Preventive Medicine 69 (2014) 202–207

Contents lists available at ScienceDirect

Preventive Medicine

journal homepage: www.elsevier.com/locate/ypmed

School food reduces household income disparities in adolescents' frequency of fruit and vegetable intake ☆

Meghan R. Longacre [a,b,*], Keith M. Drake [a,c], Linda J. Titus [a,d], Karen E. Peterson [e,f], Michael L. Beach [a,g], Gail Langeloh [a,b], Kristy Hendricks [a,b], Madeline A. Dalton [a,b,d]

[a] Community Health Research Program, The Hood Center for Children and Families, The Geisel School of Medicine at Dartmouth, Lebanon, NH, USA
[b] Department of Pediatrics, The Geisel School of Medicine at Dartmouth, Lebanon, NH, USA
[c] Greylock McKinnon Associates, Cambridge, MA, USA
[d] Department of Community and Family Medicine, The Geisel School of Medicine at Dartmouth, Lebanon, NH, USA
[e] Human Nutrition Program, School of Public Health, University of Michigan, Ann Arbor, MI, USA
[f] Department of Nutrition, Harvard School of Public Health, Boston, MA, USA
[g] Department of Anesthesiology, Dartmouth-Hitchcock Medical Center, Lebanon, NH, USA

ARTICLE INFO

Available online 16 October 2014

Keywords:
Adolescents
School
Diet
Income
Fruits
Vegetables

ABSTRACT

Objective: The aim of this study is to examine whether school food attenuates household income-related disparities in adolescents' frequency of fruit and vegetable intake (FVI).

Method: Telephone surveys were conducted between 2007 and 2008 with adolescent-parent dyads from Northern New England; participants were randomly assigned to be surveyed at different times throughout the year. The main analysis comprised 1542 adolescents who typically obtained breakfast/lunch at school at least once/week. FVI was measured using 7-day recall of the number of times adolescents consumed fruits and vegetables. Fully adjusted linear regression was used to compare FVI among adolescents who were surveyed while school was in session (currently exposed to school food) to those who were surveyed when school was not in session (currently unexposed to school food).

Results: Mean FVI was 8.0 (SD = 5.9) times/week. Among adolescents unexposed to school food, household income and FVI were strongly, positively associated. In contrast, among adolescents exposed to school food, FVI was similar across all income categories. We found a significant cross-over interaction between school food and household income in which consuming food at school was associated with higher FVI among adolescents from low-income households versus lower FVI among adolescents from high-income households.

Conclusion: School food may mitigate income disparities in adolescent FVI. The findings suggest that the school food environment positively influences FVI among low-income adolescents.

Introduction

Frequency of fruit and vegetable intake (FVI) in children is a key indicator of dietary quality (United States Department of Agriculture, 2010), associated with decreased risk of chronic disease (Couch et al., 2008; McNaughton et al., 2008), and promoted as part of weight-management guidelines (Epstein et al., 2008; Field et al., 2003; Neumark-Sztainer et al., 2008). The vast majority of U.S. youth consume far fewer fruits and vegetables than the USDA recommends (i.e., for children between 14 and 18, 1.5–2.5 cups of fruit/day and 2.5–4 cups of vegetables/day) (Foltz et al., 2011; Krebs-Smith et al., 2010; Larson et al., 2007; United States Department of Agriculture, 2010). Two recent nationally representative adolescent surveys found that the combined median frequency of fruit (including 100% fruit juice) and vegetable intake was 2.3–2.4 times per day, with the Youth Risk Behavior Survey (YRBS) data showing slightly higher vegetable intake than fruit intake (Centers for Disease Control and Prevention, 2011, 2013).

Recent research examining socioecological influences on child and adolescent dietary intake demonstrated the dual importance of home and school settings (Harrison and Jones, 2012; Sallis and Glanz, 2006; Story et al., 2008; Verloigne et al., 2012). Not surprisingly, studies have consistently demonstrated a positive association between household income and children's fruit and vegetable consumption (Bere et al., 2008; Cutler et al., 2011; Ding et al., 2012; Riediger et al., 2007), due primarily to greater availability of fruits and vegetables in higher

Abbreviations: FVI, Frequency of Fruit and Vegetable Intake; NH, New Hampshire; VT, Vermont; YRBS, Youth Risk Behavior Surveillance Survey.

☆ Funding source: This work was supported by the National Institute of Environmental Health, Grant No. R01 ES014218. The funding source had no involvement in the study.

* Corresponding author at: Community Health Research Program, Hood Center for Children and Families, Department of Pediatrics, HB 7465, The Geisel School of Medicine at Dartmouth, One Medical Center Drive, Lebanon, NH 03756-0001, USA. Fax: +1 603 653 0790.

