented in Table 1. Approximately 9% of respondents met the threshold for current depression. Half of respondents were female (52%) and 73% were aged 25–64 years. Respondents were racially and ethnically diverse, with 37% identifying as White non-Hispanic, 26% as Hispanic, 22% as Black non-Hispanic, and 13% as Asian/Pacific Islander. Approximately 43% had a household income < 200% of the FPL and 17% lived in a neighborhood with very high poverty ($\geq 30\%$ of zip code residents below FPL). The majority of respondents were US born (55%), had at least some college education (60%), and were employed (63%); 26% of respondents reported no physical activity in the past 30 days and 14% were current smokers. The mean (standard deviation, SD) FVC was 2.49 (2.07) servings on the previous day, 11% reported no FVC and 13% consumed ≥ 5 servings on the previous day. The mean (SD) daily SSB intake was 0.68 (1.34) servings, approximately 23% consumed one or more servings of SSB per day.

Results from crude and adjusted logistic regression models are presented in Table 2. FVC was associated with lower odds of current depression. In multivariable models, any FVC was associated with a 43–51% lower odds of depression (1–2 servings, aOR = 0.57, 95% CI: 0.48–0.69; 3–4 servings, aOR = 0.49, 95% CI: 0.39–0.61; and ≥ 5 servings, aOR = 0.57, 95% CI: 0.42–0.77) compared to no FVC. Each additional serving was associated with 9% lower odds of current depression (aOR = 0.91, 95% CI: 0.87–0.96). SSB intake was associated with greater odds of current depression. In multivariable models, one or more servings per day was associated with 21% greater odds compared to < 1 serving per day (aOR = 1.21, 95% CI: 1.03–1.41); each additional daily serving was associated with 7% higher odds of current depression (aOR = 1.07, 95% CI: 1.03–1.11). In models with additional adjustment for BMI, diabetes, hypertension, and self-rated general health, associations between FVC or SSB intake and current depression were slightly attenuated but remained largely consistent (Table 2).

Stratified analyses by respondent sex and nativity are presented in Table 3. The protective associations between higher FVC and current depression observed in the full model remained largely consistent across sex and nativity subgroups. For SSB intake, one or more servings per day (reference: <1 serving per day) was associated with current depression among males (aOR = 1.36, 95% CI: 1.08–1.70) but not females (aOR = 1.11, 95% CI: 0.90–1.38) and among foreign-born respondents (aOR = 1.41, 95% CI: 1.10–1.81) but not US-born respondents (aOR = 1.14, 95% CI: 0.93–1.39), though confidence intervals overlapped substantially across subgroups.

Discussion

Our findings indicate that FVC and SSB intake are independently associated with current depression among NYC adults, after adjustment for demographic, socioeconomic, and lifestyle factors, as well as additional adjustment for health-related variables. Collectively, these findings suggest that the observed relationships are likely not merely driven by a generally healthier lifestyle or concurrent physical health conditions. Compared to no FVC, even modest consumption (1–2 servings per day) was associated with lower odds of depression. In contrast, intakes of one or more SSB servings per day were associated with greater odds of depression.

The present FVC findings are generally consistent with existing literature. A prior meta-analysis reported inverse associations between total FVC and depression across cross-sectional studies [11]. Effect estimates in the current study were larger, which may partly reflect differences in reference categories, as prior studies compared higher to lower FVC while this study compared any FVC to none. Differences in study populations and depression measures may also contribute.

The positive association between SSB intake and depression observed in this study is consistent with prior evidence. A meta-analysis of 10 observational studies reported that higher SSB intake was associated with greater depression across both cross-sectional and cohort studies [15]. Similarly, a cross-sectional study of Korean adults found that consuming one or more SSB servings per day was associated with 54% greater odds of depression compared with non-consumers [25]. The larger association observed in that study may also stem from differences in reference categories, as that study used non-consumers as reference while this study used < 1 serving per day, as well as differences in study populations and depression measures.

The current study cannot establish a dose-response relationship between dietary behaviors and depression. For FVC, protective associations were comparable across the 1–2, 3–4, and ≥ 5 serving categories. Similarly, an Australian longitudinal study found that associations between FVC and depression did not meaningfully differ across higher intake levels. Prior research has identified non-linear patterns – Sun et al. observed a non-linear association between vegetable intake and depressive symptoms [26]. For SSB, the continuous models demonstrated statistically significant associations but only captured the overall trend rather than the shape of the dose-response relationship. Indeed, a meta-analysis of SSB studies found a non-linear dose-response relationship between SSB intake and depression [15]. These findings highlight the complexity of diet-depression associations. Notably, in this sample, 11% reported no FVC on the previous day, and only 13% of our sample consumed ≥ 5 servings daily, approximating current dietary recommendations [24]. Meanwhile, approximately 23% consumed one or more SSB servings per day. Together, these data suggest substantial room for improvement in dietary behaviors among NYC adults.