E-mail address: Meghan.R.Longacre@dartmouth.edu (M.R. Longacre).

http://dx.doi.org/10.1016/j.ypmed.2014.10.008
0091-7435/

income homes (Bere et al., 2008; Berge et al., 2012; Ding et al., 2012; Molaison et al., 2005; Neumark-Sztainer et al., 2003; Rasmussen et al., 2006). In contrast, studies assessing the impact of school food environments on FVI have produced mixed results, showing both positive (Cohen et al., 2012; Cullen et al., 2009; Davis et al., 2009; Slusser et al., 2007) and negative (Briefel et al., 2009; Kubik et al., 2003) associations with FVI, depending on the characteristics of the school food environment. It is not clear whether the impact of school food environments on FVI varies by student socioeconomic status.

The current study was conducted to determine the extent to which school food modifies the known influence of household income on adolescents' FVI. To accomplish this goal, we identified a cohort of adolescents who typically obtained breakfast or lunch at school during the school year. We then compared FVI in two subgroups: those who were randomly allocated to be surveyed during the school year (i.e., currently *exposed* to school food), and those who were randomly allocated to be surveyed during the summer when school was not in session (i.e., currently *unexposed* to school food). This approach, which has not been utilized in prior research on this topic, allowed us to compare exposed and unexposed adolescents who were otherwise comparable in all other respects.

Methods

Study design

Data for this analysis were collected as part of a longitudinal cohort study of adolescent health, approved by the Committee for the Protection of Human Subjects at Dartmouth College. Information on cohort recruitment and survey methods was published previously (Dalton et al., 2006, 2011). Briefly, in 2002–2003, we surveyed 87% of students in grades 4–6 at 26 randomly selected New Hampshire (NH) and Vermont (VT) public schools. Seventy one percent ($N = 2631$) of these students were enrolled in a longitudinal telephone survey of adolescent–parent dyads. Surveys were administered over the phone by trained interviewers. Adolescents and parents were interviewed separately; parental consent and adolescent assent were obtained at each interview. Participants were randomly assigned to be surveyed during different months throughout the year, including summer months when school was not in session. Of the original baseline cohort, 1885 (72%) participated in the 2007–2008 follow-up survey, which provided data for the current study. Follow-up participants were similar to non-participants in terms of gender, age and grade, but were more likely to have higher household incomes ($p < 0.001$) and parents with higher education levels ($p < 0.001$).

Measures

We assessed FVI with a 2-item measure adapted from the YRBS (Centers for Disease Control and Prevention, 2013, 2014). We asked adolescents, "In the past 7 days, how many times did you eat fruits, including fresh or canned?" and "In the past 7 days, how many times did you eat vegetables, including fresh, frozen, canned, and salad, but not including French fries?" For population based studies, Eaton et al. (2013) found that a 7-day recall of the number of times adolescents consumed fruit and vegetables was closest to 24-hour dietary recall estimates of daily servings of fruit and vegetables. Because our results were consistent whether we used fruit, vegetable, or fruit and vegetable intake combined as an outcome, adolescents' responses were summed to indicate the total number of times they ate fruit or vegetables during the previous 7 days.

We also asked all adolescents (regardless of whether they were surveyed while school was in session or not), "In a typical school week, on how many days do you: buy or get breakfast at school? buy or get lunch at school?" Positive responses to these questions were summed to indicate the frequency with which adolescents obtained school food.

Household income was assessed by asking parents to select the category that best described their annual household income from the following list: <$10,000; $10,001–15,000; $15,001–25,000; $25,001–35,000; $35,001–50,000; $50,001–75,000; $75,001–100,000; $100,001–150,000; >$150,000. The first two categories were combined in the analysis due to small sample sizes. Adolescents reported their gender and grade; age was calculated from their date of birth. Adolescent race/ethnicity and participation in free or reduced price lunch at school were assessed through the parent survey. School enrollment and grade configuration were obtained from the Department of Education websites of both states (New Hampshire Department of Education, 2014; Vermont Agency of Education, 2014). School town population size was obtained from the U.S. Census Population Estimates (United States Census Bureau, 2014) and categorized into four groups (<2500; 2500–4999; 5000–9999; ≥10,000).