Sex and nativity differences in both depression prevalence and dietary behaviors are well documented. Women experience higher rates of depression and consume more fruits and vegetables than men [19, 27], while foreign-born residents tend to maintain healthier dietary patterns and lower depression rates than their US-born counterparts [28, 29]. The broadly consistent diet-depression associations observed across these subgroups support the generalizability of the present findings.

Both depression and dietary behaviors are shaped by complex social determinants, including food environment, economic constraints, and neighborhood characteristics. Nevertheless, diet-depression associations persisted after adjustment for a comprehensive set of socioeconomic factors, suggesting that dietary behaviors may remain relevant even within socially disadvantaged populations. NYC residents with food insecurity, for example, face both higher rates of depression and greater barriers to fruit and vegetable access, underscoring the need for targeted interventions addressing diet quality

among disadvantaged populations [30, 31]. School-based interventions targeting dietary behaviors among NYC adolescents may also be warranted, given that dietary habits and depression established in adolescence have been shown to persist into adulthood [13, 32]. NYC has existing programs to improve fruit and vegetable access among low-income residents, including Health Bucks – which doubles the purchasing power of Supplemental Nutrition Assistance Program (SNAP) benefits at farmers markets – and Get the Good Stuff, which provides similar benefits at select supermarkets [33, 34]. However, geographic coverage remains uneven, with many lower-income neighborhoods in outer boroughs underserved [33]. Meanwhile, SSB intake in NYC remains high and has plateaued after several years of decline [20]. Currently, NYC has no SSB tax nor a dual-action policy simultaneously targeting SSB reduction and FVC promotion. A modeling study found that subsidizing fruit and vegetable purchases through an SSB tax was projected to be highly cost-effective in NYC [35]. Yet, that analysis was limited to cardiovascular disease outcomes, and the authors acknowledged that the full benefits of the policy were likely underestimated. The potential mental health benefits of promoting FVC and limiting SSB intake, as suggested by this study, lend further support to the adoption of such policies in urban populations.

This study had several strengths and limitations. Among the strengths, diet-depression associations were examined in a large, racially and ethnically diverse urban population – a context underrepresented in prior research. The data came from a rigorously designed population-based survey representative of NYC adults, with a large sample size providing sufficient statistical power. Unlike studies that categorize dietary intake into sample-specific groups such as tertiles or quartiles, which vary across populations and are often reported without specifying the actual intake amounts, this study measured dietary exposures in servings per day – units directly interpretable for public health practice and more comparable across studies. Despite these strengths, several limitations should be acknowledged. A primary limitation was the use of cross-sectional data, which precludes causal inference – we cannot determine directionality, including the possibility that depressive symptoms might lead to poorer dietary choices (e.g., "comfort eating" or reduced motivation to cook). Second, although models were adjusted for a comprehensive set of demographic, socioeconomic, lifestyle, and health-related variables, residual confounding is still a possibility. Third, FVC was assessed based on the previous day's intake, which may not reflect habitual consumption patterns due to day-to-day variability and may introduce random measurement error. SSB intake, by contrast, was assessed as self-reported consumption frequency (per day, per week, or per month) rather than previous day recall, which may limit direct comparability between the two dietary exposures. Fourth, the use of self-reported measures for both diet and depression introduces potential recall and social desirability bias. Finally, as a telephone-based survey of non-institutionalized adults, the CHS excludes those without telephone access and institutionalized populations such as those in correctional facilities or long-term care – groups that may have higher rates of depression and poorer dietary behaviors, potentially limiting generalizability of findings to all NYC adults.

Conclusion

This cross-sectional study examined associations between fruit and vegetable consumption, sugar-sweetened beverage intake, and current depression among a large, diverse sample of New York City adults. Both exposures were independently associated with depression regardless of demographic, socioeconomic, lifestyle, and health-related factors, and associations were broadly consistent across sex and nativity subgroups. These findings contribute to growing evidence linking dietary behaviors to depression, extending this evidence to a large, diverse urban population. Policies and programs promoting fruit and vegetable consumption and reducing sugar-sweetened beverage intake represent potential strategies for supporting mental health in urban populations. Targeted interventions addressing dietary behaviors among disadvantaged communities may also be warranted.

Declarations

Competing interests

The authors declare no competing interests.

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Author Contribution

Zhi Liu: conceptualization, methodology, formal analysis, data curation, writing – original draft, writing – review and editing. Andrea L Deierlein: methodology, writing – review and editing. Ann Gaba: methodology, supervision, writing – review and editing.

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Data Availability

Data from the New York City Community Health Survey are publicly available from the New York City Department of Health and Mental Hygiene at <https://www.nyc.gov/site/doh/data/data-sets/community->

health-survey-public-use-data.page. The 2016–2018 multi-year combined survey weight used in this analysis is not included in the public-use files and was obtained from the Department upon request.

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