Comparison groups

Our main purpose was to determine whether school food modified the known influence of household income on adolescents' FVI. Thus, the analysis was based on 1542 adolescents who reported obtaining school food during a typical school week. Adolescents who did not typically obtain food at school ($n = 343$) were excluded from the main analysis. Among adolescents who typically obtained school food, those who were randomly allocated to be surveyed while school was in session were classified as "currently exposed" to school food using two levels: exposed 1–5 times per week (low/moderate); exposed >5 times per week (high). The reference group of "currently unexposed" adolescents comprised those who typically obtained school food but were randomly allocated to be surveyed when school was not in session. Because our choice of comparison groups resembles an experimental design (i.e., all variables remain constant except for current exposure to school food), it minimizes possible bias and confounding, and specifically averts distortions that could arise from including adolescents who never obtain school food, as they likely differ from adolescents who typically obtain food at school (Hastert and Babey, 2009; Stevens et al., 2013).

Statistical analysis

The primary outcome variable was mean FVI. The independent variables of interest were household income and current exposure to school food. We used linear regression to estimate mean FVI. Generalized estimating equations (Liang and Zeger, 1986), with an exchangeable correlation matrix and robust variance estimates (Huber, 1967), were used to account for clustering of adolescents within schools and heteroscedasticity caused by a slightly positive skew in FVI. Adjusted regression models included terms for exposure to school food, household income, and the covariates gender, grade, free/reduced price lunch participation, school enrollment, school grade configuration, and school town population. The final model included a term for the interaction between household income and adolescent school food exposure, in which unexposed adolescents at the lowest income level were the referent group. To explore the robustness of the interaction, we conducted a sensitivity analysis with the 343 adolescents who did not typically obtain school food to determine if the association between household income and FVI was consistent regardless of whether students were surveyed while school was in session or not. In all models, the results were expressed as coefficients representing the expected change in mean FVI for a one unit change in the predictor variable. To maximize the sample size, we employed multiple imputation by chained equations (Azur et al., 2011) to impute values for all variables in the multivariate models with missing data (less than 0.2% of the participants were missing values for adolescent characteristics, 5.5% had a missing value for parent characteristics, and 10.1% were missing values for school/town characteristics). Our results were consistent with and without multiple imputation. All analyses were conducted in 2014 using STATA version 11 (StataCorp LP, College Station, Texas).

Results

Half (52.0%, $N = 804$) the adolescents were male and the majority (94.6%, $N = 1392$) were non-Hispanic white, which reflects the underlying population (Table 1). The mean age for the sample was 14.4 years (SD 1.04). Adolescents attended over 70 schools (34.9% attended 32 schools in NH; 62.2% attended 38 schools in VT; 2.9% attended schools in other states). Schools ranged in enrollment size from 83 to 3329 students, with a mean of 958 (SD = 600). Approximately one-third of the schools were located in settings with less than 5000 residents (school data not shown). Two-thirds ($N = 1043$) of the adolescents were in high school (grades 9–11). Nineteen percent ($N = 280$) received free or reduced price lunch at school. Almost one third ($N = 461$) of parents reported annual household incomes of $50,000 or less; 41.6% ($N = 592$) reported incomes over $75,000. Seventeen percent ($N = 267$) of adolescents were currently unexposed to school food (i.e., surveyed while

Table 1
Adolescent frequency of fruit and vegetable intake (FVI) by adolescent, parent, and school characteristics ($N = 1542$).[a, b]

	N	Frequency of fruit and vegetable intake in past week		
		Mean (SD)	Unadjusted coefficient (95% CI)	Adjusted coefficient (95% CI) [c]
Gender				
Female	738	8.88 (6.17)	Reference	Reference
Male	804	7.31 (5.42)	−1.54 (−2.06,−1.01)***	−1.64 (−2.20,−1.08)***
Grade				
7–8	499	7.51 (5.39)	Reference	Reference
9	604	8.26 (5.49)	0.78 (0.10,1.45)*	0.32 (−0.67,1.31)
10–11	439	8.41 (6.73)	0.83 (−0.16,1.81)	0.56 (−0.66,1.77)
Race				
Not White	80	7.35 (4.79)	Reference	Reference
White	1392	8.11 (5.93)	0.72 (−0.57,2.01)	0.37 (−0.79,1.54)
Free or reduced price lunch				
No	1195	8.47 (6.05)	Reference	Reference
Yes	280	6.42 (4.71)	−2.00 (−2.95,−1.04)***	−1.10 (−1.95,−0.24)*
Household income[d]			0.51 (0.32,0.71)***	0.32 (0.13,0.52)**
School food				
Unexposed, school not in session	267	7.96 (6.58)	Reference	Reference
Low/moderate exposure (1–5 times/week)	961	8.29 (5.70)	0.33 (−0.52, 1.17)	−0.05 (−0.86,0.76)
High exposure (>5 times/week)	314	7.45 (5.59)	−0.50 (−1.52,0.52)	−0.38 (−1.48,0.71)
School enrollment				
<350	130	7.94 (5.45)	Reference	Reference
350–599	275	8.05 (5.76)	0.10 (−1.30,1.51)	−0.30 (−1.73,1.14)
600–949	316	8.04 (5.78)	0.09 (−1.18,1.37)	0.16 (−0.95,1.26)
≥950	667	7.93 (5.44)	−0.02 (−1.19,1.15)	−0.31 (−1.67,1.04)
School grade configuration				
No high school grades	343	7.28 (5.23)	Reference	Reference
Elementary/middle and high school grades	307	7.90 (5.39)	0.62 (−0.32,1.55)	0.28 (−1.02,1.58)
Only high school grades	738	8.33 (5.79)	1.05 (0.12,1.99)*	0.59 (−0.90,2.07)
School town population				
<2500	126	7.83 (5.65)	Reference	Reference
2500–4999	400	8.79 (5.61)	0.96 (−1.22,3.14)	0.44 (−0.92,1.79)
5000–9999	406	7.50 (5.48)	−0.32 (−2.41,1.76)	−0.65 (−2.37,1.06)
≥10,000	453	7.69 (5.53)	−0.13 (−2.18,1.92)	−0.40 (−1.85,1.04)

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.
[a] Data collected in 2007–2008; analysis conducted in 2014. Study conducted in New Hampshire (NH) and Vermont (VT), USA.
[b] Not all variables sum to 1542 due to missing values.
[c] Adjusted for all other variables in the table.
[d] Eight increments in household income (i.e., ≤$15,000; $15,001–25,000; $25,001–35,000; $35,001–50,000; $50,001–75,000, $75,0010–100,000, $100,001–150,000; and >$150,000) are used as a continuous variable.

school was not in session). Among adolescents currently exposed to school food, the majority ($N = 961$) had low/moderate exposure (i.e., typically obtained school food 1–5 times/week); most ($N = 688$) of the adolescents in this category obtained school food five times/week. About twenty percent ($n = 314$) of adolescents had high exposure (i.e., typically obtained school food >5 times/week). Adolescents participating in the free or reduced price lunch program were almost twice as likely to have high exposure to school food compared to those not participating in the program (32.5% vs. 17.1%, respectively).

The mean FVI among all participants was 8.0 (SD = 5.9) and the median was 7.0, indicating a slightly positive skew in the distribution. Mean FVI was lower for males than females, and for those who participated in free/reduced price lunch (Table 1). The unadjusted and adjusted models demonstrated the strong positive association between household income and adolescent FVI. Overall, we found no association between the frequency of obtaining school food and mean FVI. In the unadjusted model, adolescents attending schools with only high school grades had a higher FVI than adolescents attending non-high schools, but this association was not statistically significant in the adjusted model.

We noted a statistically significant interaction between exposure to school food and household income in relation to mean FVI, in which school food attenuated the overall positive influence of household income on FVI (Table 2). Among adolescents who were unexposed to school food, the mean FVI was 1.04 (95% CI: 0.61, 1.48) higher with each increment in household income category ($p < 0.001$). In contrast, among adolescents with low/moderate exposure to school food, mean FVI was only 0.22 (95% CI: −0.05, 0.49) higher with each increment in household income category (i.e., 1.04 minus 0.82). Among adolescents with high exposure to school food, mean FVI was 0.07 (95% CI: −0.46, 0.32) lower with each increment in household income category (i.e., 1.04 minus 1.11). The effect of household income on FVI was not significantly different from zero for adolescents exposed to school food.

The first graph in Fig. 1, which is based on the adjusted interaction model in Table 2, illustrates the positive association between household income and mean FVI among adolescents unexposed to school food. It also illustrates that exposure to school food substantially attenuates the relationship between household income and mean FVI. In contrast to the unexposed group, household income had a relatively weak relationship with FVI among adolescents exposed to school food. Further, the first graph depicts the cross-over interaction between school food and income. Specifically, school food exposure was associated with higher FVI among low-income adolescents versus lower FVI among high-income adolescents. The second graph in Fig. 1 depicts the results from the sensitivity analysis with the 343 adolescents who never obtained food at school. This second graph illustrates the consistent positive association between household income and FVI, regardless of whether students were surveyed while school was in session or not.

Discussion

Similar to previous studies, we found a positive association between adolescents' household income and FVI (Bere et al., 2008; Cutler et al., 2011; Ding et al., 2012; Riediger et al., 2007). However, our analysis

Table 2
Interaction between school food and household income as predictors of adolescent FVI ($N = 1542$).[a]

	Adjusted linear regression interaction model (95% CI) [b]
Household income [c]	1.04 (0.61,1.48)***
School food [d]	
Unexposed, school not in session	Reference
Low/moderate exposure (1–5 times/week)	3.22 (1.14,5.29)**
High exposure (>5 times/week)	3.80 (1.53,6.07)**
School food × household income interaction [e]	
Unexposed × household income	Reference
Low/moderate × household income	−0.82 (−1.29,−0.35)***
High × household income	−1.11 (−1.65,−0.57)***
Constant	4.73 (1.90,7.56)***

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

[a] Data collected in 2007–2008; analysis conducted in 2014. Study conducted in New Hampshire (NH) and Vermont (VT), USA.

[b] Adjustments made for gender, grade, race, free or reduced price lunch, school enrollment, school grade configuration, and school town population.

[c] Eight increments in household income (i.e. ≤$15,000; $15,001–25,000; $25,001–35,000; $35,001–50,000; $50,001–75,000, $75,0010–100,000, $100,001–150,000; and >$150,000) are used as a continuous variable. This coefficient can only be interpreted independent from the interaction terms for adolescents unexposed to school food, which was the reference category.

[d] Coefficients for school food exposure represent the mean increase in FVI for two categories of school food [low/moderate (1–5 times/week) and high (>5 times/week)] compared to students unexposed to school food. These coefficients can only be interpreted independent from the interaction terms for adolescents in the lowest household income group (<$15,000 per year), which was the reference category.

[e] Interaction values indicate (1) the decrease in slope for household income and FVI for each category of school food exposure, and (2) the decrease in school food coefficients for every unit increase in household income.

revealed that this relationship was primarily evident among students currently unexposed to school food. Among students exposed to school food, there was very little difference in FVI by household income. The cross-over interaction between school food and household income was so strong, we observed opposite associations between school food exposure and FVI by household income. Adolescents in the lowest income category had higher FVI if they obtained school food, whereas adolescents in the highest income category had lower FVI if they obtained school food. The validity of this finding is supported by the sensitivity analysis which demonstrates that the interaction is specific to adolescents who consume school food during the school year and not solely due to seasonal differences in FVI. Our results indicate that exposure to school food mitigates income-related disparities in adolescent FVI, and this mitigation is beneficial for low-income students.

Previous studies have found a greater availability of fruits and vegetables in high-income homes (Bere et al., 2008; Neumark-Sztainer et al., 2003; Berge et al., 2012). Thus, it is not surprising that among those surveyed when school was not in session, high-income adolescents consumed fruits and vegetables more frequently than those from low-income homes. In contrast, among adolescents surveyed while school was in session – and thus, who were obtaining school food – the frequency of FVI was similar across all income levels. This supports the notion that adolescents' FVI is highly influenced by the food environment, which could include both fruit and vegetable availability and the manner in which they are served (Cullen and Zakeri, 2004; Cullen et al., 2000; Davis et al., 2009; Slusser et al., 2007).Our finding that schools may be having a positive impact on FVI among students in the lowest income groups is encouraging. However, we also note that obtaining food from school was not beneficial for higher income adolescents. Furthermore, regardless of household income or time of survey, overall mean FVI was infrequent (about 1.1 time/day), as it is unlikely that adolescents would consume the USDA daily recommended amount of fruits and vegetables (3.5–6 cups) all at once.

Similar to previous studies of school food influences on FVI (Hastert and Babey, 2009; Hernandez et al., 2011; Taber et al., 2013), we did not specifically measure which foods adolescents ate at school, and thus cannot directly ascertain the independent impact of meals offered through the National School Meal programs, a la carte menus, or other school food options, such as snack bars or vending machines. This limits our ability to determine which characteristics of school food environments contributed to the observed effects, and highlights an area for

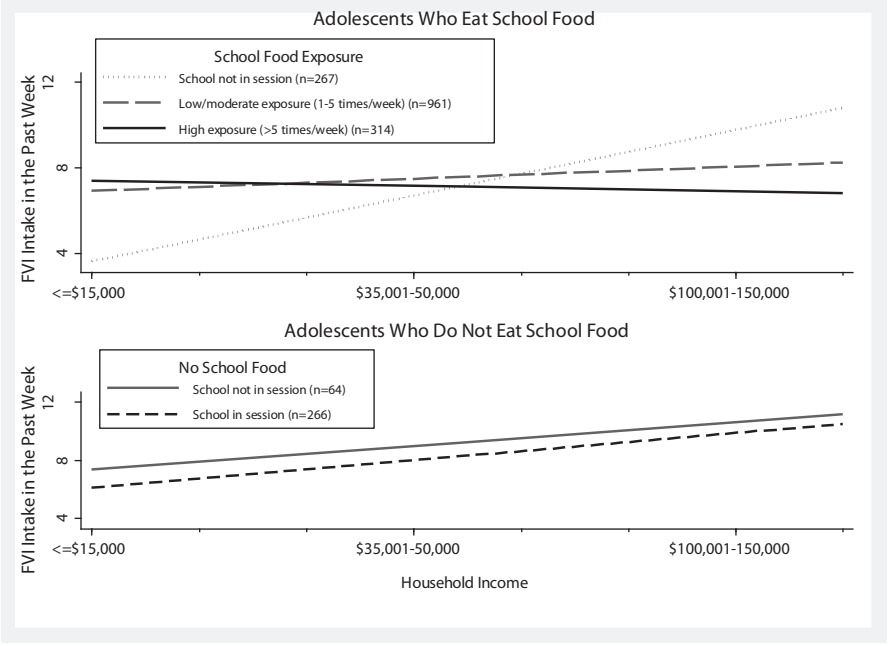

Fig. 1. Frequency of adolescents' fruit and vegetable intake (FVI) in the past week by household income among those who typically eat school food (main analysis) and those who do not (sensitivity analysis).[a]. [a] Data collected in 2007–2008; analysis conducted in 2014. Study conducted in New Hampshire (NH) and Vermont (VT), USA.

future study. However, in exploratory analyses confined to low-income students, we observed higher FVI among students participating in free/reduced price lunch, compared to those who were not. This finding, although based on small numbers, supports a beneficial impact of the National School Meal programs for low-income students. Although we cannot account for the decreased FVI among high-income adolescents who obtained school food, this reduction may reflect choosing snacks or a la carte foods, or simply a reduction in FVI relative to summer, when most meals are consumed at home, in what is likely a fruit and vegetable-rich environment (Cox et al., 2000; Locke et al., 2009).

Our sample included primarily white adolescents from Northern New England. The FVI (1.1 times/day) for our sample was lower than that reported in national samples (Centers for Disease Control and Prevention, 2011, 2013). We did not include 100% fruit juice in our FVI outcome measure, which may partially account for the discrepancy. In post-hoc analyses, adding consumption of 100% fruit juice increased adolescents' intake slightly, but did not impact the observed associations. Our unique study design with random survey allocation throughout the calendar year created a type of "natural experiment" in which we were able to identify a population of adolescents who were comparable with regard to obtaining food at school, and to create comparison groups who were exposed (i.e., surveyed while school was in session) or unexposed (i.e., surveyed while school was not in session) to school food. This design was employed to minimize potential bias and confounding. To better understand the mechanisms by which the home and school environments impact adolescent FVI, future studies are needed to isolate sources (e.g., home, school, other) and contexts of how adolescents access and where they consume fruit and vegetables, and to identify how these factors interact with the specific school foods (e.g., a la carte options) and programs (e.g., National School Meals) that are utilized by adolescents at school.

Conclusion

New federal rules guiding nutrient standards in school meals (United States Department of Agriculture, 2014), as well as innovative school food campaigns (Let's Move!, 2014), emphasize greater availability of fresh fruits and vegetables in schools. The efficient distribution and success of such policies and programs will depend, in part, on targeting efforts to subpopulations that could benefit most. Our study suggests that school food options are a valuable resource for increasing FVI among lower income adolescents, and provides evidence that supports extending school-based food programs year-round. However, a different strategy may be needed to increase or at least maintain FVI among higher income students who obtain food from school.

Conflict of interest statement

The authors declare that there are no conflicts of interests.

Acknowledgments

The current study was supported by the National Institute of Environmental Health Sciences, grant number R01-ES014218. The funding agency had no involvement in the study. We would like to express our appreciation to our team of survey administrators and participating schools for data collection. We would also like to acknowledge the valuable feedback from the anonymous reviewers.

References

Azur, M.J., Stuart, E.A., Frangakis, C., Leaf, P.J., 2011. Multiple imputation by chained equations: what is it and how does it work? Int. J. Methods Psychiatr. Res. 20, 40–49.
Bere, E., van Lenthe, F., Klepp, K.I., Brug, J., 2008. Why do parents' education level and income affect the amount of fruits and vegetables adolescents eat? Eur. J. Public Health 18, 611–615.
Berge, J.M., Arikian, A., Doherty, W.J., Neumark-Sztainer, D., 2012. Healthful eating and physical activity in the home environment: results from multifamily focus groups. J. Nutr. Educ. Behav. 44, 123–131.
Briefel, R.R., Crepinsek, M.K., Cabili, C., Wilson, A., Gleason, P.M., 2009. School food environments and practices affect dietary behaviors of U.S. public school children. J. Am. Diet. Assoc. 109 (2 Suppl.), S91–S107.
Centers for Disease Control and Prevention, 2011. Fruit and vegetable consumption among high school students—United States. 2010. MMWR 60, 1583–1586.
Centers for Disease Control and Prevention, 2013. State Indicator Report on Fruits and Vegetables. Centers for Disease Control and Prevention, U.S. Department of Health and Human Services, Atlanta, GA.
Centers for Disease Control and Prevention, 2014. Adolescent and school health: Youth Risk Behavior Surveillance SurveyAvailable at: http://www.cdc.gov/healthyyouth/yrbs/index.htm.
Cohen, J.F., Smit, L.A., Parker, E., et al., 2012. Long-term impact of a chef on school lunch consumption: findings from a 2-year pilot study in Boston middle schools. J. Acad. Nutr. Diet. 112, 927–933.
Couch, S.C., Saelens, B.E., Levin, L., Dart, K., Falciglia, G., Daniels, S.R., 2008. The efficacy of a clinic-based behavioral nutrition intervention emphasizing a DASH-type diet for adolescents with elevated blood pressure. Pediatrics 152, 494–501.
Cox, B.D., Whichelow, M.J., Prevost, A.T., 2000. Seasonal consumption of salad vegetables and fresh fruit in relation to the development of cardiovascular disease and cancer. Public Health Nutr. 3, 19–29.
Cullen, K.W., Zakeri, I., 2004. Fruits, vegetables, milk, and sweetened beverages consumption and access to a la carte/snack bar meals at school. Am. J. Public Health 94, 463–467.
Cullen, K.W., Eagan, J., Baranowski, T., Owens, E., de Moor, C., 2000. Effect of a la carte and snack bar foods at school on children's lunchtime intake of fruits and vegetables. J. Am. Diet. Assoc. 100, 1482–1486.
Cullen, K.W., Watson, K.B., Konarik, M., 2009. Differences in fruit and vegetable exposure and preferences among adolescents receiving free fruit and vegetable snacks at school. Appetite 52, 740–744.
Cutler, G.J., Flood, A., Hannan, P., Neumark-Sztainer, D., 2011. Multiple sociodemographic and socioenvironmental characteristics are correlated with major patterns of dietary intake in adolescents. J. Am. Diet. Assoc. 111, 230–240.
Dalton, M.A., Adachi-Mejia, A.M., Longacre, M., et al., 2006. Parental rules and monitoring of children's movie viewing associated with children's risk for smoking and drinking. Pediatrics 118, 1932–1942.
Dalton, M.A., Longacre, M.R., Drake, K., et al., 2011. Built environment predictors of active travel to school among rural adolescents. Am. J. Prev. Med. 40, 312–319.
Davis, E.M., Cullen, K.W., Watson, K.B., Konarik, M., Radcliffe, J., 2009. A fresh fruit and vegetable program improves high school students' consumption of fresh produce. J. Am. Diet. Assoc. 109, 1227–1231.
Ding, D., Sallis, J.F., Norman, G.J., et al., 2012. Community food environment, home food environment, and fruit and vegetable intake of children and adolescents. J. Nutr. Educ. Behav. 44, 634–638.
Eaton, D.K., Olsen, E.O., Brener, N.D., et al., 2013. A comparison of fruit and vegetable intake estimates from three survey question sets to estimates from 24-hour dietary recall interviews. J. Acad. Nutr. Diet. 113, 1165–1174.
Epstein, L.H., Paluch, R.A., Beecher, M.D., Roemmich, J.N., 2008. Increasing healthy eating vs. reducing high energy-dense foods to treat pediatric obesity. Obesity 16, 318–326.
Field, A.E., Gillman, M.W., Rockett, H.R., Colditz, G.A., 2003. Association between fruit and vegetable intake and change in body mass index among a large sample of children and adolescents in the United States. Int. J. Obes. 27, 821–826.
Foltz, J.L., Cook, S.R., Szilagyi, P.G., et al., 2011. U.S. adolescent nutrition, exercise, and screen time baseline levels prior to national recommendations. Clin. Pediatr. 50, 424–433.
Harrison, F., Jones, A.P., 2012. A framework for understanding school based physical environmental influences on childhood obesity. Health Place 18, 639–648.
Hastert, T.A., Babey, S.H., 2009. School lunch source and adolescent dietary behavior. Prev. Chron. Dis. 6, A117.
Hernandez, D.C., Francis, L.A., Doyle, E.A., 2011. National School Lunch Program participation and sex differences in body mass index trajectories of children from low-income families. Arch. Pediatr. Adolesc. Med. 164, 346–353.
Huber, P.J., 1967. The behavior of maximum likelihood estimates under nonstandard conditions. Proceedings of the Fifth Berkeley Symposium on Mathematical Statistics and Probability vol 1. University of California Press, Berkeley, CA.
Krebs-Smith, S.M., Guenther, P.M., Subar, A.F., Kirkpatrick, S.T., Dodd, K.W., 2010. Americans do not meet federal dietary recommendations. J. Nutr. 140, 1832–1838.
Kubik, M.Y., Lytle, L.A., Hannan, P.J., Perry, C.L., Story, M., 2003. The association of the school food environment with dietary behaviors of young adolescents. Am. J. Public Health 93, 1168–1173.
Larson, N.I., Newmark-Sztainer, D., Hannan, P.J., Story, M., 2007. Trends in adolescent fruit and vegetable consumption, 1999–2004: project EAT. Am. J. Prev. Med. 32, 147–150.
Let's Move!, 2014. Healthy schoolsAvailable at: http://www.letsmove.gov/healthy-schools.
Liang, K., Zeger, S.L., 1986. Longitudinal data analysis using generalized linear models. Biometrika 73, 13–22.
Locke, E., Coronado, G.D., Thompson, B., Kuniyuki, A., 2009. Seasonal variation in fruit and vegetable consumption in a rural agricultural community. J. Am. Diet. Assoc. 109, 45–51.
McNaughton, S.A., Ball, K., Mishra, G.D., Crawford, D.A., 2008. Dietary patterns of adolescents and risk of obesity and hypertension. J. Nutr. 138, 364–370.
Molaison, E.F., Connell, C.L., Stuff, J.E., Yadrick, M.K., Bogle, M., 2005. Influences on fruit and vegetable consumption by low-income black American adolescents. J. Nutr. Educ. Behav. 37, 246–251.
Neumark-Sztainer, D., Wall, M., Perry, C., Story, M., 2003. Correlates of fruit and vegetable intake among adolescents. Findings from Project EAT. Prev. Med. 37, 198–208.

Neumark-Sztainer, D., Flattum, C.F., Story, M., Feldman, S., Petrich, C.A., 2008. Dietary approaches to healthy weight management for adolescents: the New Moves model. Adolesc. Med. State Art Rev. 19, 421–430.
New Hampshire Department of Education, 2014. Attendance and enrollment reports. Available at: http://www.education.nh.gov/data/attendance.htm.
Rasmussen, M., Krølner, R., Klepp, K.I., et al., 2006. Determinants of fruit and vegetable consumption among children and adolescents: a review of the literature. Part I: quantitative studies. Int. J. Behav. Nutr. Phys. Act. 3, 22.
Riediger, N.D., Shooshtari, S., Moghadasian, M.H., 2007. The influence of sociodemographic factors on patterns of fruit and vegetable consumption in Canadian adolescents. J. Am. Diet. Assoc. 107, 1511–1518.
Sallis, J.F., Glanz, K., 2006. The role of built environments in physical activity, eating and obesity in childhood. Future Child. 16, 89–108.
Slusser, W.M., Cumberland, W.G., Browdy, B.L., Lange, L., Neumann, C., 2007. A school salad bar increases frequency of fruit and vegetable consumption among children living in low-income households. Public Health Nutr. 10, 1490–1496.
Stevens, L., Nicholas, J., Wood, L., Nelson, M., 2013. School lunches v. packed lunches: a comparison of secondary schools in England following the introduction of compulsory school food standards. Public Health Nutr. 16, 1037–1042.
Story, M., Kaphingst, K.M., Robinson-O'Brien, R., Glanz, K., 2008. Creating healthy food and eating environments: policy and environmental approaches. Annu. Rev. Public Health 29, 253–272.
Taber, D.R., Chriqui, J.F., Chaloupka, F.J., 2013. State laws governing school meals and disparities in fruit/vegetable intake. Am. J. Prev. Med. 44, 365–372.
United States Census Bureau, 2014. Population estimates: cities and towns—minor civil divisions, 2000–2007Available at: http://www.census.gov/popest/data/historical/2000s/vintage_2007/city.html.
United States Department of Agriculture, 2010. Report of the Dietary Guidelines Advisory Committee on the Dietary Guidelines of AmericansAvailable at: http://www.cnpp.usda.gov/DGAs2010-DGACReport.htm.
United States Department of Agriculture, 2014. Nutrition standards for school meals. Available at: http://www.fns.usda.gov/cnd/Governance/Legislation/nutritionstandards.htm.
Verloigne, M., Van Lippevelde, W., Maes, L., Brug, J., De Bourdeaudhuij, I., 2012. Family- and school-based correlates of energy balance-related behaviours in 10–12-year-old children: a systematic review within the ENERGY (EuropeaN Energy balance Research to prevent excessive weight Gain among Youth) project. Public Health Nutr. 15, 1380–1395.
Vermont Agency of Education, 2014. School data and reports: enrollment reportAvailable at: http://education.vermont.gov/new/html/data/enrollment.html.